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Proceedings

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Foreword

The Proceedings of the 2nd International Conference on Management of Technology, Innovation, and Project (MOTIP 02) is a scientific publication of the MOTIP 02's presenters and authors, which presented online on February 27th, 2021. Meanwhile, MOTIP 02 is a conference hosted by the Department of Technology Management, Institut Teknologi Sepuluh Nopember as an academic event for the researchers, academicians, students, practitioners, and observers to disseminate their research findings, best practices, and ideas related to the scope of technology management.

MOTIP 02 has a collaboration with the 10th International Conference on Operations and Supply Chain Management (OSCM). Thus, the conference theme is "Technology, People, and Innovation in Supply Chain". This join conference already received 224 abstract submissions from more than 20 countries, and more than 20 different affiliations. After screening process, we finally accepted papers which have been presented on the conference and the papers are published in this proceedings.

The Proceedings of MOTIP 02 contains 106 articles which address current issues in management of technology and beyond, which we classified into several subjects, i.e. Supply Chain and Logistics Management, Quality Management, Lean Manufacturing, Performance and Cost Management, Finance Management, Marketing Management, Strategic Management, Management of IT/IS, Project Management, Risk Management and Analysis, Decision Support System in Business, Simulation and Optimization, Factor Analysis, and Innovation on Application.

On the top of that, this proceedings also contains article of the keynote speakers, Professor Chee Yew Wong, from Leeds University Business School, UK, entitled "Researching Technology, People, and Innovation in Supply Chains: Towards meaningful and impactful scholarly research articles".

On behalf of the editors and committees, we would like to express our gratitude to all authors, speakers, presenters, and participants for the contributions to the Proceedings of MOTIP 02. We hope you get new experience, new knowledge, as well as new insights from this proceedings.

Surabaya, February 27th, 2021

Gita Widi Bhawika

Chair

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TOPIC

Supply Chain and Logistics Management

DESIGNING SUPPLY CHAIN RISK MITIGATION STRATEGY AT GAS PROCESSING PLANT USING HOUSE OF RISK METHOD

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ABSTRACT

A gas processing plant is an essential natural gas management facility. Processed natural gas is fuel for use by power plants. Considering electricity is the vital energy to meet the general public's needs, the gas supply must not be disrupted. However, there is still often the failure of operations at the gas processing plant that is not expected. The supply of gas to the plant is also disrupted and resulting in constraints to the distribution of electricity to consumers. This supply failure also occurred at the CPPG gas processing plant owned by PT. X. There is currently no supply chain risk management in CPPG. The risks resulting from the failure of gas supply from CPPG to the power plant have not been identified. They are not well mitigated, so it is necessary to do a supply chain risk mitigation strategy at the CPPG gas processing plant so that there is no failure of gas supply in the future. This study aims to design a supply chain risk mitigation strategy at the CPPG gas processing plant. The framework used in this study is ISO31000:2018. In the initial stages, risk identification is carried out through focus group discussions with participants from cross-functional departments. The risk identification process is based on business processes regarding the Supply Chain Operation Reference. The results show 32 identified risk events and 35 risk agents. After conducting an evaluation using House of Risk phase 1, ten risk agents need to be prioritized. The selection of options for risk mitigation was carried out using the House of Risk phase 2 method and resulted in 10 preventive actions that the company could implement.

Keywords: gas processing plant, house of risk, mitigation, supply chain risk.

1. INTRODUCTION

A gas processing plant is an essential natural gas management facility. Processed natural gas is used as fuel for power plants. Considering that electricity is an energy that is very important to meet the general public's needs, the gas supply must not be interrupted. In carrying out this function, the CPPG gas processing plant cannot stand alone. The gas processing plant requires another party to form its supply chain network.

There are uncertainties in the supply chain that can disrupt the management of the supply chain itself. The first uncertainty stems from demand. The amount of demand from power plants through gas transporter can vary according to the electric power needs. Besides, the gas transporter and power plant facilities' unpreparedness due to a sudden disruption can lead to a demand for the gas processing plant to stop the gas supply.

The second uncertainty comes from suppliers. This can be in the form of the lead time for delivery of MRO materials, the uncertainty of prices for supporting materials or spare parts due to exchange rate fluctuations, the uncertainty of quality and quantity of MRO materials sent. The third uncertainty comes from internal sources, such as machine failure, labor absences, andproduction quality uncertainty. The fourth uncertainty can come from the environment, such as natural disasters or political stability factors.

These uncertainties have the potential to pose risks. From a supply chain perspective, risks can arise in various events throughout the process of material flow, production, and finished products. This risk can disrupt the flow of material, information, and finance, affecting supply chain performance. The negative impact of uncertainties causes supply chain risk management's need through the Supply Chain Risk Management (SCRM) approach.

Currently, there is no supply chain risk management at the CPPG gas processing plant. The company has not included supply chain risks in the risk register. Supply chain risks have not been properly identified and mitigated. It can cause disruptions to supply chain performance, so it is necessary to implement a supply chain risk mitigation strategy at the CPPG gas processing plantso that gas supply failures do not occur in the future.

2. METHOD

2.1 Risk Management Framework

ISO 31000: 2018 is a standard for aligning risk management processes with existing and future standards. This International Standard provides a general approach to support standards relating to specific risks. This International Standard provides general guidance, and it is not intended to promote uniform risk management across organizations. The design and implementation of a risk management plan and working framework needs to consider a particular organization's needs with its specific objectives, context, structure, operations, processes, functions, projects, products, services or assets, and the specific practices used.

In the risk management process, according to ISO 31000: 2018, there are several stages or processes, which include establishing a context, risk identification, risk analysis, risk evaluation, risk treatment, monitoring, and review. In this research, the monitoring and review stages are not included in the scope.

2.2 Business Process Identification

The Supply Chain Operation Reference (SCOR) is a model developed by the Supply Chain Council as a standard diagnostic tool for supply chain management that can be used for various industries. The SCOR model describes business activities to meet customer demands using a process modeling block. The SCOR model can describe supply chains from simple to verycomplex supply chains using a series of general definitions.

Business process identification is the first step in this research. Business processes are identified by reviewing an activity carried out in the company. This business process is mapped with the latest SCOR framework (Plan, Source, Make, Deliver, Return and Enable). The company's role or stakeholders in identifying this business process is essential. The company or stakeholders are people who know and understand the big picture of the business processes that occur within the company. The business process in a gas processing plant is shown by Table 1.

2.3 Risk Identification

This stage consists of identifying risk agents that can cause more than one risk event in the CPPG business process. In general, risk identification is carried out using Root Cause Analysis

(RCA). The first step in RCA is the identification of risk events that may occur in each business sub-process. Early identification of risk events is obtained from literature studies, previous research that discusses supply chain risks, and observations in the field. The second step is the verification of the identified risks through a focus group discussion (FGD) by involving a cross- functional team. In the FGD activity, risk agent identification was also carried out. Table 1 shows that risk event identification in each business process.

Table 1. Risk Event Identification

Process	Sub-Process	Risk Events	Code
Plan	Gas demand forecasting	Large forecast error	E1
	Gas reserves calculation	Inaccurate calculation	E2
	MRO material forecasting	MRO material forecast error	E3
	Production planning	Sudden changes in production plans	E4
	Plant maintenance planning	Delayed plant maintenance execution	E5
Source	Well preparation	Delayed well preparation	E6
		Dry-hole	E7
	Natural gas inspection	Out-of-specification in quality	E8
		Volume lower than demand	E9
	Gas-in	Loss volume	E10
	MRO material procurement	Delayed tender process	E11
		Delay in MRO material delivery	E12
		MRO material price hikes	E13
	MRO material inspection	MRO material doesn't meet requirement	E14
	Supplier evaluation	Supplier breach contract	E15
	MRO material inventory	Inaccurate inventory record	E16
		Chemical material surplus	E17
Make	Production execution	Unplanned shutdown	E18
	Quality control	Gas out-of-spec	E19
	Plant maintenance execution	Delayed maintenance execution	E20
	Waste processing	Waste processing is not optimum	E21
Deliver	Gas delivery to customer	Gas is not received by customer	E22
	Sales gas metering	Difference in measurement	E23
Return	Returning condensate	Delay in return condensate from customer	E24
	Returning MRO material	Delay in return process to supplier	E25
Enable	Human resource management	Gap in the number of workers	E26
		Worker competency gaps	E27
	Data & IT management	Data and information leakage	E28
		Breakdown IT system	E29
	Contract management	Expired contract	E30
	Financial management	Payment from customer is late	E31
	Compliance management	Fraud	E32

2.3 Risk Analysis

This stage collects data and summarizes supply chain risk, including risk agents and risk events in the CPPG business process. The risk variables used in the study were obtained from the results of verification through interviews with several people who have specific experience and expertise in the fields that are under the topic of discussion. Then, an FGD activity that involves a cross-functional team is carried out to assess the severity of the risk event and the occurrence of a risk agent. The scale used to determine severity is the value {1,2,3,4,5} representing insignificant, minor, moderate, significant, and catastrophic. Meanwhile, the scale used to assess occurrence is a value of {1,2,3,4,5} representing the rare, unlikely, moderate, likely, and almost certain.

2.4 Risk Evaluation

The purpose of risk evaluation is to determine the priority order of risk agents for mitigation. The method used is House of Risk phase 1. The first step is to create a relationship matrix between the risk event and the risk agent. Furthermore, it provides an assessment of the correlation between the risk event and the risk agent with a value of {1,3,9}, representing a weak, moderate, and strong correlation. A value of 0 is given if there is no correlation between the risk event and the risk agent. The next step is to calculate the Aggregate Risk Potential (ARP) value based on the total multiplication between the severity risk event, the occurrence risk agent, and thecorrelation value between the risk event and risk agent. Risk agent is prioritized based on the ARPvalue ranking from the highest to lower. Pareto concept (80/20) can help determine risk agents which make a significant contribution. Table 2 shows that the top ten risk agents: A2, A8, A17, A20, A22, A9, A34, A5, A6, and A21, contributed 78.2% of the total ARP value. Several risk agents who contribute this large percentage are prioritized for preventive action.

Table 2. Risk Agent Rank

Rank	Risk Agent (Code)	Aggregate Risk Potential (ARP)	% ARP	Cumulative % ARP
1	Limited information (A2)	216	10,4	10,4
2	Spare part stock-out (A8)	210	10,2	20,6
3	Dependence on one supplier (A17)	180	8,7	29,3
4	Custom clearance problem (A20)	180	8,7	38,0
5	Large shipping lot sizes (A22)	180	8,7	46,7
6	Social conflict (A9)	162	7,8	54,5
7	Customer cashflow problems (A34)	135	6,5	61,1
8	Lack of worker competence (A5)	132	6,4	67,5
9	Low vendor competence (A6)	132	6,4	73,8
10	Exchange rate fluctuations (A21)	90	4,4	78,2
11	Main equipment malfunction (A24)	45	2,2	80,4
12	Inaccurate data (A12)	36	1,7	82,1
13	Bankrupt customer (A30)	36	1,7	83,8
14	Difference in customer perceptions (A31)	36	1,7	85,6
15	Contract is not available (A28)	28	1,4	86,9
16	Unpreparedness of customer facilities (A7)	27	1,3	88,2
17	Breach operation procedure (A27)	21	1,0	89,3
18	Natural disasters (A19)	19	0,9	90,2
19	Bid evaluation take long time (A18)	18	0,9	91,1
20	No workload analysis (A32)	18	0,9	91,9
21	Employee development is not running (A33)	18	0,9	92,8
22	Fraud prevention system does not work (A35)	18	0,9	93,7
23	Sabotage (A11)	15	0,7	94,4
24	PR specification is not clear (A16)	15	0,7	95,1
25	Labor strike (A23)	15	0,7	95,8
26	Instrumentation system malfunction (A25)	15	0,7	96,6
27	Natural gas shortage (A26)	15	0,7	97,3
28	Pipe leak (A13)	13	0,6	97,9
29	Government policy (A3)	12	0,6	98,5
30	Waste processing capacity (A29)	12	0,6	99,1

31	Natural factor (A10)	8	0,4	99,5
32	Theft (A15)	4	0,2	99,7
33	Metering system is sub-standard (A14)	3	0,1	99,8
34	Seasonality (A1)	2	0,1	99,9
35	Natural gas prices (A4)	2	0,1	100,0

2.5 Risk Treatment

The risk treatment stage aims to develop risk mitigation as an alternative solution in preventing risk at an optimum cost. In this study, the risk mitigation design uses the House of Risk phase 2 method. At this stage, it focuses on determining the most appropriate step to take first by considering the effectiveness of the resources used and the level of performance of the related objects.

The first step is to formulate a preventive action to deal with risk agents that are prioritized for mitigation. Then create a relationship matrix between each risk agent and each preventive action, and provide a correlation value of {0,1,3,9} which represents no correlation, low, moderate, and high relationship. The next step is to calculate the total effectiveness (TE) of action based on the total multiplication between the ARP and the correlation value.

After getting total effectiveness, the next step is to calculate the ratio of total effectiveness to the difficulty level. This difficulty level is obtained by conducting an assessment and giving a value of {3,4,5} which represents low, medium, and high difficulty levels. The effectiveness to difficulty ratio (ETD) is obtained by dividing the total effectiveness by difficulty level. Preventive action priority is based on the ETD rating from highest to low. The preventive action rank based on ETD is shown in Table 3.

Table 3. Preventive Action Rank

Rank	Preventive Action (Code)	Total Effectiveness (TE)	Difficulty (D)	Effectiveness to Difficulty Ratio (ETD)
1	Local vendor empowerment (PA4)	1755	3	585
2	TVM contract (PA2)	1620	3	540
3	Multi-sourcing & Vendor Development (PA3)	1701	4	425
4	VMI contract with penalty scenario (PA5)	1188	3	396
5	Conduct S&OP by involving customer (PA6)	630	3	210
6	Conduct SQM (PA9)	576	3	192
7	IT system development (PA1)	540	5	108
8	Worker competence development (PA8)	405	4	101
9	Hedging (PA10)	324	4	81
10	Searching for a new customer (PA7)	270	4	68

3. RESULTS AND DISCUSSION

From this research, it was found that there were 32 risk events and 35 risk agentsidentified in the gas processing plant. There are ten priority risk agents for prevention, namely: limited information, spare part stock-out, dependence on one supplier, custom clearance problems, large shipping lot sizes, social conflicts, customer cash flow problems, lack of worker competence, low vendor competence, and exchange rate fluctuations.

The results that have managerial implications are preventive actions that can be proposed to company management to be implemented into a reliable supply chain risk mitigation strategy. The managerial implications of this study are discussed below.

Local Vendor Empowerment

The gas processing plant's location is designed to be near a gas source or well for economic reasons. Gas sources or wells are generally located in remote areas, so the gas processing plant's location is also in remote areas. In this remote area, most of the population has a standard of living below average. This low standard of living is influenced by the small numberof jobs and the relatively low education level. This economic factor can trigger negative thingsfor the company, such as theft of pipes, sabotage of gas lines resulting in complaints of contaminating land or rice fields, bullying to outside suppliers who send materials, and demonstrations of road closures to demand jobs for residents.

One of the proactive actions that companies can take to prevent these social conflicts is by improving residents' economy. Economic improvement can be made through local empowerment policies. This local empowerment can be granted to local vendors to participate in material supply activities or supporting services. It is hoped that this material or service supply activity can provide a multiplier effect for improving the surrounding residents' economy. The following local empowerment that can be applied is to impose an obligation for large contractors to use local labor. Apart from being beneficial to residents, this local empowerment can also speed up completing a job or project in the company.

TVM (Total Vendor Maintenance) Contract

From the research results, it was found that one of the risk agents that need to beprioritized in handling is the unavailability of spare part material in the stock warehouse. The company has a policy not to stock spare parts in warehouses. Purchase of new spare parts is madeif there is damage and requires replacement. This can cause the material to arrive late so that it takes longer to repair damaged equipment. For equipment with a backup unit, this is not a problem, but if there is only one unit in the main equipment designed, it can cause prolonged plant shutdowns and reduce company revenue.

One of the proactive actions companies can take to overcome this is to develop the TVM model contract. The company does not need to stock spare parts in the warehouse in this contract. Spare part stocks are at authorized dealers. This model contract also provides maintenance services so that companies do not need to provide their experts to carry out maintenance and repair of damaged equipment. This TVM model contract will help the company maintain hundreds of equipment in its gas processing plant at minimum cost.

Multi-sourcing and Vendor Development

From the research results, it was found that one of the risk agents that needed to be prioritized in handling was dependence on one supplier. If one supplier experiences problems such as a disaster, strikes at the supplier's place, and poor financial conditions, the company will also be affected even if there is a bankruptcy. Companies need to find new suppliers so that the other suppliers can back up if one experiences problems. The search for new suppliers can be done through vendor development. The SCM department can carry outsourcing, namely looking for new vendor candidates, conducting assessments both from an administrative and technical perspective. After the vendor has passed these stages, it is included in the approved vendor list. Ifa vendor does not meet the requirements but is considered potential, the company can foster the vendor concerned until the vendor is declared to have passed. Multi-sourcing and vendor development programs should be prioritized for potential vendors. Later, this program can also solve problems during the material importation or custom clearance process, which often occurs.

Developing a VMI Contract with a Penalty Scenario

From the research results, it was found that one of the risk agents that need to be prioritized in handling is a considerable lot of material delivery. From field studies, it was found that the company is very focused on continuous operation. The company issued a policy that fast-moving materials such as chemicals should not out-of-stock. One of the company's things is to develop a VMI (Vendor Managed Inventory) contract. This VMI model contract is useful for maintaining stock levels in a safe condition and does not require special personnel from the company to monitor relatively large numbers of fast-moving materials.

However, on the other hand, suppliers tend to send large quantities of material to maximize profits from the concept of economies of scale. This supplier's motivation resulted in the delivery of material exceeding the amount of use and excess stock. In the end, the material is not used and expired.

One of the proactive actions that companies can take to overcome this is to develop a VMI contract with a penalty scenario. In this model, suppliers will be subject to penalties if they send and stock materials beyond a certain level. Of course, It will make suppliers more careful in determining the number of material shipments.

Conducting S&OP (Sales and Operation Planning) by Involving Customers

From the research results, it was found that one of the risk agents that need to be prioritized in handling is limited information. This limitation of information can lead to suboptimal forecasting of material requirements and production planning. From field studies, it isknown that customers often request a gas processing plant to change the volume of gas deliveriessuddenly. When the volume changes drastically, there will be a lot of gas volume that must be disposed of because of its nature, which is difficult to store. The discharge of this gas also impacts the environment and has social impacts that lead to costs.

Companies can take proactive actions to anticipate requests for sudden volume changes from customers, namely conducting S&OP by involving customers. This S&OP can be scheduled regularly weekly. The benefit of doing this S&OP is that the company can find out in advance if there will be a change in gas delivery volume.

Conducting SQM (Supplier Quality Meeting)

The research results found that limited information and low vendor competence were included in the list of risk agents that need to be prioritized in handling. The lack of vendors' competence can cause various negative impacts such as delays in delivery of materials or completion of work. Besides, it is also the cause of the material's quality or works not according to the order. The need for MRO material in the gas processing plant that is not well informed to the supplier can cause delays in material delivery because suppliers cannot anticipate sudden changes, especially for materials that have to be imported from abroad.

SQM is a way to overcome limited information and vendor competencies. At this event, the company can submit a material requirement plan for some time to come. At this event, companies can also provide feedback regarding supplier performance and provide input to be better. SQM is useful for improving coordination in supply chain activities.

Hedging

The research results found that exchange rate fluctuations were included in the list of risk agents that need to be prioritized in handling. If seen in the annual financial statements, the company experiences losses due to foreign exchange differences. This loss can happen due to the difference in currency between the contract and the payment. The price of the gas sales contract that applies internationally is determined in USD, while the payment is made in the local currency or IDR. Likewise, the contract for purchasing imported materials is denominated in USD. Exchange losses can occur when the company receives payments from customers when the USD weakens, or the company has to pay to suppliers when the USD strengthens.

The proactive action that companies can take to reduce losses due to exchange rate fluctuations is by hedging. There are several ways of hedging. The simplest one is to add a clause in the contract to fix the exchange rate in a tight range. So the exchange rate used for payment does not refer to the fluctuating foreign exchange market.

4. CONCLUSION

House of Risk can be implemented easily in practice. It can be used widely in any company. There is no study to mitigate supply chain risk using the House of Risk method at a gas processing plant from our best knowledge. This research also uses the latest Supply Chain Operation References covering six processes: Plan, Source, Make, Deliver, Return, and Enable.

There are ten priority risk agents and ten priority preventive actions identified from this research. Seven preventive actions are already discussed in section 3. Two preventive actions, namely: IT system development and worker competence development, already progress. One of the preventive actions, namely searching for a new customer, can not be implemented because of limited plant capacity.

There are some suggestions by the authors in order to improve the next research. First, precautions are taken to consider the resources available in the company. Second, the risk agent is prioritized for prevention to consider the company's risk appetite. Third, it is necessary to examine dependencies or linkages between risk events or risk events in further research. Lastly, in further research, quantitative methods can be used to compare this study using semi-quantitative methods.

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REFERENCES

APICS Association for Operation Management, (2017). *SCOR : Supply Chain Operation Reference Model version 12.0*, APICS Association for Operation Management, Chicago.

Blackhurst, J., Scheibe, K.P. dan Johnson, D.J. (2008). Supplier risk assessment and monitoring for the automotive industry. *Physical Distribution & Logistics Management* 38(2), 143-165.

Chopra, S. dan Sodhi, M.S. (2004). Managing Risk To Avoid Supply-Chain Breakdown. *MIT Sloan Management Review*, 53-61.

Christopher, M. dan Peck, H. (2004). Building the resilient supply chain. *International Journal of Logistics Management* 15(2), 1-13.

Frosdick, M. (1997). The techniques of risk management are insufficient in themselves. *Disaster Prevention and Management* 6(3), 165-177.

Hadavale, R. S., dan Alexander, S. M. (2009) Supply chain risk management, *Proceedings of the industrial engineering research conference*, 1363–1369.

Hillson D., (2001) Extending the Risk Process to Manage Opportunitie, *Proceeding of the Fourth European Project Management Conference*, London.

International Standard for Organization, (2018). *ISO31000 Risk Management – Principles and Guidelines*, International Standard for Organization, Geneva.

Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D. dan Zacharia, Z.G. (2001). Defining Supply Chain Management. *Journal of Business Logistics* 22 (2), 1-25.

Nurcahyo, R., Farid, A. dan Yadrifil (2016) Risk factor analysis of Liquified Natural Gas Supply Process Chain in Indonesia, *Proceeding of 9th International Seminar on Industrial Engineering and Management*, Padang.

Olson D.L. dan Wu, D. (2011). Risk management models for supply chain: a scenario analysis of outsourcing to China. *Supply Chain Management: An International Journal* 16(6), 401–408.

Pujawan, I.N. dan Geraldin, L.H., (2009). House of Risk: A Model for Proactive Supply Chain Risk Management. *Journal Business Process Management* 15(6), 953-967.

Pujawan, I.N. dan Mahendrawati, (2017). *Supply Chain Management, ed.3*. Penerbit Andi, Yogyakarta.

Punniyamoorthy, M., Thamaraseilvan N. dan Manikandan, L. (2013). Assessment of supply chain risk: scale development and validation. *Benchmarking: An International Journal* 20(1), 79-105.

Ritchie, B. dan Brindley, C. (2007). An emergent framework for supply chain risk management and performance measurement. *Journal of the Operational Research Society* 58(11), 1398–1411.

Skipper, J. B. dan Hanna, J. B. (2009). Minimizing supply chain disruption risk through enhanced flexibility. *International Journal of Physical Distribution & Logistics Management* 39(5), 404–427.

Tang, C.S. (2006). Perspectives in supply chain risk management. *International Journal of Production Economics* 103, 451-488.

Tummala, R. dan Schoenherr, T. (2011). Assessing and managing risks using the SupplyChain Risk Management Process (SCRMP). *Supply Chain Management: An International Journal*, 474– 483.

Waters, D. (2007). *Supply Chain Risk Management: Vulnerability and Resilience in Logistics,* Kogan Page, London.

Zsidisin, G.A. dan Ritchie, B. (2004). *Tutorial: Risk Management Standard AS/NZS 4360:2004*, Broadleaf Capital International Pty Ltd.

DEVELOPMENT OF SUPPLY CHAIN RISK MANAGEMENT STRATEGIES FOR INFUSION SOLUTION PRODUCTS IN PHARMACEUTICAL COMPANY

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ABSTRACT

PT. XYZ is a pharmaceutical company that produces intravenous fluids to support the national health insurance program by participating in an e-catalog tender conducted by the government. Many of the obstacles faced by companies come from activities related to the uncertainty of the number of orders from customers with the e-catalog system. In addition, the covid-19 outbreak in many countries has also caused uncertainty in the supply ofmaterials imported by PT. XYZ. Therefore, it is necessary to identify risks and risk management to overcome potential supply chain risks which have never been carried out by PT. XYZ.
In this study, designing a supply chain risk management framework for PT. XYZ. The risk management design process goes through the stages of risk identification, risk analysis, risk evaluation, risk treatment and preparation of recommendations for improvement. The method used is the House of Risk (HOR) model, Supply Chain Operations Reference (SCOR) and Root Cause Analysis (RCA). The results of identification of risk events in the supply chain process obtained 55 risk events, consisting of 8 risk events in the plan process, 15 risk events in the source process, 23 risk events in the make process, 4 risk events in the deliver process and 5 risk events in the return process. The results of the identification of thecauses of risk obtained 117 causes of risk. After calculating the phase 1 HOR model to calculate the Aggregate Risk Potential (ARP) value, then use the Pareto diagram applicationto get the cumulative total percentage of ARP. There are 24 selected risk causes, then 10 riskcauses are selected. The recommendation proposed is to minimize machine mishandling dueto human error factors, planning and setting production patterns if the realization of the e- catalog tender is not in accordance with the agreed national commitment / umbrella contract and also the efforts that must be made in case of problems / trouble in the production process.

Keywords: E-catalog, Demand & Supply Uncertainty, House of Risk (HOR), SCOR

1. INTRODUCTION

The emergence of uncertainty, both in terms of demand and uncertainty in the supply of raw materials and packaging materials from suppliers, certainly has a huge impact on thecompany and causes huge losses. For this reason, the company must know all potential problemsfor the company due to uncertainty of supply and demand and prepare mitigation measures to reduce or eliminate these problems. Supply chain risk management is used to manage uncertainty on the demand side as well as supply (Kouvelis et al. 2006). Currently PT. XYZ does not yet have risk management related to supply chain activities, so it has never carried out risk identification and risk management to address the risks that may occur within the company. Based on the above conditions, research on supply chain risk management that will be carriedout at PT. XYZ uses the Supply Chain Operation Reference (SCOR) method in identifying risks and their risk agents, and uses the House of Risk (HOR) model to analyze the risks that occur coupled with the Root Cause Analysis (RCA) method. The results of this study are expected to provide recommendations for appropriate mitigation strategies as an effort to minimize or eliminate risks that may occur.

2. LITERATURE REVIEW

2.1 Supply Chain Management

According to Pujawan (2005) the supply chain is a network of companies that work together to create and deliver a product into the hands of the end user. These companies usually include suppliers, factories, distributors, shops or retailers, as well as supporting companies such as logistics service companies.

Supply Chain Management or Supply Chain Management is an integrated application that provides information system support to management in terms of procurement of goods and services for companies as well as managing relationships between partners to maintain the level of product and service availability needed by the company optimally (Anwar, 2013). SCM integrates order delivery and processes, raw material procurement, order tracking, information dissemination, collaborative planning, performance measurement, after-sales service, and new product development.

2.2 Supply Chain Operation Reference (SCOR) Model

The SCOR model has developed supply chain risk management (SCRM). This model presents a business process framework, work indicators, best practices and technology to support communication and collaboration between supply chain partners, so as to improve supply chain management effectiveness and supply chain improvement effectiveness (Paul, 2014).

SCOR is structured into five distinct management processes: Plan, Source, Make, Deliver, Return; from suppliers to consumers. The approach in building SCOR consists of Process, Practice, Performance, and Human Resources Skills. The application of the SCOR model effectively contributes to efficient logistics in supply chain operations (Salazar, Caro, & Cavazos, 2012).

2.3 House of Risk (HOR) Method

The House of Risk is a renewable method of analyzing risk. Its application uses theprinciple of FMEA (Failure Mode and Error Analysis) to measure risk quantitatively combined with the House of Quality (HOQ) model to prioritize risk agents which must be prioritized first andthen choose the most effective action to reduce potential risks posed by agent risk.

The HOR model underlies risk management with a prevention focus, namely reducing the likelihood of risk agents occurring. So the earliest stage is to identify risk events and risk agents. Usually one agent can cause more than one risk event. Adapting from the FMEA method, the risk assessment applied is a Risk Priority Number (RPN) which consists of 3 factors, namely the probability of occurrence, the severity of the impact that appears, and detection.

The HOR method only establishes the probability for the risk agent and the severity of the risk event. Because it is possible for one risk agent to cause more than one risk event, it is necessary to quantify the aggregate risk potential of the risk agent.

Adapting the House of Quality (HOQ) model to determine risk agents should be given priority as a precautionary measure. A rating is given for each risk agent based on the amount of the ARPj value for each risk agent j. Therefore, if there are many risk agents, the company can first select an agent with a high potential for risk events. This two-spread model is called the House of Risk (HOR) which is a modification of the HOQ model (Pujawan & Geraldin, 2009).

- HOR 1 is used to determine the priority level of risk agents that should be given as a preventive measure
- HOR 2 is a priority in taking actions that are considered effective

3. RESEARCH METHODS

Data collection was carried out through brainstorming and interviews with a team of experts who master the field of supply chain. Data processing begins with the mapping of the company's supply chain activities using the SCOR method, which consists of Plan, Source, Make, Delivery and Return.

From the company's business process activities, risks that occur and those that have the potential to occur are identified. Each risk is analyzed further to find a risk agent and the consequences caused by these risks. Next is a weighted risk assessment to determine the severity of each risk; the degree of occurrence of a risk agent; as well as the correlation value between risk events and risk agents (causes).

The next stage is the calculation of the Aggregate Risk Potential (ARP) value to determine the ranking and risk prioritization, namely determining the order of risk agent priorities which are important to be mitigated.

The determination uses the Pareto Diagram, where the risk agent who dominates 80% means that it must be mitigated. Thus HOR 1 is completed until the determination of the ARP value. HOR 2 aims at planning a mitigation strategy, which provides guidelines for which risk agent companies should be mitigated first based on the level of effectiveness and ease of implementation based on the effectiveness to difficulty ratio; each of which is assessed in terms of weight.

Before starting the calculation, the researcher must identify the preventive action that can be done to overcome the risk agents in the company. One action can solve several risk agents, and one risk agent can be completed by several actions, so weighting is very useful in this step. The result of the House of Risk method is to determine the mitigation strategy that should be implemented by the company first.

3.1 Data Collection

Risk identification is carried out to determine the risks that occur in company activities that have the potential to occur and can affect the company's supply chain activities. Identification is carried out based on supply chain activities using the SCOR method which consists of plan, source, make, deliver, and return. Risk identification is carried out by interviewing a team of experts in the field of supply chain including the marketing team, supply chain management and the production team.

Based on the supply chain activities in Table 1, the identification of risk events and risk agents is carried out and an assessment of the determination of severity, occurrence, and correlationvalues. Table 2 contains the identification of risk events, and Table 3 contains data which is the identification of risk agents.

Table 1. Flow of PT XYZ Supply Chain Activities Based on Business Processes

Process	Activity
Plan	Forecasting product demand from customers
	Production planning and control
	Calculating material requirements (raw materials and packaging materials)
	Control material inventory and finished products
Source	Planning the procurement of goods
	Create a purchase requisition
	Create a purchase order
	Supplier receive a purchase order
	Supplier make delivery of the order
	Receipt of raw materials
	Rejection (returns) of raw materials that do not comply with standards

Make	Make material requests to the material warehouse
	Receive raw materials from the material warehouse
	Weighing Process (weighing)
	Mixing Process
	The process of making bottles (Blow-Fill-Seal or BFS system)
	Sterilization Process
	Packaging Process
	Inspection Process (Quality Control)
	The process of transferring the finished product to the Finished Goods warehouse
Deliver	Receive Purchase Orders from distributors
	Update product release availability (inspection from QA)
	Transporter selection
	Delivery of finished products to distributors
Return	Return of finished products from distributors to factories
	Return of finished product from factory to distributor
	Return of material from factory to supplier

Table 2. Risk Event

Process	Activity	Code	Risk Events
Plan	Forecasting product demand from customers	E1	The sales realization can be smaller or bigger than the target
	Production planning and control	E2	The production realization was less than the target
		E3	Production planning changes frequently
	Calculating the need for raw materials and packaging materials	E4	Calculation data is not accurate
	Control material inventory and finished products	E5	The stock of finished products is very high
		E6	There was a shortage of the finished product stock
		E7	Material inventory is very high
		E8	There is a shortage of material for production
	Doing Procurement Planning	E9	*Forecast error*
		E10	Delayed Delivery Process

Source		E11	Production Plan Changes
	Make a Purchase Requisition	E12	Error entering data in the system (due date, supplier, code, price)
		E13	Delay in making Purchase Requisitions
		E15	*Purchase Order* missed (not made) / late delivery to the supplier
	Supplier receive a Purchase Order	E16	*Supplier* did not receive a purchase order from the factory
	Supplier do Order Delivery	E17	Raw materials sent do not match the list of Purchase Order
		E18	Raw materials ordered are out of stock
		E19	Late delivery of raw materials from suppliers
		E20	Logistics costs are relatively expensive
	Receipt of raw materials	E21	Raw materials received do not meet specifications and do not pass inspection (reject)
	Rejection (returns) of raw materials that do not comply with standards	E22	Additional costs for eliminating B3 waste
		E23	There was a shortage of raw materials in the warehouse

Process	Activity	Code	Risk Events
		E15	*Purchase Order* missed (not made) / late delivery to the supplier
	Supplier receive a Purchase Order	E16	*Supplier* did not receive a purchase order from the factory
	Supplier do Order Delivery	E17	Raw materials sent do not match the list of Purchase Order
		E18	Raw materials ordered are out of stock
		E19	Late delivery of raw materials from suppliers
		E20	Logistics costs are relatively expensive
	Receipt of raw materials	E21	Raw materials received do not meet specifications and do not pass inspection (reject)
	Rejection (returns) of raw materials that do not comply with standards	E22	Additional costs for eliminating B3 waste
		E23	There was a shortage of raw materials in the warehouse
Make	Make a list of material requests to the material warehouse	E24	The items ordered do not match (number and lots)
		E25	The raw material has not been released
	Receive raw materials from the material warehouse	E26	Material sent from the warehouse is not in accordance with the picking list (number and lots)
		E27	There are raw materials that are damaged
	Weighing Process (Weighing)	E28	Error in the process of weighing raw materials
		E29	Errors in the verification process based on the master management procedure (PPI)
		E30	Error in the labeling process of weighed raw materials
		E31	Read errors in the reconciliation verification process (used materials and remaining materials)
	Mixing Process	E32	There was mixing machine downtime
		E33	The results of the test solution levels do not match the standards
		E34	There was a mix up with the results of the previous solution
	Blowing, Filling, Sealing Process (BFS)	E35	There was a downtime on the BFS machine
		E36	The product has leaked
	Sterilization Process	E37	The autoclave machine is downtime
		E38	There was a mix up between the product that entered the sterilization process and the previous product
		E39	There was a mix up between the sterile and non-sterile products
Make		E40	Miss arrangement of product on the sterilization rack
	Packaging Process	E41	Error in entering product in outer box
		E42	Error in labeling process
	Inspection Process (quality control)	E43	There is a defect in the product
		E44	The product has leaked
	Transfer the finished product to the Finished Goods warehouse	E45	Delay in delivery from the production unit
		E46	There is a defect in the product during the transport process
Deliver	Receive Purchase Orders from distributors	E47	Not receiving purchase orders from distributors
	Inspection from Quality Assurance Transporter selection	E48	*Passing date inspection* longer / late

Process	Activity	Code	Risk Events
	Delivery of finished products to distributors	E49	Transporter performance is not good (price, timeliness, billing process)
		E50	Late delivery to distributors
Return	Return of finished goods from distributor to factory	E51	The finished goods are defective / expired or are damaged when they arrive at the distributor
	Delivery of finished goods from factories to distributors	E52	Late delivery to distributors
		E53	The finished product that is used to replace out of stock damage
	Delivery of material from the factory to the supplier	E54	Material does not pass QC inspection
		E55	Long shipping process

Table 3. Risk Agent

Code	Risk Agent
A1	Marketing forecast mismatch
A2	There is a seasonal demand during the dengue fever symptom season
A3	The realization of the e-catalog tender was not in accordance with the contract
A4	Sales focus on the total target, real orders per item are ignored
A5	Production is more in products with high sales
A6	The production plan only focuses on product items whose sales are large, even bigger than the initial plan
A7	There is a problem or trouble in the production process
A8	There was a change in demand from marketing
A9	Changes in regulations from the POM (BPOM)
A10	There are other alternatives from suppliers
A11	There is a product development process from the development department (Technical)
A12	The supplier's unpreparedness will change the production schedule given by the factory
A13	*Preventive maintenance* less effective
A14	Mishandling of the machine (human error)
A15	Error in data entry (code, due date, etc.) into the system
A16	Users are late in entering price changes into the system
A17	User does not make Purchase Requisition according to the schedule specified
A18	User does not make Purchase Order according to the specified schedule
A19	An error occurred while accessing email and fax or the internet network was disconnected / problematic
A20	The company's target budget limit has not been reached
A21	An unfocused or careless operator
A22	Errors in reading the specifications of the goods ordered on the purchase order
A23	*Quality Agreement* which has not been planned and agreed upon
A24	Sudden change in production plans
A25	The factory is less active in following up on orders for raw materials to suppliers
A26	Users are missed / late in sending the latest forecast demand
A27	There was a natural disaster in the country
A28	The production process was stopped for about 1 month
A29	Changes in policies from authorized officials related to government regulations (Customs rules, BPOM etc.)
A30	Difficulty in finding transportation modes during high season (Christmas, Eid and New Year holidays)
A31	There are products that require a special mode of transportation (cooling truck)

Code	Risk Agent
A32	Damage to the mode of transportation
A33	There was a problem on the way (traffic jam, etc.)
A34	Equipment malfunction at the port
A35	Unfavorable weather
A36	Transportation costs set by authorize
A37	The order submitted is less than the vehicle's load capacity
A38	*Quality Agreement* that has not been planned and agreed upon
A39	The absence of initial information from suppliers regarding constraints in production
A40	There are differences in specifications, methods / testing methods from suppliers
A41	Operators are less careful in operating handling tools (forklifts, trucks, etc.)
A42	The trucks used do not match the qualifications (dirty or damaged)
A43	The capacity of the reject raw materials is too much
A44	There is an internal problem from the supplier (constraints on the supply of raw materials from the supplier)
A45	Raw materials sent do not meet specifications
A46	Error in entering the number of lots of items to be ordered into the system
A47	Server from the center down
A48	UPS failure (backup server)
A49	Missed in the process of changing the status of quarantine items to release
A50	The number of material queues to be tested
A51	Limited human resources
A52	Broken testing equipment
A53	Error in taking / determining lots (not in accordance with FIFO / FEFO rules)
A54	The forklift operator made the mistake of placing the same material from the truck
A55	Operators are less careful in operating handling tools (forklifts, trucks, etc.)
A56	The trucks used do not match the qualifications (dirty or damaged)
A57	Errors in recording the results of the scale
A58	The scale has not been calibrated
A59	A scale that is used too often without regular maintenance
A60	Exhausted operator (a large amount of material verified)
A61	There is no two-person verification
A62	The formula values listed on the PPI are almost the same from one material to another
A63	Error in writing labels on raw materials
A64	Errors in the weighing process are not sorted according to the PPI
A65	Weighing two or more materials at the same time (same characteristics)
A66	The operator does not label the bag of material directly after the weighing process
A67	The operator (note taker) is unclear or difficult to read
A68	*Breakdown* mechanically on parts that are worn or damaged in the mixing machine
A69	The software program on the mixing machine error
A70	Utility supply for unstable mixing machines (electricity, cooling water, steam, temperature, etc.)
A71	Does not adhere to the order of mixing the ingredients in the solution preparation procedure
A72	There was a malfunction in the temperature regulation
A73	There is no SOP that regulates this process
A74	Different operator capabilities
A75	There is no SOP that regulates this process
A76	Weighing checker error

Code	Risk Agent
A77	Operator incorrectly reads the lot scale on the weighing checker
A78	There is no process of checking directly into the tank
A79	Mechanical breakdown of worn or damaged parts in BFS engines
A80	*Software program* on BFS machine error
A81	Utility supply for unstable BFS engines (electricity, cooling water, steam, temperature, etc.)
A82	There was a design error (feasibility study)
A83	Increase quality and cost saving
A84	Increase engine capacity speed
A85	Fatigue operator (large number of products inspected)
A86	*Breakdown* mechanically on worn or damaged Automatic Leakage Tester (ALT) machine parts
A87	The software program on the Automatic Leakage Tester (ALT) machine error
A88	*Breakdown* mechanically on worn or damaged parts in the autoclave machine
A89	*Software program* error on autoclave machine
A90	Utility supply for unstable autoclave machines (electricity, cooling water, steam, temperature, etc.)
A91	There was a leak in the steam line
A92	There was a malfunction in the temperature regulation
A93	*Heating* and abnormal cooling
A94	There is no line clearance checklist
A95	No before / after sterile product marking
A96	There is no SOP that regulates this process
A97	Batch marking error from the quality control team
A98	Error in taking labels
A99	Wrong printing label from supplier
A100	The warehouse sent the wrong type of label
A101	Change of old production machines to new machines (machine reconditioning)
A102	The resulting product is reject / leak
A103	The operator is wrong in mixing the raw materials
A104	An incorrect procedure occurred in the CIP / SIP process
A105	There is no line clearance process
A106	*Breakdown* mechanically on part handling equipment
A107	Maintenance of ineffective handling tools
A108	Operators are less careful in placing on the rack
A109	*Breakdown* mechanically in part handling
A110	There are indications of abnormalities US
A111	The production process report has not been completed (recorded)
A112	Transporter management is not professional
A113	Fleet not available
A114	The order submitted is less than the vehicle's load capacity
A115	The product needed was not produced
A116	There was a process abnormality at the supplier
A117	The vehicle is not available because the load is always full

3.2 Data processing

After the identification is carried out, then conduct an assessment (assessment) of the severity level, namely the severity of a risk event and an assessment of occurrence, namely the level of chance for a risk event to occur on a scale of 1-5 each. based on the values 1, 3, 9 can be seen in table 4 Risk agent based on the value of potential risk agents and their ratings can be seen in table 5.

Table 4. HOR-1

Risk \ Risk Agent	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P101	P102	P103	P104	P105	P106	P107	P108	P109	P110	P111	P112	P113	P114	P115	P116	P117	Severity
E1	9	3	9																									4
E2			9																									5
E3				9																								4
E4					9																							4
E5	9																											5
E6				9																								5
E7	9																											5
E8						9																						4
E9	9	3	9																									4
E10							9	9	1	1																		4
E11	9																											4
E12																												4
E13																												4
E14																												4
E15																												4
E46																			9									3
E47																												2
E48																				9	9							3
E49																						3	9					3
E50																								9				3
E51																												3
E52																												4
E53																									1			3
E54																										9		4
E55																											3	3
Occurance	4	2	4	2	2	2	3	4	2	2	1	2	2	1	1	2	2	2	2	2	1	2	2	3	2	2	2	
ARP	792	48	468	162	72	72	108	144	8	8	9	54	54	27	27	54	54	18	54	54	27	18	54	81	6	72	18	
Rank	1	47	2	6	21	21	10	7	110	110	108	35	35	74	74	35	35	90	35	35	74	90	35	18	115	21	90	

In determining the priority of the causes of risk, it is done using the Pareto diagram method to show a problem using the order of the number of events with the 80-20 rule. This rule means that about 80% of the effects are caused by 20% of the problems. Thus, from 117 causesof risk, approximately 24 causes of risk will be generated. In this study, the selected risk potential results only took 10 risks that had the greatest impact on the continuity of supply chain activities at PT. XYZ

Table 5. Risk Agent Based on ARP and P rank

Code	Risk Agent	ARP*j*	Rank
A1	Marketing forecast mismatch	792	1
A3	The realization of the e-catalog tender was not in accordance with the umbrella contract	468	2
A14	Mishandling of the machine (human error)	384	3
A30	Difficulty in finding transportation modes during high season (Christmas, Eid and New Year holidays)	234	4
A55	Operators are less careful in operating handling tools (forklifts, trucks, etc.)	216	5
A4	Sales focus on the total target, real orders per item are ignored	162	6

A8	There was a change in demand from marketing	144	7
A24	Sudden change in production plans	135	8
A21	An unfocused or careless operator	132	9
A7	There is a problem or trouble in the production process	108	10

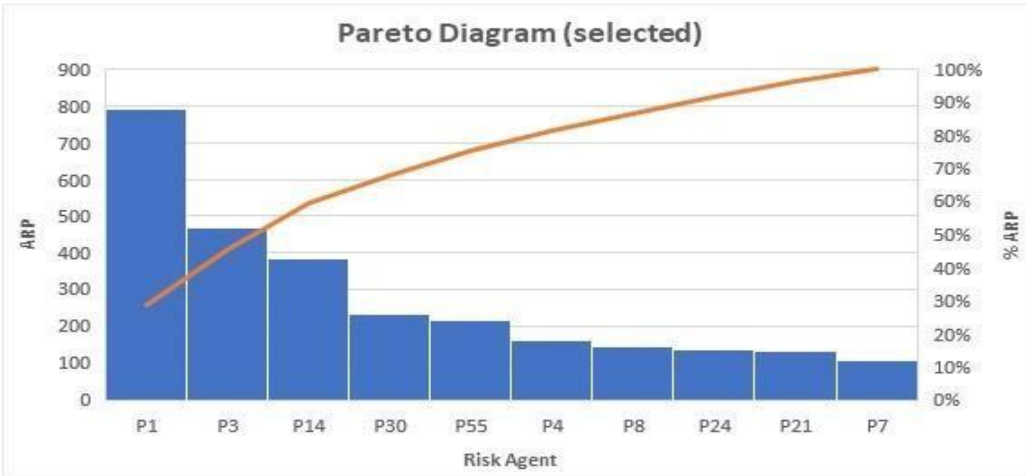

Figure 1. Pareto HOR-1 diagram

The Pareto diagram gets 10 risk agents which are the main causes in supply chain activities at PT. XYZ. Based on the risk agent obtained, there is a Preventive Action that can be applied in activities to solve problems that occur. This is shown in Table 6. Then the correlation matrix between risk agents and preventive action in HOR 2 is mapped, as stated in Table 7.

Table 6. Risk Agent Based on ARP and P rating

Code	Causes of Risk	Risk Response Measures	PA code
P1	Marketing forecast mismatch	Integrate a software or web system that can be accessed by the PPIC team and the marketing team so that the forecast information compiled can be known by both parties with the same information and real time	PA1
P3	The realization of the e-catalog tender was not in accordance with the umbrella contract	A comprehensive sales data analysis from the marketing team is needed (business data analysis), including a strategy to create order opportunities so that the products that have been prepared can be absorbed by the market, so that the production process in the factory is not disrupted. And also communicate any sales changes that occur to top management and also SCM in the factory so that adjustments to production planning, material needs and inventory control both material and product can be made.	PA2
P14	Mishandling of the machine (human error)	The main cause of machine damage by humans is a lack of knowledge in operating the tool or machine.	PA3

Code	Causes of Risk	Risk Response Measures	PA code
		Therefore, the operator in charge is obliged to study and understand the manual book of machine operation and also should be given training before operating the tool, so that damage caused by human error can be minimized.	
P30	Difficulty in finding transportation modes during high season (Christmas, Eid and New Year holidays)	Maximizing delivery before the “D” day, placing truck orders and planning for early delivery (D-10) as well as more intensive coordination with the receiving branches.	PA4
P55	Operators are less careful in operating handling tools (forklifts, trucks, etc.)	Re-socialize work tools operational SOPs and impose sanctions in the form of verbal and written warnings if operators are careless in their use.	PA5
P4	Sales focus on the total target, real orders per item are ignored	It is necessary to update the forecast every month, so that the production plan can adjust to the needs of each product item and total sales	PA6
P8	There was a change in demand from marketing	Make adjustments to the production plan and review material requirements again, so that inventory levels are still in a safe condition (in accordance with regulations).	PA7
P24	Sudden change in production plans	Required provisions governing the process of revising the daily production schedule, for example, at least 1 day before the process is carried out, so that there is enough time for the related department to prepare all the needs / documents for changes.	PA8
P21	An unfocused or careless operator	Approaching workers to find the reasons why they cannot work with focus and thoroughness, and provide training according to the needs of workers in both formal and outdoor activities for just refreshment.	PA9
P7	There is a problem or trouble in the production process	Investigate every trouble / problem that arises, whether the engine trouble is caused due to human error, use / age factor (life time) or due to lack of maintenance and make corrective steps so that the same trouble does not appear again.	PA10

Table 7. HOR-2

		Preventive Action										
		PA1	PA 2	PA 3		PA5	PA 6	PA 7	PA 8	PA 9	PA1 0	**ARP**
Risk Agent (treated)	P1	3										792
	P3		3									468
	P1 4			9								384
	P3 0				3							234
	P5 5					9						216
	P4						3					162
	P8							3				144
	P2 4								3			135
	P2 1									9		132
	P7										9	108
T E		**2376**	**1404**	**3456**	**702**	**1944**	**486**	**432**	**405**	**1188**	**972**	
D		4	5	3	3	3	3	3	3	4	4	
ETD		**594**	**281**	**1152**	**234**	**648**	**162**	**144**	**135**	**297**	**243**	
Rank		**3**	**5**	**1**	**7**	**2**	**8**	**9**	**10**	**4**	**6**	

Information:

PA: Risk Response Action ARP: Aggregate Risk Potential
P: Causes of Risk TE: Total effectiveness of risk response measures D: Difficulty level of implementing risk response measures ETD: The ratio of effectiveness to difficulty Rank: The ranking of the effective risk measures

Table 8. Priority for Preventive Action of PT. XYZ

Rank	Code	Risk Response Measures
1	PA3	The main cause of machine damage by humans is a lack of knowledge in operating the tool or machine. Therefore, the operator in charge is obliged to study and understand the manual book of machine operation and also should be given training before operating the tool, so that damage caused by human error can be minimized.
2	PA5	Re-socialize work tools operational SOPs and impose sanctions in the form of verbal and written warnings if operators are careless in their use.
3	PA1	Integrate a software or web system that can be accessed by the PPIC team and the marketing team so that the forecast information compiled can be known by both parties with the same information and real time

4	PA9	Approaching workers to find the reasons why they cannot work with focus and thoroughness, and provide training according to the needs of workers in both formal and outdoor activities for just refreshment.
5		And also communicate any sales changes that occur to top management and also SCM in the factory so that adjustments to production planning, material needs and inventory control both material and product can be made.
6	PA10	Investigate every trouble / problem that arises, whether the engine trouble is caused due to human error, use / age factor (life time) or due to lack of maintenance and make corrective steps so that the same trouble does not appear again.
7	PA4	Maximizing delivery before the "D" day, placing truck orders and planning for early delivery (D-10) as well as more intensive coordination with the receiving branches.
8	PA6	It is necessary to update the forecast every month, so that the production plan can adjust to the needs of each product item and total sales
9	PA7	Make adjustments to the production plan and review material requirements again, so that inventory levels are still in a safe condition (in accordance with regulations).
10	PA8	Required provisions governing the process of revising the daily production schedule, for example, at least 1 day before the process is carried out, so that there is enough time for the related department to prepare all the needs / documents for changes.

This priority sequence then provides direction for the company regarding the steps that need to be taken to overcome the risk agent in order to prevent risk events in the process at PT XYZ.

4. RESULTS AND DISCUSSION

There are several types of risks that may occur in a company, one of which is supply chain risk. There are several ways that can be done to measure supply chain risk, including House of Risk (HOR), SCOR and Root Cause Analysis (RCA). House of Risk combines the FMEA method with HOQ (House of Quality) into a simple quantitative calculation to map risks based on their priorities. The calculation is simple, but this method takes into account things that are not taken into account in FMEA, for example the possibility of a risk agent causing morethan one risk agent or vice versa risk events caused by several risk agents. This method paysmore attention to risk agents, where the mitigation plan (preventive action) is based on a priority risk agent.

Based on the risk agent's priority problems based on the Aggregate Risk Potential value and the Pareto Diagram, there are several preventive actions that can be considered as a solution to the problem. The calculations in Table HOR 2 have provided direction regarding the priority of mitigation actions that the company should take.

5. CONCLUSION

Based on the identification results of risk events (risk events) in the supply chain business process of PT. XYZ obtained 55 risk events, 117 risk causes (risk agents) with a probability level of risk (occurrence) and correlation value for each risk event (risk event) which will be processed in the House of Risk-1. Results of the House of Risk-1 is processed using the Pareto diagram, where 10 selected risk agents will be selected as priority risk agents for preventive action according to the top ranking.

The results of the House of Risk model phase 2, there are 10 preventive actions which are then calculated the ETD value. Furthermore, the ranking is carried out according to the highest to lowest ETD values. Following are the preventive actions that are sorted by top ranking. Based on the Pareto diagram, of the 117 causes of risk, there are approximately 24 causes of risk. Of course, this figure is quite a lot so it is possible not to focus on the potential that has a major impact on supply chain activities. Therefore, in this study the results of selected risk potentials only took 10 risks that had the greatest impact on the continuity of supply chain activities at PT. XYZ.

BIBLIOGRAPHY

Assoc. Prof. Teresa Wu, Assoc. Prof. Jennifer Blackhurst, *Managing Supply Chain Risk and Vulnerability, Tools and Methods for Supply Chain Decision Makers*. Springer-Verlag London Limited 2009

Antonius Alijoyo, 31 Teknik Penilaian Risiko Berbasis ISO 31010, CRMS 2020

Anggrahini, D., Karningsih, P. D., & Sulistiyono, M. (2015). Managing quality risk in a frozen shrimp supply chain: a case study. *Procedia Manufacturing 4*, 252-260.

Chopra, S. dan Sodhi, M.S. (2004), *"Managing Risk to Avoid Supply-Chain Breakdown",* MIT Sloan Management Review, hal. 53-61.

ISO. (2018, Februari). *ISO 31000:2018 Risk Management*. Retrieved from ISO: https://www.iso.org/standard/65694.html

Leo J. Susilo & Victor R. Kaho, "Manajemen Risiko Berbasis *ISO 31000:2018"*. Grasindo Jakarta 2018.

Olson D.L. dan Wu, D. (2011), *"Risk management models for supply chain: a scenario analysis of outsourcing to China",* Supply Chain Management: An International Journal 16/6, 401–408.

Parenreng, S.M., (2016), Model Pengelolaan Risiko Supply chain Mempertimbangkan Kepentingan Multistakeholder Pada Komoditas Tuna, Penelitian Disertasi, Institut Teknologi Sepuluh Nopember, Surabaya.

Pujawan, I.N. dan Geraldin, L.H., (2009), *"House of Risk: A Model for Proactive Supply Chain Risk Management",* Journal Business Process Management, Vol. 15, No. 6, hal. 953-967.

Pujawan, I.N. dan Mahendrawati, (2017), *Supply Chain Management, ed.3*. Penerbit Andi, Yogyakarta.

Peraturan Mentri Kesehatan No. 63 Tahun 2014, Tentang Pengadaan Obat Berdasarkan Katalog Elektronik (E-katalog).

Peraturan Presiden No. 157 Tahun 2014, Tentang Perubahan Atas Peraturan Presiden Nomor 106 Tahun 2007 Tentang Lembaga Kebijakan Pengadaan Barang/Jasa Pemerintah.

Ritchie, B. dan Brindley, C. (2007), "*An emergent framework for supply chain risk management and performance measurement",* Journal of the Operational Research Society, Vol.58 No.11, hal. 1398– 1411.

Siahaan, H, (2009), Manajemen Risiko pada Perusahaan dan Birokrasi, Elex Media Komputindo, Jakarta.

Tantangan Implementasi pengadaan obat dengan *e purchasing* melalui katalog elektronik era JKN, *Public Health Symposium 3rd UGM*, Tanggal 7- 9 Mei 2018

Waters, D. (2007). *Supply Chain Risk Management: Vulnerability and Resilience in Logistics.* London and Philadeplhia: Kogan Page.

Zsidisin, G.A. dan Ritchie, B. (2004), *Tutorial: Risk Management Standard*, AS/NZS 4360: 2004, Broadleaf Capital International Pty Ltd.

COORDINATION OF TWO-LEVEL SUPPLY CHAIN (MANUFACTURER-RETAILER) WITH PERMISSIBLE DELAY IN PAYMENTS AND TRANSPORTATION DISCOUNTS

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ABSTRACT

An effective cooperation mechanism between manufacturer and retailer is needed to reach maximum profit for both parties in the supply chain management. Some of commonly used mechanisms in cooperation system are delay in payment, price discount, and so forth. In permissible delay in payment, the vendor (manufacturer) will provides a certain period for buyer (retailer) to settle their balance without any additional interest charges. The transportation cost in supply chain are usually considerably implicitly as part of ordering cost, even though in the fact that transportation costs are one of the dominant factors causing total operating cost to increase. This research aims to develop a cooperation whichis constructed based on two mechanisms, the first one is delay in payment, while the secondone is the transportation cost discount. The duration of delay in payment and shipment lot size which becomes the decision variable. The research method used numerical calculations for two cases of delay in payment models and considered the discount scheme into the calculation to obtain a mechanism model with optimal result. Furthermore, the sensitivity analysis was then conducted to examine the parameter changes towards the developed model. By combining delay in payment and transportation cost discount, the result of numerical calculation shows lower total cost of the supply chain system compared to a calculation with only one coordination mechanism.

Keywords: supply chain, permissible delay in payment, discounts, transportation cost.

1. INTRODUCTION

Supply chain management (SCM) is important for manufacturing and service companies to improve competitiveness and sustainability. One of the form coordination that could have applied to minimize total costs in supply chain is the Joint Economic Lot Sizing (JELS). According to Aljazzar et al, (2016) coordination is the matter that determines the sustainability of supply chain players, so that it can be a key to the company's success in reducing operational costs. As a result of good coordination in determining supply and demand, this will reduce unnecessary costs and increase sales will also be obtained due to increased supply chain profitability. Goyal (1988), examined JELS for supply chain in two level player (vendor-buyer). Hill (1997), and Jaber et al. (2010) also develop the model of JELS for two level supply chain. Three of them produced three different manufacturing production policies. Aljazzar et al, (2015) compared the three policies and used delay in payment as a form of coordination. Aljazzar et al, (2017), said although JELS can minimize total costs of supply chain, but not all players get the benefit because the value of savings is only collected on one of the players. Therefore, the coordination scheme must contain incentives to attract buyers.

Permissible delay in payment is a payment mechanism with a reduction in payment delays for a certain period of time without any interest charges given by the vendor to the buyer. This will be different if the buyer makes a payment beyond the time limit given by the vendor, then the buyer will be charged interest. Within the period of postponement of payments provided by the vendor, it will indirectly make the buyers invest their loan in risk-free investment up to the time limit allowed. Some researchers use delay in payment as a form of coordination in the supply chain. Goyal (1985) became the first scientist to model of delay in payment to find the optimal economic order quantity. The result of the research was that information obtained when the supplier gave a delay in payment to the retailer without any interest, it caused an increase in the interval replenishment. Chung et al (2005), Jaber and Osman (2006), adopted a delay in payment model too. They focused on determining the optimal lot size as a function of objectives. Then, Goyal et al (2007) again developed a model for determining the economic order quantity by applying a progressive interest scheme on delay in payment. Aljazzar et al, (2016) utilized a delay in payment coordination mechanism in a three-level supply chain model. Aljazzar et al, (2018), Ibrahim and Putri (2019) adopted the delay in payment model as a mechanism to reduce supply chain carbon emissions. Several recent studies have combined delay in payment with other coordination methods. Moussawi-Haidar et al, (2014) combined the form of delay in payment witha discount interest rate. Ibrahim and Suparno (2017) created a delay in payment model and penaltycontracts in the three-echelon supply chain.

According to Zhao et al., (2004), when the product was shipped to a buyer, there were transportation costs which must be incurred. In the traditional concept of economic order quantity, transportation costs were included in production costs or with ordering costs. In fact, transportation costs were not always constant, so it was necessary to consider transportation costs as a variable. As a form of buyer loyalty, vendors could provide discounts for transportation costs. Giving a discount was one of the methods often used by sellers to attract buyers to make purchaseswith a larger number of lots than their economic orders. There are two types of quantity discounts that can offered by vendor to buyer. Those were all-unit quantity discount applies to the entire lot in each purchased order. Meanwhile, for the incremental discount model, this only applied if the number of buyer's orders was within a certain amount range. Several studies have applied a discount mechanism with other forms of coordination in the supply chain. Tsao and Lu (2012) studied supply chain networks by considering discount in the transportation cost. Chang (2013) developed a form of determining the lot size by using a mixed discount case on freight and quantity. Ertogral et al, (2007), Kim and Sarkar (2017) used the form of an all-unit quantity discount on transportation costs for lot sizing and supply chain stochastic models. Huang et al, (2007), Aljazzar et al, (2017) in the supply chain which combine of delay in payment with cash discounts and price discounts.

In this research, a two-level supply chain coordination concept (manufacture-retailer) will be developed delay in payment with considering transportation cost discount. The delay in payment mechanism in this study refers to the supply policy of Jaber et al, (2010), with a mathematical model referring to research by Aljazzar et al, (2015). Furthermore, the transportationcost discount scheme uses the all-unit quantity discount type, referring to research by Ertogral et al, (2007). Two scenarios that represent the delay in payment problem in the supply chain system will be simulated using Wolfram Mathematica 9.0. Then, a discount scheme will be applied in each case and the total supply chain cost is calculated. The results of these calculations will look for scenarios that produce the minimum total supply chain costs.

The organizational form of scientific research is as follows. Section 2 will examine the methods used in the research, including assumptions, notations, and mathematical model formulations. Section 3 will contain the results of the calculation simulation from the developed model and discussion and analysis of several parameters to the optimal solution of the calculation results. Section 4 contains conclusions and advices for research in the future.

2. METHOD

2.1 Notations and Assumptions

The following below is a notation of each parameter in this study:

i : Players in supply chain (m: manufacturer, r: retailer)
Ai : Setup / ordering costs incurred by players to the party *i*
Ci : Production / purchasing costs incurred by players to the party *i*
hi : Financial holding cost per item players *i*
si : Storage (physical) holding cost per item incurred by players to the party *i*
Q : Ordering quantity retailer
n : Amount of shipments by manufacturers to retailers per cycle
t : The time period of delay in payment allowed by the manufacturer
τ : Time when retailer settle their balance to manufacturer
δi : Return of invested for the player *'i'*
P : Production rate for manufacturer
D : Demand rate for retailer, D < P
T : Length of cycle, $T = \frac{Q}{D}$
Uj : Unit transport cost to *j*, (*j*=1,2,3,…,j)
αj : The quantity range of transport cost

This research has assumptions:

- A single product type.
- Demand is deterministic and constant over time
- Shortages unpermitted
- Demand of retailer are lower than level production of manufacturer
- The holding cost consists of storage dan financial holding cost.
- Manufacturers offer retailers a period of delay in payment and transportation cost discounts.
- Vehicles (trucks) that are used pass through the same lane.
- Retailers invest debts to manufacturers in risk-free investments during the permissible period.
- Retailers pays the balance in a single payment.

2.2 Model Formulation of Permissible Delay in Payment

Mathematical models are formulated with the aim of obtaining the optimal decision variables in the supply chain with several considerations. In this study, manufacturing is assumed to be able to deliver to retailers even though the production process is ongoing. Moreover, manufacturers will start production when the inventory level hits zero.

Scenario I : $0 \le t = \tau \le \frac{Q}{D}$

In this scenario, manufacturer gives retailer the time period t to settle their balance without any interest expense. Then, the retailer makes payments in the time period τ, where the time of payment is right at the end of the delay in payment permitted by the manufacturer t (t = τ). Total annual cost of manufacturer composed of set up, production, holding cost (physical and financial), and opportunity cost, as follows:

$$\psi_m{}^I = \frac{A_m D}{nQ} + C_m D + (h_m + s_m)\frac{Q}{2}\left(n + 1 - \frac{nD}{P}\right) + h_m tD + (C_r - C_m)De^{\delta_m t} - C_r De^{\delta_m(\tau - t)} \quad (1)$$

In the retailer, total annual cost composed of order, purchase, holding cost (financial and physical), and interest earnings, as follows:

$$\psi_r{}^I = \frac{A_r D}{Q} + C_r D + h_r \frac{(Q - Dt)^2}{2Q} + \frac{s_r}{2}Q + C_r D(1 - e^{\delta_m t}) \quad (2)$$

Total annual cost of the supply chain system is sum of total annual costs manufacturers and retailers. Here is the total system cost:

$$\psi_{SC}{}^I = \frac{A_m D}{nQ} + C_m D + (h_m + s_m)\frac{Q}{2}\left(n + 1 - \frac{nD}{P}\right) + h_m tD + (C_r - C_m)De^{\delta_m t} - C_r De^{\delta_m(\tau - t)} + \frac{A_r D}{Q} + C_r D + h_r \frac{(Q - Dt)^2}{2Q} + \frac{s_r}{2}Q + -C_r D(1 - e^{\delta_m t}) \quad (3)$$

From equation (3), then the first derivation is made of Q, until the following equation is generated:

$$Q^I = \sqrt{\frac{2D\left(\frac{A_m}{n} + A_r\right) + h_r (Dt)^2}{h_r + s_r + (h_m + s_m)(n + 1 - \frac{D}{P}n)}} \quad (4)$$

To minimize the equation for the total annual cost system, therefore equation (3) is first derived from n and equated to zero, so that the following is obtained:

$$n^I = \frac{1}{Q}\sqrt{\frac{2A_m D}{(h_m + s_m)(1 - \frac{D}{P})}} \quad (5)$$

Scenario II : $0 \le t < \tau \le \frac{Q}{D}$

In this scenario, manufacturer gives retailer the time period t to settle their balance without any interest expense. However, the retailer made payments on the time period τ, where that period exceeds the time limit given by the manufacturer t ($t < \tau$). Therefore, in this case, the retailer must provide a certain amount of compensation (interest expense) to the manufacturer. Total annual cost of manufacturer consists of set up cost, production, holding cost (physical and financial), opportunity cost, and interest income delay in payment, as follows:

$$\psi_m{}^{II} = \frac{A_m D}{nQ} + C_m D + (h_m + s_m)\frac{Q}{2}\left(n + 1 - \frac{nD}{P}\right) + h_m \tau D + (C_r - C_m)De^{\delta_m t} - C_r De^{\delta_m(\tau - t)} \quad (6)$$

Total annual cost of retailer composed of order, purchase, holding cost (financial and physical), and interest expense for delay in payment, as follows:

$$\psi_r{}^{II} = \frac{A_r D}{Q} + C_r D + h_r \frac{(Q - D\tau)^2}{2Q} + \frac{s_r}{2}Q + C_r D(e^{\delta_m(\tau - t)} - e^{\delta_r \tau}) \quad (7)$$

Total annual cost of the supply chain system is sum of the total annual costs manufacturers and retailers. Here is the total system cost:

$$\psi_{SC}{}^{II} = \frac{A_m D}{nQ} + C_m D + (h_m + s_m)\frac{Q}{2}\left(n + 1 - \frac{nD}{P}\right) + h_m \tau D + (C_r - C_m)De^{\delta_m t} - C_r De^{\delta_m(\tau - t)} + \frac{A_r D}{Q} + C_r D + h_r \frac{(Q - D\tau)^2}{2Q} + \frac{s_r}{2}Q + C_r D(e^{\delta_m(\tau - t)} - e^{\delta_r \tau}) \quad (8)$$

For the Q equation in scenario II this is the same as equation (4), and it is only necessary to change t with τ. Moreover, to minimize the total annual cost system equation, equation (8) is derived first from n and equated to zero, so that the following equation is obtained:

$$n^{II} = \frac{1}{Q}\sqrt{\frac{2A_m D}{(h_m+s_m)(1+\frac{D}{P})}} \qquad (9)$$

2.3 Formulation of Transportation Cost

The discount scheme in this paper uses all–unit quantity discount type. Scheme structure of transportation discount in this paper is similar to Ertogral et al, (2007), which transportation cost as a function of the shipment lot size, and the unit transportation cost structure is shown as follows:

$$TC = \begin{cases} U_0 D, & 0 \le Q \le \alpha_1 \\ U_1 D, & \alpha_1 \le Q \le \alpha_2 \\ U_2 D, & \alpha_2 \le Q \le \alpha_3 \\ \vdots & \\ U_j D, & \alpha_j \le Q \end{cases} \qquad (10)$$

Where the value of U0 > U1 > U2 > …. > Uj, so that the total annual cost system in equations (3) and (8) needs to be added with the transportation cost (TC) as follows:

$$\psi_{SC}{}^{I} = \psi_m{}^{I} + \psi_r{}^{I} + TC \qquad (11)$$

3. RESULTS AND DISCUSSION

We calculate from the model that described in the section above. The input parameter values used in this study refer to Aljazzar et al, (2015) : $D = 411$; $P = 1200$; $A_m = 200$; $A_r = 30$; $C_m = 15$; $C_r = 20$; $h_m = 0.0082$; $h_r = 0.011$; $s_m = 0.025$; $s_r = 0.033$; $k_m = 0.0003$; $k_r = 0.0006$. As for the discount scheme used in this study, this refers more to Ertogral et al, (2007), as shown in Table 1.

Table 2. Structure of Transportation Cost

Range	Unit Transportation Cost
$0 \le Q < 400$	0.4
$400 \le Q < 800$	0.25
$800 \le Q < 1200$	0.17
$1200 \le Q$	0.14

Numerical calculations were carried out using Wolfram Mathematica 9.0 on two delay in payment scenarios that consider the transportation cost discount and there is an additional scenario where there is a delay in payment without considering the transportation cost discount (Scenario 0). The aim of calculation which determine the supply chain system that will result minimum total annual cost. Decision variables in this paper is length of the delay in payment period and shipment lot size.

Tabel 3. Numerical Results

Scenario	n	Uj	Q	t	τ	Ψ_m	Ψ_r	Ψ_{SC}
0	3	-	664	2	2	81.58	8321.43	8403.01
I	1	0.14	1497	4	4	111.42	8291.57	8402.99
	2	0.14	1200	3	3	91.72	8293.18	8384.90
		0.17	1004	3	3	90.94	8304.57	8395.51
	3	0.14	1200	3	3	93.28	8293.18	8386.46
		0.17	800	2	2	81.21	8308.59	8389.80
		0.25	789	2	2	81.15	8341.51	8422.66
	4	0.14	1200	3	3	100.56	8293.18	8393.70
		0.17	800	2	2	81.31	8308.59	8389.90
		0.25	664	2	2	78.45	8342.59	8421.04
II	1	0.14	1526	1	5	103.99	8297.17	8401.16
	2	0.14	1200	1	4	97.32	8296.21	8393.53
		0.17	1019	1	3	85.36	8309.04	8394.40
	3	0.14	1200	1	4	88.88	8296.21	8385.09
		0.17	800	1	2	78.44	8310.81	8389.25
		0.25	799	1	2	78.43	8343.69	8422.12

The numerical calculations of all scenario are shown in Table 3. The results shows that minimum total cost of the supply chain system Ψ_{SC} = 8384.90 $/day occurs in scenario I which the shipment lot size is n = 2, and delay in payment period is t = 3 days. This happens where in scenario I, manufacturer provides a delay in payment time period t to the retailer, and the retailer settle the balance at the right time τ which same as t period (t = τ). Retailer takes advantage of the discount scheme offered by manufacturers in increasing the order quantity to achieve the lowest unit transportation cost. The benefit will be obtained by all players in supply chain. Manufacturers get the benefit from a larger number of purchases by retailers, while the advantage for retailers is that they get time to delay before making payments and can make a greater risk-free investment.

From the optimal solution obtained based on previous numerical calculations, a sensitivity analysis will then be carried out. The sensitivity analysis is done by varying the input parameter values. This aims to determine the impact of changing parameters in the total cost of supply chain system from models are being studied by authors. In this research, the input parameters h_r/h_m and A_r/A_m were varied.

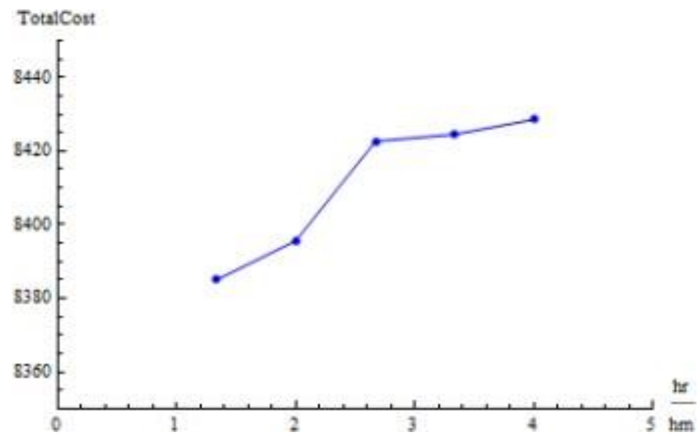

Figure 1. Total cost while varying h_r/h_m

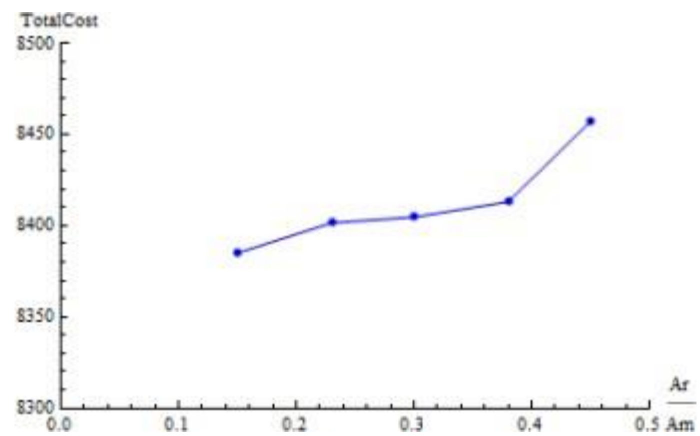

Figure 2. Total cost while varying A_r/A_m

Figure 1 shows the effect of variations in retailer financial holding cost ratios on manufacturing on the total cost of the supply chain system. When manufacturer financial holding cost increases, period time of delay in payment provided by manufacturer to retailer becomes shorter. Therefore, quantity order of the retailer decrease but total cost of supply chain system are still increase. It is because total cost manufacturer increases as a result of their financial holding also increase. The increasing financial holding costs retailers causes the total cost of retailers also increase, so that indirectly increase total cost of the supply chain system. **Figure 2** shows the impact of variations in ordering cost retailers over set-up costs of manufacturer on the total cost of the supplychain system. When the shipment lot size increases, it will result in ordering cost at retailers to also increase. Therefore, the total cost of retailers has increased and effected to total cost of supply chain system has also increased.

4. CONCLUSION

In this paper, we develop a coordination mechanism for permissible delay in payment and transportation discounts in two-level supply chains. We formulate a model of supply chain system which the decision variables of long duration delay in payment with shipment lot size can minimize their total cost. First, we construct the supply chain system model into two delay in payment scenarios. Then from the two delay in payment scenarios that have been constructed, a transportation cost discount is considered. This paper uses the all-unit quantity discount type.

Numerical calculation aims to obtain the minimum total cost from supply chain system. From calculation on the two delay in payment scenarios that take into account the transportation discounts, the minimum total cost of the supply chain system occurs in scenario I. On that scenario manufacturer provides a delay in payment period t to the retailer to complete their payment and the retailer makes the payment at the right time τ which same as t period. Retailer also makes purchases in larger lots because manufacturers offer a discount scheme on transportation costs.

The sensitivity analysis is carried out on the best scenario which aims to determine impact from changing parameter of the total cost system. The first analysis is implemented by testing variations financial holding cost of retailer's on manufacturing. The result showed when financial holding costs increased in supply chain system, the total cost also increase. Then, a second analysis is carried out to examine variations in ordering cost retailers for manufacturing set-up costs. It shows that when cost of ordering increasing in supply chain system, the total cost to increase accordingly. We conclude that total cost system in supply chain can be minimum by implementing two mechanisms of coordination. The best scenario is retailer settle their balance were same as the period of delay in payment that given by manufacturer, and retailer utilizing the transportation discount scheme from manufacturer. The model developed in this paper can be extended by considering environmental sustainability and the form of online retailers (online channels).

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6. REFERENCES

Aljazzar, S. M., Jaber, M. Y., & Goyal, S. K. (2015). Coordination of a two-level supply chain (manufacturer–retailer) with permissible delay in payments. *International Journal of Systems Science: Operations and Logistics*, *3*(3), 176–188.

Aljazzar, S. M., Jaber, M. Y., & Moussawi-Haidar, L. (2016). Coordination of a three-level supply chain (supplier–manufacturer–retailer) with permissible delay in payments. *Applied Mathematical Modelling*, *40*(21–22), 9594–9614.

Aljazzar, S. M., Jaber, M. Y., & Moussawi-Haidar, L. (2017). Coordination of a three-level supply chain (supplier–manufacturer–retailer) with permissible delay in payments and price discounts. *Applied Mathematical Modelling*, *48*(2017), 289–302.

Aljazzar, S. M., Gurtu, A., & Jaber, M. Y. (2018). Delay-in-payments - A strategy to reduce carbon emissions from supply chains. *Journal of Cleaner Production*, *170*(2018), 636-644.

Chang, H. C. (2013). A note on an economic lot size model for price-dependent demand under quantity and freight discounts. *International Journal of Production Economics, 144(1),* 175-179.

Chung, K. J., Goyal, S. K., & Huang, Y. F. (2005). The optimal inventory policies under permissible delay in payments depending on the ordering quantity. *International Journal of Production Economics*, *95*(2), 203–213.

Ertogral, K., Darwish, M., & Ben-Daya, M. (2007). Production and shipment lot sizing in a vendor-buyer supply chain with transportation cost. *European Journal of Operational Research*, *176*(3), 1592– 1606.

Goyal, S. K. (1985). Operational Research Society is collaborating with JSTOR to digitize, preserve, and extend access to Journal of the Operational Research Society. ® www.jstor.org. *Journal of the Operational Research Society*, *38*(3), 277–286.

Goyal, S.K. (1988). A joint economic-lot-size model for purchaser and vendor: A comment. *Decision Sciences*, *19*, 236–241.

Goyal, S. K., Teng, J. T., & Chang, C. T. (2007). Optimal ordering policies when the supplier provides a progressive interest scheme. *European Journal of Operational Research*, *179*(2), 404–413.

Hill, R. M. (1997). The single-vendor single-buyer integrated production-inventory model with a generalized policy. *European Journal of Operational Research*, *97*(3), 493–499.

Huang, Y. F., Chou, C. L., (2007). An EPQ model under cash discount and permissible delay in payments derived without derivatives. *Yugoslav Journal of Operations Research*, *17(2)*, 177-193.

Ibrahim, M. F., & Putri, M., M. (2019). Integrated green supply chain model to reduce carbon emission with permissible delay-in-payment consideration. *Jurnal Teknik Industri*, *20* (2), 24-35.

Jaber, M. Y., Bonney, M., & Guiffrida, A. L. (2010). Coordinating a three-level supply chain with learning-based continuous improvement. *International Journal of Production Economics*, *127*(1), 27–38.

Jaber, M. Y., & Osman, I. H. (2006). Coordinating a two-level supply chain with delay in payments and profit sharing. *Computers and Industrial Engineering*, *50*(4), 385–400.

Kim, S. J., & Sarkar, B. (2017). Supply Chain Model with Stochastic Lead Time, Trade-Credit Financing, and Transportation Discounts. *Mathematical Problems in Engineering*, *2017*.

Tsao, Y. C., & J. C. Lu. (2012). A Supply chain network design considering transportation cost discounts. *Transportation Research Part E: Logistics and Transportation Review, 48 (2)*, 401–414

Zhao, Q. H., Wang, S. Y., Lai, K. K., & Xia, G. P. (2004). Model and algorithm of an inventory problem with the consideration of transportation cost. *Computers and Industrial Engineering*, *46*(2), 389–397.

INVENTORY CONTROL OF MAIN DISTRIBUTION MATERIAL (MDU) IN PT PLN UP3 PONOROGO

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ABSTRACT

As an electricity service provider company, one of the operational activities of PT PLN UP3 Ponorogo is to serve *Pasang Baru* (PB) and *Perubahan Daya* (PD) requests, especially for household power tariff (R) customers. Short-term forecasting was carried outto determine the estimated future demand for PB and PD using the exponential smoothing method which was then converted into MDU. needs. There are 2 MDUs in ABA class, 4 MDUs in ABB class and 9 MDUs in ABC class which will take into account the minimum
(s) and maximum (S) inventory parameters by comparing existing policies, continuous review methods (s,S) and periodic reviews (R,s,S). With the application of the periodic review method inventory policy (R,s,S) 13.36% and the achievement of a service level of 98% per month on average when compared to the current policy.

Keywords: safety stock, reorder point, quantity optimum, forecasting, *continuos review*, *periodic review*

1. INTRODUCTION

A case study in this research is PT PLN UP3 Ponorogo that is one of the electrical implementation units of the East Java Main Distribution area to service order customers in the Ponorogo district. A case study serves people demands for “*Pasang Baru*” (PB) and “*Perubahan Daya*” (PD) household rates (R) per month. "*Pasang Baru*" (PB) demand is the activity of submitting requests to become PLN customers at a certain rate while PD is the activity of fulfilling order customers to change the type of tariff or power (increase or decrease) that has been connected. To be able to fulfil PB and PD requests, Main Distribution Materials (MDU) are needed. MDU has made a Unit Price Contract (KHS) by the Supply Chain Management Division so that the central Unit can only immediately place orders as are needed to the KHS manufacturer.There are 31 MDUs that are used to serve PB and PD with 1-phase and 3-phase household rates (R), both those requiring network expansion or not.

From the evaluation of PB and PD requests for household rates (R) in 2019, it is knownthat the average monthly service level achievement is 82% in detail for 12 months as in Figure 1. The highest cause (29.7%) of low service level is due to MDU un-availability (stock out). As the only company that can serve PB and PD, a backorder system is implemented to meet customer demands. Bahagia (2006:156), backorder means that the customer is willing to wait until the material is available and the company will place an order to fulfill unserved requests. This has an impact on low service levels and high inventory costs.

Previous research on inventory control topics in Indonesian's companies has often been carried out, such as Meilanitasari et al., 2016a, 2016b, Widodo et al., 2019. A few previous research for the Indonesian's electricity sector has been carried out such as Arifin and Vanany., 2019 and Musyahidah and Vanany.,2019. This study also seeks to contribute research to the electricity industry. The practical implications of this research for inventory managers in the case study are motivation and contribution of this study. The results of this research can help inventory managers in case studies to improve their inventory management. Increasing the service level for each material item is the goal of this research with determining safety stock and Reorder Level (ROL) in the case study.

2. LITERATUR REVIEW

2.1 Inventory

Inventories are items that must be stored for use or sale in the future (Ristono, 2009: 2). In material inventory, 3 things that must be considered are the determination of safety stock, reorder points and order quantity, this is important because when material procurement requires time and market demand is not constant. Inventory management at the company will certainly lead to inventory costs. Tersine (1994), the cost of inventory is related to the operation of the company's inventory system where the inventory cost consists of several cost components, including purchase costs, ordering costs, storage costs, inventory shortage costs.

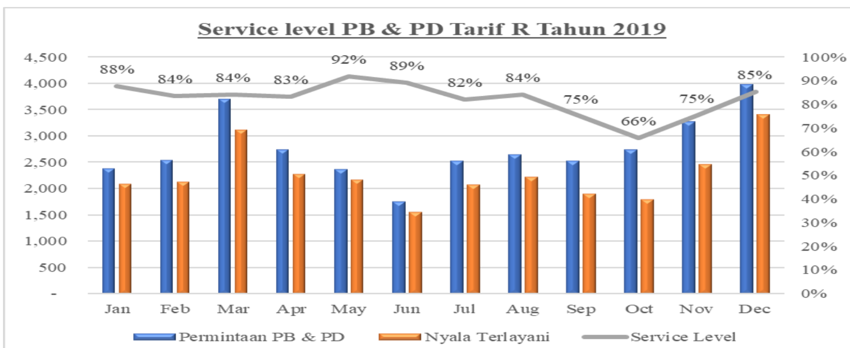

Figure 1. Service Level Demand for PB and PD Tariff R

2.2 MDU Classification using Company Policy

ABC classification is a method used to classify materials based on the criteria for the level of criticality, the level of availability and the level of usage. This classification is based on the company's inventory policy which is used to determine the service level of the material according to the classification. ABA and ABB class service level 97% and ABC class 95%.

2.3 Classification based on Usage Patterns

According to A.A. Ghobbar * (2002) states that materials with a continuous use pattern are included in the fastmoving material type, while materials with intermittent usage patterns can be grouped into intermittent demand, erratic demand, lumpy demand, and slow moving. By using a classification approach in the range of average demand sizes for a certain period / Average Demand Interval (ADI) and the Coefficient of Variations (CV), intermittent material patterns can be determined using the following equation;

$$ADI = \frac{\sum_{N}^{i=1} t_i}{N} \quad (1)$$

$$CV = \frac{\sqrt{\frac{\sum_{i=1}^{N}(\varepsilon_i - \varepsilon)^2}{N}}}{\varepsilon} \quad (2)$$

$$\varepsilon = \frac{\sum_{i=1}^{N} \varepsilon_i}{N} \quad (3)$$

Information:

a. N for ADI is the number of periods without zeros
b. N for CV is the total number of periods
c. t_i is the interval between two consecutive nonzero demand periods

2.4 Probabilistic Inventory

Probabilistic inventory is an inventory model for the characteristics of demand and arrival of orders that are not known with certainty in advance, but the expected values, variations and possible distribution patterns can be predicted by being approximated based on probability distributions. There are 3 conditions of the probabilistic inventory model, demand is constant and lead time varies, demand varies and lead time is constant, and demand and lead time varies.

2.5 Continuous Review (s,S)

The continuous review method or often called the Q method is a method of controlling inventory levels continuously, not paying attention to the time interval (R) at the time of execution but ordering inventory is done when the inventory level has reached reorder points. One of the Q methods is the continuous review method (s, S) which has the characteristic of ordering will be made when the inventory has reached the reorder point or below it by ordering not only the optimal number of messages but can only be done when ordering the items needed is not at (EOQ)but up to the supply maximum message limit (S). This method is called the min-max system because the inventory position is at the minimum s and maximum S.

2.6 Periodic Review (R,s,S)

The periodic review method or often called the P method is a method of controlling inventory levels based on the time interval (T) where the number of orders varies with a constant message period. One of the P methods is the periodic review method (R, s, S) which has the characteristic of ordering will be made if the inventory level is at or below the minimum supply, with the maximum order point order S for each period R. still above s even though it has reached period R

2.7 Forecasting with the Exponential Smoothing Method

According to Heizer and Render (2009: 162), forecasting is the art and science of predicting future events by taking historical data and projecting it in the form of a mathematical model. Forecasting using exponential smoothing method is a quantitative forecasting that connects the relationship between the dependent variable (the variable sought) and the independent variableor variables that influence it, then it is linked to time according to forecasting needs. This methodis suitable for predicting things with random values. Each data is weighted with the symbol α. The value of α can be selected between the values 0-1, it can be formulated as follows:

$$F_t = F_{t-1} + \alpha\,(D_{t-1} - F_{t-1}) \quad (4)$$

Information:

Ft : Current demand forecast
F_{t-1} : Estimated past requests
α : smoothing constant (0-1)
D_{t-1} : Real request

3. METHODOLOGY

The stages of this research began with the initial stage of literature and field studies, then the data collection stage, the data processing stage and finally the analysis and conclusion stages. At the initial stage, a literature study was conducted to understand the concepts related to research and a field study was carried out to determine the condition of the company's existing inventory policy. Furthermore, the data collection stage, PB and PD request data use data from past 3 years (2017-2019). Data 2020 are not used due to anomalous conditions for Covid-19. Short-term forecasting of PB and PD demand was carried out using the exponential smoothing method. To determine the accuracy of forecasting, the RMSE and MAPE calculations are performed, wherethe smaller the value, the closer to the accurate forecasting result. The results of the forecast are converted into MDU requirements according to the Bill of Quantity Materials. The next stage is toclassify the MDU based on the ABC classification criteria. Then the classification is done to see the pattern of MDU usage as a result of ABC classification using the ADI-CV method. After knowing the usage pattern of each MDU, the MDU needs forecast is carried out using a method based on the results of the usage pattern (slow moving, erratic, intermittent, lummpy). Next is the calculation of the existing condition inventory parameters, continuous review (s,S) and periodic review (R,s,S) by using the forecast data of each MDU. Furthermore, to determine the total cost ofinventory and service level MDU, a simulation is carried out using the Material Requirement Planning (MRP) then analyzed the monthly average cost of the total inventory and the service level of the three methods used.

4. ANALYSIS AND DISCUSSION

4.1 Inventory Cost

Total inventory cost consists of :

1. Purchase costs are costs incurred when purchasing goods, calculated from the total MDU purchased multiplied by the MDU unit price in Table 2 column d
2. Ordering costs can be defined as all costs incurred to place an order for goods and are assumed to be fixed for each MDU as detailed in Table 1.
3. Holding costs are costs arising from the storage of goods as detailed in Table 1 multiplied by the MDU unit price;

Table 1. Ordering Cost and Holding Cost Composition

Ordering Cost			Holding Cost Composition		
a. Communication cost	:	Rp 350.000,-	a. Capital cost	:	10%
b. Administration cost	:	Rp 500.000,-	b. Finance cost	:	2%
c. Labor cost	:	Rp 150.000,-	c. Warehouse cost	:	1%
Total	**:**	**Rp 1.000.000,-**	d. Insurance free	:	3%
			e. Tax cost	:	10%
			Total	**:**	**26%**

4. Stockout costs are calculated using the unserved PB and PD requests caused by MDU stockouts so that the company experiences loss opportunity income. The calculation of stockout cost per MDU is calculated by providing the coefficient per MDU obtained from the total use of MDU per category of PB and PD. The coefficient is multiplied by the amount of power (VA) that cannot be connected after being converted into kWh then multiplied by rupiah per kWh for each power tariff as in Table 2 culumn e

Table 2. Recapitulation of Inventory Cost Components

Nomor Material	Nama Material	Lead Time (Days)	Unit Price	Stockout Cost	MDU Needs (Month)	ABC Classification	ADI-CV	Average MDU Forecast (Month)
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*
2190224	MTR;kWH E-PR;;1P;230V;5-60A;1;;2W	45	242,540	1,112,255	1,918	ABA	Erratic	1,935
3110025	CABLE PWR;NFA2X;2X10mm2;0.6/1kV;OH	45	4,554	730,941	67,130	ABA	Erratic	67,735
3110542	CABLE PWR;NFA2X-T;3X70+1X70;0.6/1kV;OH	45	1,910	260,543	159	ABB	Lumpy	159
3250012	MCB;220/250V;1P;2A;50Hz;	30	30,700	140,786	1,320	ABB	Erratic	1,321
3250015	MCB;220/250V;1P;4A;50Hz;	30	30,700	140,786	585	ABB	Erratic	571
3250018	MCB;220/250V;1P;6A;50Hz;	30	30,700	250,343	529	ABB	Erratic	547
2190218	MTR;kWH E;;3P;230/400V;5-80A;1;;4W	30	1,384,510	761,301	3	ABC	Erratic	3
3110029	CABLE PWR;NFA2X;4X16mm2;0.6/1kV;OH	45	13,803	88,933	85	ABC	Erratic	85
3250022	MCB;380/440V;3P;10A;50Hz;	30	132,400	275,523	15	ABC	Erratic	14
3250024	MCB;380/440V;3P;16A;50Hz;	30	132,400	275,523	2	ABC	Erratic	2
3250007	MCB;220/250V;1P;10A;50Hz;	30	30,700	250,343	111	ABC	Erratic	110
3250008	MCB;220/250V;1P;16A;50Hz;	30	30,700	250,343	5	ABC	Erratic	5
3250010	MCB;220/250V;1P;20A;50Hz;	30	30,700	250,343	19	ABC	Erratic	19
3250011	MCB;220/250V;1P;25A;50Hz;	30	30,700	250,343	5	ABC	Erratic	5
3250013	MCB;220/250V;1P;35A;50Hz;	30	30,700	250,343	5	ABC	Erratic	5

4.2 Demand PB and PD Forecasting using Exponential Smoothing

By using the formula in equation (4), the average demand for PB and PD is obtained as shown in Table 3 below;

Table 3. Actual and Forecast Average Demand Tariff R

Tariff R	Average PB (month)					Average PD (month)				
	Actual Demand	Forecasting Demand	α	MAPE	RMSE	Actual Demand	Forecasting Demand	α	MAPE	RMSE
R-1 450 VA	1,286	1,254	1.00	32%	478	64	66	0.64	6%	122
R-1 900 VA	1,395	1,371	0.72	18%	205	351	344	1.00	13%	704
R-1 1300 VA	371	389	1.00	29%	66	140	138	0.61	13%	333
R-1 2200 VA	26	27	0.87	38%	77	86	85	0.71	13%	209
R-2 > 2.200 s/d 6.600 VA	8	8	1.00	31%	24	41	40	0.51	21%	137
R-3 >6.600 VA	1	1	0.49	22%	4	3	3	0.77	23%	10

4.3 Converting PB and PD Forecasting Results into MDU Needs

The results of PB and PD forecasting in Table 3 are converted into MDU requirements according to the standard bill of quantity set by the company, as an example shown in Table 2 column f.

4.4 MDU Classification using Company Policy

ABC classification is based on 3 criteria in Table 4, for example, MDU 2190224, from the critical criteria it is categorized as A because without the MDU PB and PD cannot be served, from the avaibility criteria, the lead time for 45 days is included in category B and the usage criteria, Usage for 1 year amounting to Rp5,582,300,640,- so the MDU is ABA class. Details of the ABC classification results can be seen in Table 2 column g.

Tabel 4. Criteria of ABC Classification

Category	Critically	Availability	Usage
A	Very critical	Long lead time (> 90 days)	Usage per year > Rp 500 million
B	Critical	Medium lead time (30-90 days)	Usage per year Rp 100 - 500 million
C	Less critical	Short lead time (< 30 days)	Usage per year < Rp 100 million
D	-	-	Usage per year Rp 0

4.5 Classification using ADI-CV Method

By using the formula in equations (1) to (3), the ADI-CV value of each MDU can be obtained so that the usage pattern can be seen by referring to the criteria below and the result as show in Table 2 column h.

1. *Smooth demand* if ADI < 1.32 and CV< 0.49,
2. *Intermittent demand* if ADI >= 1.32 and CV< 0.49,
3. *Erratic demand* if ADI < 1.32 and CV >= 0.49
4. *Lumpy demand* if ADI >= 1.32 and CV >= 0.49

4.6 Forecasting MDU Needs with the Exponential Smoothing Method

To obtain a near-accurate demand forecast, MDU needs forecasting will be carried out using the exponential smoothing method for both Erratic and Lumpy Demand MDUs. The results are shown in Table 2 column i.

4.7 Calculation Existing Condition (s,S) Parameters

The calculation of the existing policy parameters is calculated using the min-max level method which means calculating the minimum stock amount (s) and the maximum stock (S), as an example MDU- 3250012

Average demand (month) : 1320 units
Lead time : 30 days = 1 monthThe

calculation steps are as follows;

1. $Safety\ Stock\ (SS) = \frac{average\ demand\ (month)\ x\ lead\ time}{2} = \frac{(1320)(1)}{2} = 660\ units$
2. $Level\ minimum = average\ demand\ (month)\ x\ lead\ time = (1320)(1) = 1320\ units$
3. $Reorder\ poin\ (s) = level\ minimum + SS = 1320 + 660 = 1980\ units$
4. $Maximum\ inventory\ (S) = s + 2x\ level\ minimum = 1980 + (2x1320) = 4620\ units$

So for the existing conditions MDU-3250012 minimum inventory value (s) is 1,980 units and the maximum inventory value (S) is 4,620 units

4.8 Calculation Continous Review (s,S) Parameter

Continuous review method (s, S), it means that the inventory is monitored continuously and an order will be made when it reaches the reoder point (s) or below with the number of orders reaching the maximum point (S). The following is an example of MDU calculation using the Continous review method for material items 2190224;

Demand (month)	(D)	: 1.935	Lead time (month)	(L)	1,5
Stdev demand	(S)	: 1.592	Stdev lead time	(σ_L)	43,33
Unit price	(p)	: Rp 242.540,-	Holding cost	(h)	Rp 63.060.40,-
Order cost	(A)	: Rp 1.000.000,-	Stockout cost	(C_u)	Rp 1.112.255,-

The calculation steps are as follows;

1. $q_{01} = q_{0w} = \sqrt{\frac{2\ A\ D}{h}} = \sqrt{\frac{2(1.935)(1.000.000)}{63.060}} = 248\ unit$

2. $\alpha = \frac{hq_0}{C_u D} = \frac{(63.060)(248)}{(1.112.255)(1.935)} = 0{,}01$

3. $r_1 = \left(Z_\alpha x S x \sqrt{L}\right) + D_L = (2{,}44)(1{,}592)(\sqrt{1{,}5}) + (1.935)(1{,}5) = 7.668\ unit$

4. $N = SL\left[f(Z_\alpha) - Z_\alpha \Psi(Z_\alpha)\right] = (1.570)(1{,}5)[0{,}0488 - 2{,}02(0{,}0074)] = 28\ unit$

5. $q_{02} = \sqrt{\frac{2D\left[A + Cu\int_{r_1}^{\sim}(x - r_1)f(x)dx\right]}{h}} = \sqrt{\frac{2(1.935)(1.000.000 + 1.1125.255)x1}{63.060}} = 1.405\ unit$

6. $\alpha = \frac{h_{q02}}{h_{q02} + C_u D} = \frac{1.405}{290 + (1.1125.255)(1.935)} = 0{,}04$

7. $r_2 = D_L + Z_\alpha S\sqrt{L} = (1.9535)(1{,}5) + (1{,}73)(1.570)(\sqrt{1{,}5}) = 2.988\ unit$

Then compared between r_1 and r_2 (1,405 units with 2,988 units) there is still a difference, so the iteration is continued where $r_1 = r_2 = 2.988\ unit$ to find the difference between the smallest values. For this calculation, the iteration stops at the 8th iteration with the value $r_1 = r_2 = (s) = 5.179\ unit$ and $q_{01} = 4.228$, so that $S = q + r = 4.228 + 5.179 = 9.385\ unit$

4.9 Calculation Periodic Review (R,s,S) Parameter

Periodic review method (R, s, S) means that the order of supplies is made based on a scheduled basis at a certain time interval (R), the order is made when the inventory has reached reorder points (s) with the maximum number of orders (S) but orders cannot be made if inventory has not reached reorder points even though it has entered the order period The following is an example of MDU 3250012;

Average Demand (month)	(D)	1321	Standard deviation review interval and lead time	(σRL)	:2090
Standard Deviation Demand	(S)	:1478	Unit price	(v)	:30.700
Lead time (month)	(L)	:30 days = 1 months	Order cost	(A)	:Rp1.000.000
Standard deviation Lead time	(σdL)	:1478.180235	Holding cost	(r)	:Rp7982
Review interval (month)	(R)	:1	Stockout cost	(B3)	:Rp140.786

The calculation steps are as follows;

1. $X_R = RD = 1.321 \ x \ 1 = 1.321 \ unit$
2. $X_{R+L} = (R + L)D = (1 + 1)x1.321 = 2.642 \ unit$
3. $Q_p = 1{,}3X_R^{0,494}\left(\frac{A}{vr}\right)^{0,506}(1 + \frac{\sigma_{R+L}^2}{X_R})^{0,116} = 1{,}3x1.321\left(\frac{1.000.000}{(30.700)(7.982)}\right)^{0,506}\left(1 + \frac{2.090}{1.321}\right)^{0,116} = 38 \ unit$
4. $Z = \sqrt{\frac{Q_p r}{\sigma_{R+L} B3}} = \sqrt{\frac{(38)(7.982)}{(2.090)(140.786)}} = 0.00655$
5. $S_p = 0{,}973X_{R+L} + \sigma_{R+L}(\frac{0.183}{z} + 1{,}063 - 2{,}192z)$
   $S_p = 0{,}973\ (2.642) + (2.090)(\frac{0.183}{0{,}00665} + 1{,}063 - 2{,}192(0.0227) = 63.157 \ unit$
6. $apakah\ \frac{Q_P}{X_R} > 1{,}5 \ sehingga \ \frac{38}{1.321} > 1{,}5 = 0.0287 > 1{,}5$
7. $p_u(k) = 1 - P_1 = 1 - 0.0287 = 0{,}971$
8. $S_o = X_{R+L} + k\sigma_{R+L} = 2.642 + (1{,}899)(2.090) = 6.612 \ unit$
9. $s = minimum\ \{S_p, S_o\}$
   $s = minimum\ \{63.157\ , 6.612\}$
   $s = 6.612\ unit$
   $S = maksimum\ \{S_p + Q_p\ , S_0\}$
   $S = maksimum\ (63.195\ , 6.612\}$
   $S = 63.195\ unit$

From the above calculations it is known that the reorder points for the MDU-3250012 is when the inventory reaches 6,612 units with a maximum inventory of 63,195 units.

4.10 Material Requirement Planning

MPR is an order scheduling so that the number and when to place an order is known and of course by paying attention to the lead time per MDU. This is done to determine the cost of supplies and the service level of each MDU. The calculation was carried out for 36 months inorder to obtain the average cost of inventory per month and the average service level per month. As an example of calculating the MRP for MDU-2190224, MRP existing conditions, with a maximum number of orders (S) 10.070, a lead time of 1.5 months and orders will be made when MDU stockout. From the calculation, the average cost of inventory per month is Rp. 3,423,243,211, - with a service level of 75%. For policies with continuous review parameters (s,S)with a maximum order number (S) of 9,385 units, an order will be made. when the inventory has reached the reorder point (s) 5,157 units. From the calculation, the average cost of inventory per month is Rp. 1,262,026,823, - with a service level of 91%. And the last for periodic review (R,s,S)with a maximum order number (S) of 31,849 units, a lead time of 1.5 months and orders will be placed when supplies reach reorder point (s) 11,876 units. From the calculation, the average inventory cost per month is Rp. 1,262,701,701, - with a service level of 95%.

To be able to clarify the comparison of inventory costs and service levels of the three policies in each ABC classification, 1 MDU is taken per ABC classification which is considered the most critical of each classification so that it can represent the overall condition with data as in Table 7.

Table 7. Comparison of Total Costs based on MDU Classification

Classification	Material Number	Existing (s,S)		*Continuous review* (s,S)		*Periodic review* (R,s,S)	
		Inventory Cost	***Service level***	**Inventory Cost**	***Service level***	**Inventory Cost**	***Service level***
ABA	2190224	2,064,570,209	74%	1,262,701,701	90%	1,657,449,626	95%
ABB	3250012	143,575,076	82%	88,453,953	97%	188,209,573	100%
ABC	3250007	10,962,815	81%	6,131,694	100%	5,308,229	100%
Total		**2,219,108,099**		**1,357,287,348**		**1,780,724,600**	

From the three evaluation conditions, the total cost of inventory and service level can be concluded per cost component per category for each policy as shown in Table 8. From Table 8 it is known that for the existing conditions, ordering costs for the ABB and ABC categories are the highest among the two other policies, stockout costs dominate the highest in all classifications which have an impact on the total cost of inventories. For policies with continuous reviews, the cost component is 90% lower when compared to the other two policies, only in the ABA category the message cost for continuous reviews is higher than the others.

Table 8. Recapitulation of Evaluation of Inventory Cost Components by Classification

Class	Existing (s,S)						*Continuous review (s,S)*						*Periodic review (R,s,S)*					
	BB	BP	BS	BSO	BTP	SL	BB	BP	BS	BSO	BPT	SL	BB	BP	BS	BSO	BTP	SL
ABA				High	High			High					High		High			High
ABB		High		High	High								High		High			High
ABC		High		High	High							High	High		High			High

Note :

BB : Purchase cost
BP : Order cot
BS : Holding cost
BSO : Stockout cost
BTP : Total inventory cost
SL : Service Level

For the periodic review policy, the dominance of the highest cost component compared to the other two policies is the purchase cost and storage cost for all classifications.

Furthermore, in terms of service level to fulfill MDU needs, the existing condition provides the lowest level of service among the other two policies in all classifications. The service level continuous review policy is between the other two policies except in the ABC category, the service level is the same as the periodic review with an achievement of 100%. And for periodic review policies, the three categories have the highest service levels ranging from 95% to 100%.

From the results of the analysis, it is recommended to apply a periodic review policy (R, s, S) for MDU in the ABA category, a continuous review policy for the ABB category and a periodic review for the ABC category so that a saving of 17.4% is obtained with a service level of 97%. But when discussion with UP3 Ponorogo management, management prioritizes service level rather than inventory costs so that companies tend to choose the periodic review policy method (R,s, S) rather than continuous review (s, S) with consideration of service demands that must be 100% fulfilled, limited human resources to manage logistics and warehousing applications not yet supported to support company inventory management. Regarding the amount of inventory costs that must be spent to achieve a 100% service level, it was reported that periodically it would be necessary to forecast needs and evaluate inventory parameters to obtain optimal inventory costs. So if all classification ABC controlled using periodic review (R,s,S), 13,36% inventory cost saving with service level 98%.

5. CONCLUSION

1. The parameters for controlling the existing inventory policy (s, S), continuous review policy (s, S) and periodic review (R, s, S) are obtained for the minimum (s) and maximum (S) values of the periodic review greater than the other two policies are due to the order interval which requires inventory at the time interval and during the lead time.
2. Inventory control using periodic reviews for MDU ABA class can provide savings for the company of 15.8% with a service level of 95%. Whereas for the MDU ABB class using the continuous review policy can provide cost savings of 38.8% with a service level of 97%. And for the ABC class MDU by using the periodic review policy, 35.4% savings were obtained with a service level of 100%. In total, if the selected policy is implemented, the company can save 17.4% with a service level achievement of 97%. If it is in accordance with the wishes of company management who prefer to apply periodic reviews in all MDU class, a savings of 13.36% will be obtained with service level achievements of 98%.

6. REFERENCES

A.A. Ghobbar*, C. F. (2002). *Sources of intermittent demand for aircraft spare parts within airline operations. Journal of Air Transport Management 8 (2002) 221–231*, 227.

Agus, Ristono. (2009). *Manajemen Persediaan*. Yogyakarta: Graha Ilmu

Arifin, W. I., & Vanany, I. (2019). *Energy Loss Analysis using Value Stream Mapping (VSM): a Power Plant Case Study*. Paper presented at the 2019 International Conference on Technologies and Policies in Electric Power & Energy.

Bahagia, S. N. (2006). *Sistem Inventory*. Bandung: ITB Press.

Edward A. Silver, D. F. (2017). *Inventory and Production Management in Supply Chains*. US: Taylor & Francis Group.

Heizer, Jay dan Barry Render. (2009). *Manajemen Operasi Buku 1 Edisi 9*. Jakarta: Salemba Empat

Leven, E. & Segerstedt, A. (2004). *Inventory Control with a Modified Croston Procedure and Erlang Distribution*. International Journal of Production Economics, 90: 361–7.

Mukhopadhyay, S., Solis, A.O., & Gutierrez, R.S. (2005). *A Comparison of Four Method of Forecasting Lumpy Demand. Department of Information & Decision Science*. The University of Texas at El Paso

Meilanitasari, P., Iwan Vanany, I., & Widodo, E. (2016). *Drug Inventory Modelling for Internal Supply Chain in The Hospital.* Paper presented at the 7 th International Conference on Operations and Supply Chain Management (OSCM).

Meilanitasari, P., Vanany, I., & Widodo, E. (2016). *Pengembangan model persediaan obat-obatan pada instalasi farmasi di internal rumah sakit.* Paper presented at the Seminar Nasional Manajemen Teknologi XXIV.

Musyahidah, B., & Vanany, I. (2019). *Integration Assessment and Evaluation of Supplier Performance System in Electricity Generation Company.* Paper presented at the IOP Conference Series: Materials Science and Engineering.

Tersine, R. J. (1994). *Principles of Inventory and Materials Management.* USA: Prentice Hall.

Widodo, E., Sitohang, E., & Vanany, I. (2019). *An Inventory Management Model for Product-Service System in Dual-Channel Supply Chain.* Paper presented at the IOP Conference Series: Materials Science and Engineering.

APPLICATION OF DATA ENVELOPMENT ANALYSIS TO INCREASE INVENTORY EFFICIENCY: A STUDY CASE OF MRO'sCOMPANY

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ABSTRACT

The market demand of MRO (Maintenance, Repair and Overhaul) companies for aircraft is quite good and makes maintenance activity increase. Increased demand will affect the inventory of maintenance materials needed to maintain aircraft. This condition makes MRO's must develop good inventory management. MRO's need valid data about material usage to reduce inventory buildup due to incorrect purchases or unused based on aircraft problem data. From this case, MRO's should be able to make a list of frequently used materials. This research is conducted at one of the aircraft MRO companies in Southeast Asia. The subject of this research is the material used for aircraft maintenance activities. In the research process, maintenance material will be clustered based on factorsthat affect the condition of the material, thus obtaining a data set to be a reference in material procurement. This reference is intended to reduce procurement costs in supporting aircraft maintenance activities. The DEA (Data Envelopment Analysis) method can be used to evaluate the relative efficiency level of DMU (Decision Making Unit) in this case are materials maintenance. DEA will produce material sequence based on the value of efficiency and can be used as a basis for material procurement. The result show that there are as many as 8 out of 16 DMU's are inefficient. Inefficient DMU'sneed to be evaluated to achieve efficient values, for example, problem parameters of DMU 14 should be reduced to 891%, the price parameters from DMU 12 should be reduced to 1115% cheaper, and material stock from DMU 8 needs to be reduced by 65%.

Keywords: Data Envelopment Analysis, Cost Efficiency, MRO, Inventory.

1. INTRODUCTION

The research was conducted at MRO (Maintenance, Repair and Overhaul) company in Southeast Asia. This MRO's focus is on aircraft maintenance services. Having huge potential market and human resources capabilities, the company is growing by making a footprint in several regions including the Middle East, Australia, Africa, and several other regions. It is intended to make the company closer to its customers. The variety of customers from the MRO's company, will increase the demand for aircraft materials for maintenance activity. With such conditions, the company needs to provide fine material usage data to reduce excess inventory dueto incorrect or unused materials.

Making an efficient inventory according to maintenance needs, it is necessary to know the efficiency value of the materials maintenance. According to Rini (2018), If inventory is too high, it will increase the interest costs, increase the storage and maintenance costs, increase the risk of damage, and decrease quality of materials. Meanwhile, if the inventory is too low, it will cause thecompany not to be able to work at full capacity and unable to meet the customer demand. The methods that can be used to obtain the efficiency value of materials with different conditions and variations is DEA (Data Envelopment Analysis). The DEA method does not require the assumption of functional relationship between input and output variables. The value measured in DEA is the relative productivity of an object, not absolute productivity (Yuli, 2009). In this research, the DEA method is used because it is a method that can be used to determine the efficiency of a material with many variations and conditions of the material itself.

The data of this research is a collection of material data that has been used between 2014 tomid 2020. Aircraft materials will be the DMU (Decision Making Unit) on this research. The focus of research is also on aircraft belonging to the company's main customer type Boeing 737-800 andmaterials listed in ATA CHAPTER 23,25 and 33. After obtaining the value of material efficiency and rank, inefficient materials will be evaluated to become efficient materials.

2. METHOD

2.1 DEA (Data Envelopment Analysis)

DEA is a technical efficiency concept developed by Charnes, Choper and Rhodes in 1978. This concept will evaluate the relative efficiency level of Decision-Making Units (DMU) which are non-parametric and multifactorial in both input and output (Charnes et al, 1978). In theDEA method, the main difficulty is for the selection of input and output because there is no standardthat regulates the determination of input and output. According to Ramanathan (2003), input is generally defined as a resource that affects the performance of the DMU. The objective of the DEA is a measure of the efficiency and notice with the value (=1).

The CCR (Charnes-Cooper-Rhodes) model was introduced in 1978, where the maximum ratio between the weighted output and weighted input of each DMU used to measure theefficiency value. The relative efficiency value of CCR is:

$$efficiency = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}}$$

Where : m = number of
inputss = number
of outputs
u_r = output weight DMU 1, 2, . . .
, rv_i = input weight DMU 1, 2,
……, i
x_{io}= the number of i inputs the DMU
uses y_{ro}= the number of r outputs the
DMU uses

s.t: $\frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \leq 1$ for each DMU in the sample.

And $u_r, v_r \geq 0$

The DEA model provides a unique set of weights for each DMU which is limited to a value between 0 and 1. The CCR model is known as the Constant Return to scale (CRS), wherethe ratio of output and input values is proportional.

After calculation of the efficiency of all DMUs, an inefficient DMU will be found. According to Tone (2001) the excesses in inputs and shortfalls in outputs are called slacks. Slack can evaluate to improve the values of efficiency. An expression for improve efficiency with slack according to Tone (2001) is:

$$x_o = X\lambda + s^-$$

$$y_o = Y\lambda + s^+$$

with X and Y are input and output values from n DMU, weight $\lambda \geq 0$, input excess $s^- \geq 0$,and output shortfall $s^+ \geq 0$.

2.2 Determine the DMU Using the Pareto Method

In determining the number of DMUs, processing is needed to decide how many DMUswill be studied. This process is carried out because the maintenance material as DMU has many types and functions. The data obtained from data retrieval is 524 maintenance material and this amount is too much to be processed by the DEA in this study. The number of DMUs needed is at least 3 times from the number of input and output variables (Yuli, 2009). In this study, it wasdetermined that the DMU was 20 percent of the material taken from the data set using the Pareto method. According to the Pareto principle every human being lives in 80/20 ratio. Although known as the 80/20 principle, the Pareto principle does not have to be 80:20 for every situation.In the computer section we can use the ratio 90:10, in the world of education we can use the ratio 75/25. The Pareto principle does not have to be applied 80:20 so that it fits 100% (Sunarto, 2020).

Table 1, shows the least amount of data before the Pareto process and it ranked from most to least problems in 2014 to middle 2020.

Table 1. Material Dataset

Part Number Material	Problem
F18T5CWRS:069X9	3560
SP21651B:K7548	3260
0L387BPGPL:S3774	3231
411N1281-4C:81205	2713
1003636-001ADR:92802	2531
2011-1-731-2845:35FB9	1194
F032CWBCAC:81205	1165
B42365-1:04577	1100
8GH005597-12: D8095	1087
85:08805	1059
5113WW:08806	1058
1002992-359ADR:92802	1035
898052:61423	1024

After being processed by the Pareto principle which takes 20% of the total problems, a Pareto chart is obtained from the DMU candidates to be studied. Figure 1 is a graph of the

Pareto results.

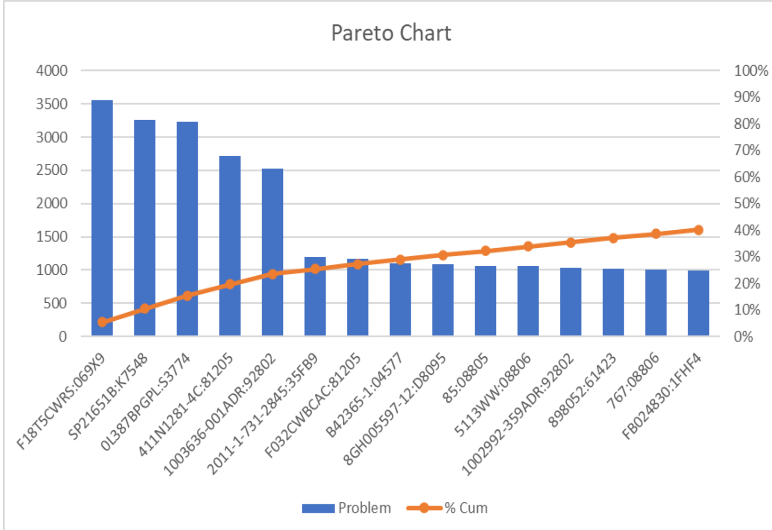

Figure 1. Pareto Chart of DMU

If 20 percent of the total is taken, it will cover the most 4 materials as DMU. To increase the number of DMU, researchers held a discussion or FGD (Forum Group Discussion with the Aircraft Maintenance Planning Engineer (AMPE) from the company to determine the maintenancematerials used in this study. From the process of determining the DMU, 16 DMUs were obtained from which the relative efficiency values were calculated to be evaluated. Table 2 shows the DMUthat will be examined in this study.

Table 2. DMU Research

DMU	Part Number	DESC	Problem Total
1	F18T5CWRS	LAMP	3560
2	SP21651B	BUTTON RECLINE	3260
3	0L387BPGPL	LAMP	3231
4	411N1281-4C	SHADE WINDOW	2713
5	F032CWBCAC	LAMP	1165
6	FB024830	LAMP	998
7	5500A1ABF23A	BOTTLE ASSY-OXY	924
8	4323070-00-66-26	OVEN	834
9	SP23997C27	CABLE - RECLINE, 27INCH	636
10	1004491-001CXW	FOODTRAY ESCUTCHEON ASSEMBLY	479
11	4360004-85-00-18	HEATER,WATER	477
12	D72D70211-111	SPRING HINGE, BIFOLD	338
13	HV17500-09	HYDROLOK - RECLINING	292
14	2D2023-7	SPRING, AMI DBL ATTD SEAT	220
15	4323100-00-66-22	OVEN	185
16	AC2600-00	CONTROL BEZEL ASSEMBLY	116

2.3 DMU Attribute Selection

Attributes or parameters will be selected to measure the relative of each DMU. Todetermine the attributes, FGD was conducted with the AMPE team and Purchaser team. From theFGD, the parameters that will be used as input variables are the number of material problems, price, material category (problem boundary resolved in days) or CAT, and stock material in store. As for the output are amount of material used and Urgent Material Request (UMR).

3. RESULTS AND DISCUSSION

3.1 DMU Interval Data

In this study, researchers had 6 years and a half (2014 to middle 2020) of DMU data and stochastic. According to Kao (2008) if the data is stochastic, then the average data of several yearscan be used to calculate the efficiency value. Table 3 shows the interval data with upper and lowerbound.

Table 3. Data DMU with Upper and Lower Bound

DMU	Problem		Price		Category		Stock		Material Used		AOG	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
DMU 1	197	822	4,45	5,5	10	10	0	1596	134	769	0	0
DMU 2	143	887	70,05	83,8	10	10	0	700	65	787	0	0
DMU 3	3	1281	2,27	3,54	3	3	0	7500	3	1281	0	0
DMU 4	23	663	226,98	405	120	120	0	1245	126	606	0	0
DMU 5	56	418	14,59	540	10	10	0	660	18	286	0	0
DMU 6	85	378	11,11	15,44	10	10	0	375	42	336	0	20
DMU 7	35	238	1247,98	1974	1	1	4	121	9	128	0	3
DMU 8	54	142	700,2	1809,39	120	120	29	181	10	135	0	0
DMU 9	7	371	30,68	112	10	10	0	784	5	367	0	0
DMU 10	9	129	28,4	95,2	10	10	0	200	4	128	0	0
DMU 11	18	140	369,06	717,29	120	120	4	130	18	138	0	11
DMU 12	0	123	561,53	752	10	10	0	109	0	70	0	4
DMU 13	13	67	126,3	189	10	10	2	88	11	63	0	10
DMU 14	6	88	84	129	3	3	0	130	6	78	0	1
DMU 15	13	40	804,92	2122,67	120	120	1	64	12	38	0	0
DMU 16	2	29	500	609	3	3	0	600	7	567	0	3

To get reliable data, we use distribution simulation to find average DMU parameters data. When there is no prior information about the distribution of the data, beta distributions have been found suitable for describing the characteristics of the data (Law, 2000). In standard betadistribution has domain [0,1], in this study the maximum value of parameters will be the upper bound and the minimum will be the lower bound. From this limitation we get betaparameters α_1 and α_2 to get the average value of the DMU parameter. From simulation with arena software, we get the beta parameter values shown in Table 4.

Table 4. The α_1 and α_2 Parameters

Material	Problem		Price		Stok		Material Used		AOG	
	α^1	α^2	α^1	α^2	α^1	α^2	α^1	α^2	α^1	α^2
DMU 1	0,555	0,558	1,02	0,859	0,202	0,304	0,335	0,397	-	-
DMU 2	0,598	0,781	0,492	0,67	0,946	0,599	0,784	0,786	-	-
DMU 3	0,065	0,116	1,89	1,23	0,211	0,406	0,064	0,129	-	-
DMU 4	0,284	0,214	0,306	0,295	0,308	0,317	0,358	0,338	-	-
DMU 5	0,295	0,671	0,143	0,192	0,139	0,214	0,455	0,633	-	-
DMU 6	0,044	0,18	0,542	0,656	0,349	0,677	0,25	0,621	0,319	0,764
DMU 7	0,356	0,389	0,263	0,292	0,509	0,541	0,196	0,264	0,825	2,09
DMU 8	0,636	0,387	0,364	0,65	0,658	0,511	0,245	0,215	-	-
DMU 9	0,177	0,243	0,094	0,084	0,14	0,219	0,178	0,243	-	-
DMU 10	0,296	0,302	0,452	0,247	0,213	0,352	0,296	0,303	-	-
DMU 11	0,223	0,245	0,301	0,433	0,345	0,388	0,215	0,246	0,367	0,987
DMU 12	0,403	0,624	0,452	0,247	0,251	0,392	0,348	0,371	0,72	1,7
DMU 13	0,653	0,604	0,358	0,299	0,53	0,623	0,639	0,614	0,135	0,459
DMU 14	0,441	0,65	0,144	0,238	0,237	0,564	0,273	0,377	2,75	5,45
DMU 15	0,522	0,528	0,228	0,356	0,184	0,144	0,596	0,814	-	-
DMU 16	0,494	0,424	0,803	0,801	0,146	0,224	0,141	0,222	0,703	1,13

The category parameter is not simulated because it has the same value every year, so the same value will be used for the category input parameter. Whereas in the AOG output parameter, some DMUs do not simulate because it has a parameter value of 0.

3.2 Monte Carlo Simulation.

To find the average value of the DMU parameters, we use a Monte-Carlo simulation. According to Kao (2008), use 2000 replications for a good estimation of efficiency from the DMUs. The simulation process uses Excel and generates the values of the input and output parameters.

Table 5 shows all the input and output parameters of the DMU. Then we use Lingo software to generate the efficiency from all DMUs.

3.3 Efficiency Value of the DMU

After getting the input and output parameter values, the process is continued by calculatingthe efficiency value. We do calculations through a program made on the Lingo. The result shown in Table 6.

Table 5. Monte-Carlo Simulation Result

NO	DMU	Problem	Price	Cat	Stock Material	Material Used	AOG
1	DMU 1	521	5,0191	10	655	418	0
2	DMU 2	468	75,927	10	427	429	0
3	DMU 3	460	3,0399	3	2771	426	0
4	DMU 4	391	318,9	120	603	376	0
5	DMU 5	167	234,79	10	257	128	0
6	DMU 6	140	13,086	10	126	127	6
7	DMU 7	132	1585,5	1	60	58	1
8	DMU 8	110	1116,9	120	115	77	0
9	DMU 9	163	72,561	10	318	155	0
10	DMU 10	69	71,133	10	77	66	0
11	DMU 11	76	515,58	120	63	73	3
12	DMU 12	49	684,69	10	43	33	1
13	DMU 13	40	159,95	10	42	38	2
14	DMU 14	39	100,39	3	37	37	0
15	DMU 15	26	1314,1	120	37	23	0
16	DMU 16	16	553,83	3	228	237	1

Table 6. Efficiency Value and Rank of DMU

DMU	Efficiency	Rank
DMU 1	1	1
DMU 2	1	2
DMU 3	1	3
DMU 4	0,8001489	12
DMU 5	0,5352108	16
DMU 6	1	4
DMU 7	1	5
DMU 8	0,6062539	14
DMU 9	0,8984728	10
DMU 10	0,8398932	11
DMU 11	1	6
DMU 12	0,741835	13
DMU 13	1	7
DMU 14	0,9580784	9
DMU 15	0,5621131	15
DMU 16	1	8

From the results obtained an efficient DMU and not. Inefficient DMUs need to be improved and based on theory, the improvement process uses the slack values. Slack value shown in table 7.

Table 7. Slack of DMU

DMU	slack_input .Problem	slack_input .Price	slack_input .Cat	slack_input .StockMate	slack_output .MaterialUs	slack_outpu t.AOG
DMU 1	0	0	0	0	0	0
DMU 2	0	0	0	0	0	0
DMU 3	0	0	0	0	0	0
DMU 4	0	0	74,3337548	0	0	12,59431998
DMU 5	0	0	0	0	0	2,709371608
DMU 6	0	0	0	0	0	0
DMU 7	0	0	0	0	0	0
DMU 8	18,649486	289,23479	0	0	0	1,947549606
DMU 9	0	0	0,02942827	0	0	5,193651711
DMU 10	1,20765775	0	0	0	0	2,442748842
DMU 11	0	0	0	0	0	0
DMU 12	13,1062674	451,548478	0	0	0	0
DMU 13	0	0	0	0	0	0
DMU 14	33,4311923	2,74800028	0	0	0	0,21050856
DMU 15	0	621,538257	45,2775883	0	0	0,591803117
DMU 16	0	0	0	0	0	0

But when the slack is processed at the DMU, the change in efficiency value does not increase significantly. Although there are changes in the input and output parameter values. We tried another way to improve the efficiency value using R-Studio. In R-Studio we can use DEAR packages to solve DEA cases.

The results of the DEA calculation have differences in the input and output parameters. There are several input parameters where the value is reduced to make the DMU efficient. Since the improvement value is obtained, we run again the program from Lingo so that all DMUs are efficient.

The most significant improvement is in DMU 5, initially it has an efficiency value of 0.5352 then increasing to 1. Improvements were made in almost all input parameters of DMU 5, each input was reduced by 87% and output on AOG had to be limited to only 2-3 times. DMU 12has decreased quite significantly, in the input price parameter a reduction must be made to 1115 percent to get the efficiency value to 1.

To see more clearly the changes that have occurred we summarize the results of changes in the DMU parameter value and can be seen in table 8. Table 8 also shows the results of improved efficiency.

The results in Table 8 can be rounded to get a non-decimal number to improve DMU parameters.

Table 8. DMU Improvement

DMU	Problem	Price	Cat	Stock Material	Material Used	AOG	Eff.
DMU 1	521	5,019057043	10	655	418	0	1
DMU 2	468	75,92709448	10	427	429	0	1
DMU 3	460	3,039855095	3	2771	426	0	1
DMU 4	312,858233	255,1699753	21,68411725	482,4898069	376	12,59431998	1
DMU 5	89,3802107	125,6645031	5,352108425	137,5491865	128	2,709371608	1
DMU 6	140	13,0860295	10	126	127	6	1
DMU 7	132	1585,5275	1	60	58	1	1
DMU 8	48,03844131	387,8881062	72,75046617	69,71919675	77	1,947549606	1
DMU 9	146,4510649	65,19416732	8,955299632	285,7143474	155	5,193651711	1
DMU 10	56,74497178	59,74389191	8,398931816	64,67177498	66	2,442748842	1
DMU 11	76	515,5808516	120	63	73	3	1
DMU 12	23,24364589	56,37484529	7,418349659	31,89890354	33	1	1
DMU 13	40	159,9505197	10	42	38	2	1
DMU 14	3,93386549	93,43327842	2,874235216	35,448901	37	0,21050856	1
DMU 15	14,61493996	117,1528874	22,17598081	20,79818379	23	0,591803117	1
DMU 16	16	553,8296511	3	228	237	1	1

Table 9. The Results of Improving DMU Parameters

DMU	Problem	Price	Cat	Stock Material	Material Used
DMU 1	0%	0%	0%	0%	0%
DMU 2	0%	0%	0%	0%	0%
DMU 3	0%	0%	0%	0%	0%
DMU 4	-25%	-25%	-453%	-25%	0%
DMU 5	-87%	-87%	-87%	-87%	0%
DMU 6	0%	0%	0%	0%	0%
DMU 7	0%	0%	0%	0%	0%
DMU 8	-129%	-188%	-65%	-65%	0%
DMU 9	-11%	-11%	-12%	-11%	0%
DMU 10	-22%	-19%	-19%	-19%	0%
DMU 11	0%	0%	0%	0%	0%
DMU 12	-111%	-1115%	-35%	-35%	0%
DMU 13	0%	0%	0%	0%	0%
DMU 14	-891%	-7%	-4%	-4%	0%
DMU 15	-78%	-1022%	-441%	-78%	0%
DMU 16	0%	0%	0%	0%	0%

4. CONCLUSION

Based on the result, it is found that the effective materials are DMU 1, DMU 2, DMU 3, DMU 6, DMU 7, DMU 11, DMU 13, and DMU 16. All these DMUs can be used as a reference for improving the efficiency value of other DMU. These results will serve as anevaluation of the company in the procurement process. The inefficient dmu needs to be evaluated from the inputand output parameters. Increasing the value of efficiency can be done from minimizing problematic materials by increasing preventive maintenance, reducing prices, evaluating the repair period, and controlling stock in the warehouse. From the output, it is also possible to prevent AOG ordering of materials to suit the needs of maintenance activities. Efficiency is a value that can change depending on the conditions of a DMU parameter. To convince the company about the efficiency value obtained, in this study a distribution simulation of the DMU parameters obtained was carried out. The simulation is expected to be able to represent the parameter value of a DMU that has stochastic data. Inefficient DMU values can be corrected, the result is that some input parameters from the DMU are reduced. The results of this improvement are shown in Table 9.

For AOG parameters, it is necessary to adjust the order to make the DMU efficient. Changes occur in DMU 4 with ranged values 12 orders, DMU 5 around 3 orders, DMU 8 around 2 orders, DMU 9 around 5 orders, DMU 10 around 2 orders.

5. REFERENCES

Anggraini, Rini. (2018). Manajemen Persediaan [Inventory Management]. *Mercu Buana University*.

Charnes, A., Cooper, W.W., Rhodes, E., 1978. Measuring the efficiency of decision making units. European Journal of Operational Research 2, 429–444.

Indrawati, Y. (2009). Analisis Efisiensi Bank Umum di Indonesia Periode 2004 – 2007: Aplikasi *Metode Data Envelopment Analysis* [Efficiency Analysis of Commercial Banks in Indonesia Period 2004-2007: Application of Data Envelopment Analysis Method]. Skripsi. UniversitasIndonesia.

Kao, C., 2006. Interval efficiency measures in data envelopment analysis with imprecise data. European Journal of Operational Research 174, 1087–1099.

Kao, C., 2008. Stochastic data envelopment analysis in measuring the efficiency of Taiwan commercial banks. European Journal of Operational Research 196, 312–322.

Law, A.M., Kelton, W.D., 2000. Simulation Modeling and Analysis, fourth ed. McGraw-Hill, New York.

Ramanathan, Ramakrishnan. (2004). ABC inventory classification with multiple-criteria using weighted linear optimization. Computers & Operations Research 33 (2006), 695– 700.

Sunarto., dan Santoso, Heru. (2020). Buku Saku Analisis Pareto [The Pareto Analysis Handbook]. Prodi Kebidanan Magetan Poltekkes Kemenkes Surabaya.

Tone, Kaoru. (2001). A Slack-based measure of efficiency in data envelopment analysis. EuropanJournal of Operational Research 130, 498-509.

THE HOQ APPROACH TO DESIGNING TRANSIT ORIENTED DEVELOPMENT (TOD) THAT REFLECT ON CUSTOMER ASPIRATIONS

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ABSTRACT

In line with the main problem of congestion faced in Indonesia, especially in the cities of Jakarta, Bogor, Depok, Tangerang and Bekasi, the implementation of the Jabodetabek LRT infrastructure work is one solution to overcome the congestion problem and opens up opportunities for implementation and implementation of regional development. with the concept of Transit Oriented Development (TOD) at the locations of LRT station points. For this reason, PT Adhi Commuter Properti plans to develop an area that is directly integrated with the LRT station. One of them is the development of an area with a TOD concept located at Jakarta's Cibubur station.

This study aims to evaluate the TOD-based area development plan that has been made. The research object is the integrated area of the Cibubur LRT station. The research begins by identifying the attributes of importance in the TOD-based area. These attributes are then weighted using HoQ and AHP. These attributes are used as the basis for evaluating the development plan and determining the improvements that must be made. In this research, it is hoped that they will be able to find out what strategies can be carried out in developing the area at the Cibubur LRT station.

The results of this research obtained the development of the TOD area with the concept of Mixed Use with 10 potential priorities in area development such as paying attention to convenience and integration facilities to LRT stations, suppressing HPP and maintaining selling prices, proper payment strategies by increasing cooperation with banks, conducting environmental market research and competitors with a radius of 5 km from the area and add additional facilities and enliven the community in the area to increase the attractiveness of the area.

Keywords: Cibubur, regional development, TOD concept, integrated station, HoQ method, AHP method.

1. INTRODUCTION

One of the problems that need to be resolved in Jakarta is congestion, referring to the 2014 survey released by the DKI Jakarta Provincial Statistics Agency, at least 1.38 million residents of Bogor, Depok, Tangerang and Bekasi come every day in Jakarta for work, school or other interests. other.

According to Ditlantas Polda Metro Jaya in 2015 the growth of vehicles in DKI Jakarta was 12% per year, while the increase in road length in DKI Jakarta Province was only 0.01% per year. The increasing density of the city of Jakarta can have a direct impact on decreasing quality of life due to reduced productive time due to traffic congestion, as well as air pollution which affects air quality. This condition raises other population problems, namely the lack of comfortable and quality housing.

This research helps certain parties in making the best decisions to achieve maximum results. So in this study, we can evaluate the previous development plan process to obtain weighting criteria from the data that has been obtained in various stages using the AnarchiHierarchy Process (AHP) and Quality Function Deployment (QFD) methods. The House ofQuality (HOQ) model is used to obtain product attributes that can maximize customer satisfaction.

2. RESEARCH STAGE

This study aims to identify attributes that are of importance to customers in selecting the TOD area so that it needs to be considered by the developer and evaluate the current development plan against the attributes that potential customers have identified and determine what improvements need to be made to increase the attractiveness of the area.

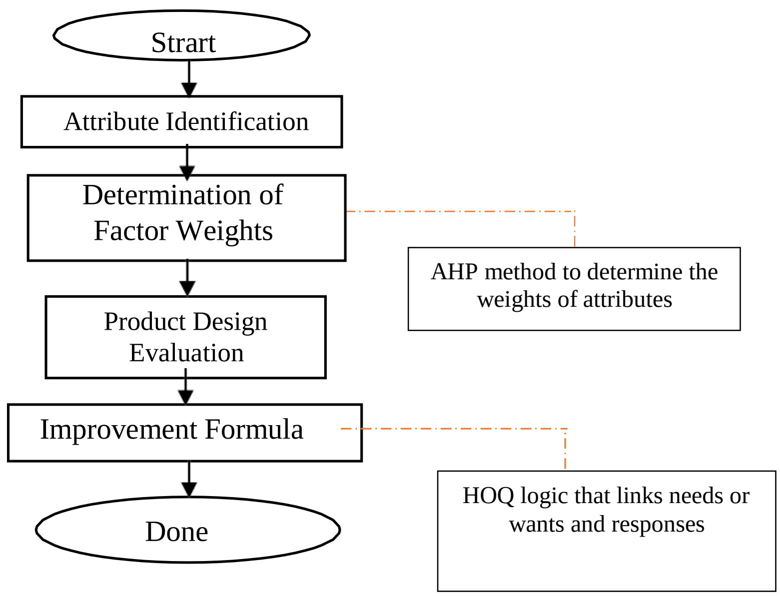


Figure 1. Research flowchart

3. DISCUSSION

3.1 Data Collection

In this study the data collected in the form of primary data obtained through interviews and also by distributing service attributes, obtained from questionnaires distributed to respondents. While the data relating to the preparation of technical responses, data on the level of organizational difficulties in process characteristics, targets, the correlation between service attributes and technical responses in the preparation of house of quality, were obtained from interviews with experts at companies or consultants as expert consultants. as an object of research as well as from the Business Model Canvas (BMC) document which is a description of the company's overall strategy.

3.2 Attribute Identificatiom

The questionnaire to be used in this study was made based on the dhelpi method in accordance with the method or description of theory and other research materials obtained from several sources including various experts or expert opinions. The questionnaire contains 15 questions consisting of 4 variables of service quality, namely facilities, area, price, method of payment. The 15 questions are divided into 2 things, namely 7 questions on consumer profile identification and 8 questions about service attributes which will later measure the four existing service quality variables. The attributes contained in this research questionnaire are as follows:

Table 1. Attribute

No	Category	Sub Category
1	Facility	Integrated LRT, Commercial, Sports facilities, Basement, Hospitals and Schools
2	Unit area	1 BR (30-40 m2), 2 BR (>40 m2), Studio BR (<30 m2)
3	Price	300-400 million, 400-500 million, 500-600 million, >600 million
4	How to Pay	Softcash (>4 tahun), Softcash (<4 bulan), KPA (10-15 tahun), Hardcash (tunai)

3.3 Determination of Number of Samples

In this study, determining the number of samples to be involved will be measured using a quota sampling technique. The quota sampling technique is a technique used to determine the number of samples that will be used by first determining how much the population will be studied, in this case the population is the same as the number of existing consumers, which the company has for an ecosystem that is a priority for development. To determine the minimum sample size to be used in the study, it will be calculated using the Solvin method. With the Slovin formula, the calculation is done by first determining the value of the total population of 100 consumers which is obtained from the production administration data in the work order and also the percentallowance for the sample error of 5%, then the following results are obtained:

From the calculations using the Slovin formula above, it is known that the minimum number of samples needed in this study is 23.

3.4 Validity Test

The validity test is shown to determine whether the questions contained in the questionnaire used in this study are in accordance with the concept or not. The validity test was carried out using SPSS software. If the SPSS (corrected item total correlation) output is positive, and the SPSS (corrected item total correlation) output is greater than the df value in table r, then the attribute is declared valid and if it is the opposite then the attribute is declared invalid.

The output value of the corrected item total correlation for all attributes is greater than the df value in r table 0.433. The value of 0.433 itself is obtained from df = 23-2 = 21 and with a value of percent allowance for sample error of 5% or 0.05, the value is 0.433. Because all attributes have a corrected item total correlation value of more than 0.433, so it is stated that all attributes contained in the questionnaire are considered valid.

3.5 Reliability Test

Reliability test is only conducted if all attributes in the questionnaire are considered valid in the validity test. The reliability test in this study was carried out using the Cronbach Alfamethod to all data obtained from the results of distributing questionnaires using the help of SPSS software. A research instrument has adequate reliability or is said to be reliable if the Cronbach alpha coefficient is greater or equal to 0.60 Zulganef, (2006).

Table 2. Reliability statistic

Cronbach Alpha	N of Items
0,671	10

3.6 Delphi Method Questionnaire Processing

This method is useful for structuring the group communication process so that the process will run effectively. This method is used when expert opinion is required but other factors such as time or distance make it difficult for panel experts to sit down together.

a. Problems are identified through a carefully crafted set of questions by group members who are asked to convey potential conclusions.
b. The first questionnaire contains 15 questions. The questionnaire was filled out by members separately and freely anonymously.
c. The results of the first questionnaire were collected, recorded and reproduced.
d. Each respondent was sent a copy of the questionnaire results
e. After reviewing the results, the respondents reconfirmed their conclusions. The new results moved the members to come up with new conclusions. Following are the conclusions of the questionnaire after feedback to 23 respondents

Table 3. The results of the questionnaire ranking

Reasons for choosing an apartment outside Jabodetabek	Rangking
Close to the previous residence	1
Affordable prices	2
Not jammed	3
Near the LRT station	4

Why buy a Cibubur apar tment, not in J akarta or West Bekasi?	Rangking
Integrated LRT station	1
Near the city center of Bekasi	2
Near where you live now	3
Near the toll gate	4

What pr ice are you inter ested in buying a studio type apar tment in the Cibubur area?	Rangking
300-400 million	1
400-500 million	2
500-600 million	3
>600 million	4

What were your considerations in choosing the pr ices above?	Rangking
Location, facilities and unit area	1
Income	2
Market price	3

What facilities do you need to buy an apar tment?	Rangking
Station integrated	1
Commersial Area	2
Sport Fasilities	3
Availability of parking basement	4
Near to hospitals and schools	5

How to pay do you choose to buy an apar tment?	Rangking
Soft Cash > 4 months	1
Soft Cash 4 months	2
KPA s/d 15 years	3
Hard Cash	4

3.7 Compilation of Analytical Hierarchy Process (AHP) from Attributes

1. Decomposition

Solve or divide a complete problem into its elements into a hierarchical form of the decision-making process, where each element or element is interrelated. First level: Goal decision (Goal), second level: criteria, and third level: Alternatives

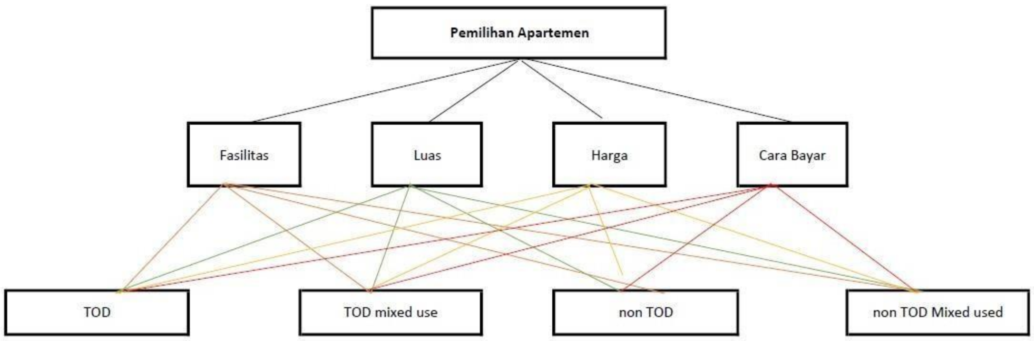


Figure 2. Structure Hierarchy AHP

Then, the pairwise comparison stage begins to determine the criteria weights. For the assessment using the 1-9 Saaty Comparison Scale as shown in the following table.

Table 5. Pairwise comparison with the Saaty scale

	Facility	Unit area	Prace	How to Pay
Facility	1	7	5	9
Unit area	1/7	1	1/3	3
Price	1/5	3	1	5
How to Pay	1/9	1/3	1/5	1

2. Comparative Judment

Comparative Judgment is at the core of using AHP because it will affect the priority order of its elements. The results of the assessment will be shown in the form of a pairwise comparisons matrix, namely the pairwise comparison matrix containing the preference levels of several alternatives for each criterion.

Table 6. Priority vector calculation matrix

1	7	5	9
1/7	1	1/3	3
1/5	3	1	5
1/9	1/3	1/5	1

Matrix

0,69	0,62	0,77	0,5
0,10	0,09	0,05	0,17
0,14	0,26	0,15	0,28
0,08	0,03	0,03	0,06

Normalization

0,64
0,10
0,21
0,05

Priority Vector

Table 7. Attribute weights

Attribute	Priority vector
Facility	64%
Unit area	10%
Price	21%
How to pay	5%

3. Synthesis of priority

Synthesis of Priority is carried out using the eigenvector method to obtain relative weights for decision-making elements.

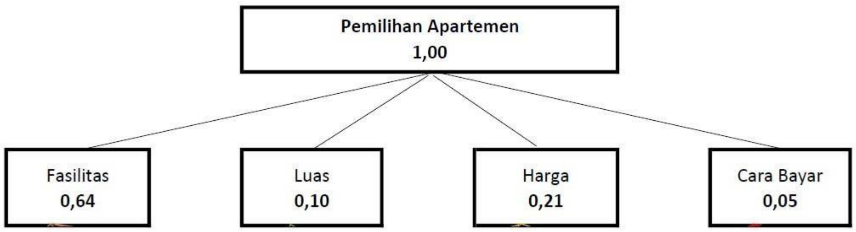


Figure 3. Attribute weights in the AHP hierarchy structure

Table 8. Comparison of alternative weight for Facility criteria

Facility	TOD	TOD Mixed Use	non TOD	Non TOD Mixed Use
TOD	1	1/5	1	1/5
TOD Mixed Use	5	1	7	3
Non TOD	1	1/7	1	1/5
Non TOD Mixed Use	5	1/3	5	1

Table 9. Priority vector calculation matrix (Facility)

1	7	5	9
1/7	1	1/3	3
1/5	3	1	5
1/9	1/3	1/5	1

Matrik

0,69	0,62	0,77	0,5
0,10	0,09	0,05	0,17
0,14	0,26	0,15	0,28
0,08	0,03	0,03	0,06

Normalisasi

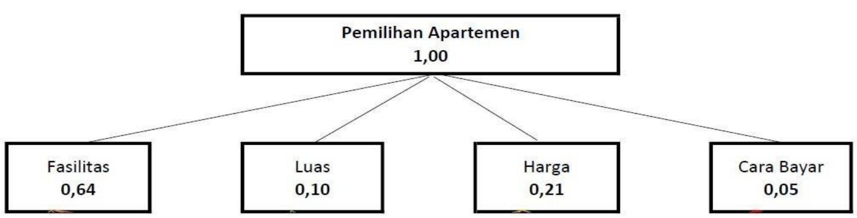
0,64
0,10
0,21
0,05

Priority Vector

In the same way it is done for the other attributes (Unit area, Price dan how to pay).

4. Comparative Judment

Alternate set by multiplying the priority weight by the attribute weight



TOD	0,08	TOD	0,15	TOD	0,15	TOD	0,25
TOD Mixeduse	0,55	TODMixed use	0,44	TOD Mixeduse	0,07	TOD Mixeduse	0,10
Non TOD	0,07	Non TOD	0,15	Non TOD	0,53	Non TOD	0,50
Non TOD Mixed use	0,30	Non TOD Mixed use	0,27	Non TODMixed use	0,25	Non TODMixed use	0,15

Figure 4. Logical consistency on hierarchy AHP structure

Multiplication of the matrix between priority weights and attribute weights.

Table 10. Matrix logical consistency

	Facility	Unit	Price	How to pay		Attribute Weigth		
TOD	0,08	0,15	0,15	0,25		0,64		0,11
TOD Mixed Use	0,55	0,44	0,07	0,10	x	0,10	=	0,42
Non TOD	0,07	0,15	0,53	0,50		0,21		0,19
Non TOD Mixed Use	0,30	0,27	0,25	0,15		0,05		0,28

TOD = 11% (Rangking 4)
TOD Mixed Use = 42% (Rangking 1)
Non TOD = 19% (Rangking 3)
Non TOD Mixed Use = 28% (Rangking 2)

3.8 Compilation of Quality Function Deployment (QFD)

In this study, the preparation of a quality function deployment is needed in order to develop pre-existing services so that in the future the service can be better than what was before.

A. Making a Consumer Information Matrix

1. Determination Attributes of Customer Requirements

This step is taken to identify and identify the needs and desires of each consumer for the services provided by the company. The method of determining the attributes of consumers' desires that is done here is by using the attributes of each service resulting from the Delphi method. The input attributes, among others.

a. The reason for choosing an apartment is that it is close to the previous residence
b. The reason for choosing the Cububur apartment is the integrated LRT station
c. The desired apartment facility is an integrated station and commercial area
d. The unit of the desired apartment area yaitun 1 BR (30-40 m2)
e. The desired price is 300-400 million
f. How to pay soft cash (installments in stages> 4 years)

2. Determination of Level of Importance

The level of importance or level of importance is the part that shows how important an existing service attribute is for consumers. Determination of the level of importance or level of importance is based on the high expectations or expectations of consumers with consumers' perceptions of company performance that have been felt by consumers in accordance with the focus of this research objective which is to reduce gaps.

Table 11. Assess the importance level of each service attribute

No	Question	SP	P	TP	STP	IR
1	The reason for choosing an apartment is that it is close to the previous residence	8	2	0	0	6,6
2	The reason for choosing the Cububur apartment is the integrated LRT station	6	4	0	0	6,2
3	Facility apartemen yang diinginkan adalah terintegrasi stasiun dan komersial area	0	10	0	0	5
4	The unit of the desired apartment area yaitun 1 BR (30-40 m2)	8	2	0	0	6,6
5	The desired price is 300-400 million	2	8	0	0	5,4
6	How to pay soft cash (installments in stages> 4 years)	2	6	2	0	5

3. Determine Level of Satisfaction

Table 12. Determination of Satisfaction Level

No	Question	SP	P	TP	STP	IR
1	The reason for choosing an apartment is that it is close to the previous residence	8	2	0	0	4,6
2	The reason for choosing the Cububur apartment is the integrated LRT station	6	4	0	0	3,8
3	The desired apartment facility is an integrated station and commercial area	0	10	0	0	4,6
4	The unit of the desired apartment area yaitun 1 BR (30-40 m2)	8	2	0	0	3,4
5	The desired price is 300-400 million	2	8	0	0	5
6	How to pay soft cash (installments in stages> 4 years)	2	6	2	0	4,2

4. Bencmarking Competitor

Table 13. Value the level of satisfaction of each service attribute

No	Question	ACP	PP Properti	WIKA Realty	Waskita realty
1	The reason for choosing an apartment is that it is close to the previous residence	4,6	6,2	5	5
2	The reason for choosing the Cububur apartment is the integrated LRT station	3,8	5	5	5
3	The desired apartment facility is an integrated station and commercial area	4,6	5,8	5	5
4	The unit of the desired apartment area yaitun 1 BR (30-40 m2)	3,4	5	4	3
5	The desired price is 300-400 million	5	4,6	4	3
6	How to pay soft cash (installments in stages> 4 years)	4,2	5	5	5

5.Setting Goals

The goal value (goal) is the value to be achieved by the company in improving anyexisting service attributes (determined by management). This objective value is the same as the scale used in the assessment of the questionnaire, namely the weighting of the rating scale 1-7, 1 for very unsatisfactory information and 7 for very satisfying information

Table 14. The value of the company's internal goals

No	Question	ACP
1	The reason for choosing an apartment is that it is close to the previous residence	6,2
2	The reason for choosing the Cububur apartment is the integrated LRT station	5
3	The desired apartment facility is an integrated station and commercial area	5,8
4	The unit of the desired apartment area yaitun 1 BR (30-40 m2)	5
5	The desired price is 300-400 million	6
6	How to pay soft cash (installments in stages> 4 years)	5,6

6.Calculation of Improvement Ratio

The calculation of the improvement ratio value in this study was carried out using a formula.

Table 15. Nilai improvement ratio

No	Question	Eksisting	Goal	Improvement Ratio
1	The reason for choosing an apartment is that it is close to the previous residence	4,6	6,2	1,35
2	The reason for choosing the Cububur apartment is the integrated LRT station	3,8	5	1,32
3	The desired apartment facility is an integrated station and commercial area	4,6	5,8	1,26
4	The unit of the desired apartment area yaitun 1 BR (30-40 m2)	3,4	5	1,47
5	The desired price is 300-400 million	5	6	1,2
6	How to pay soft cash (installments in stages> 4 years)	4,2	5,6	1,33

7. Menentukan Row Weight dan Normalized Row Weight

The determination of RW and NRW values can later be used as a consideration to determine the priority scale of each service attribute. This is because the priority scale of the calculation of RW and NRW values is also influenced by values such as sales points and also improvement ratios, both of which have been considered by the company management

Table 16. RW and NRW

No	Question	RW	NRW	Prioritas
1	The reason for choosing an apartment is that it is close to the previous residence	8,90	0,20	2
2	The reason for choosing the Cububur apartment is the integrated LRT station	8,16	0,19	3
3	The desired apartment facility is an integrated station and commercial area(mall, minimarket, café dll)	9,71	0,22	1
4	The unit of the desired apartment area yaitun 1 BR (30-40 m2)	6,30	0,14	4
5	The desired price is 300-400 million	4,97	0,11	6
6	How to pay soft cash (installments in stages> 4 years)	5,95	0,13	5

Based on the row weight and normalized row weight tables above, we can find out what service attributes are eligible to be selected and become the top priority for service improvement

B.Making Technical Information Matrix

1.Determine Technical Response

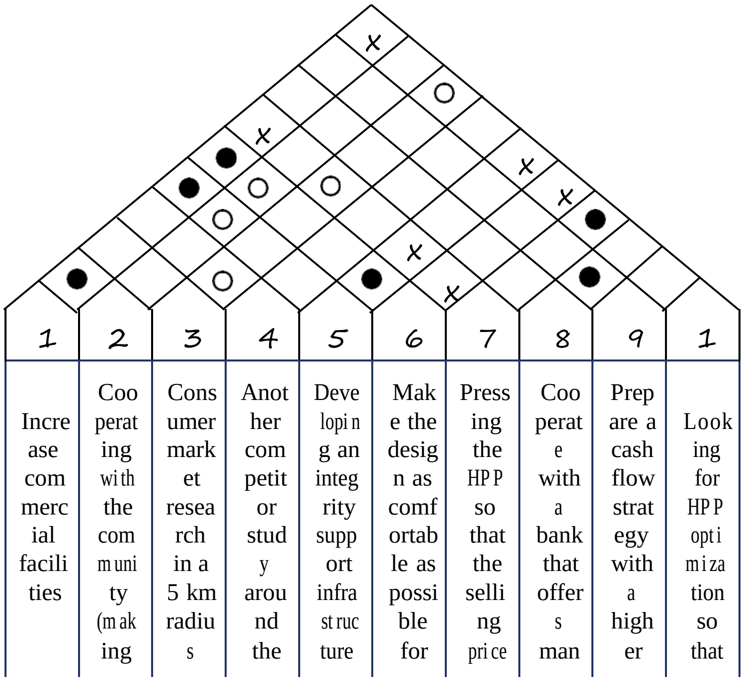
Technical response is an effort made by a company to improve the product quality of each service attribute that is then developed to meet the expectations of each consumer.

1) The desired apartment facility is an integrated station and commercial area
   -Increase commercial facility facilities
   -Enabling communities in the area
2) The reason for choosing an apartment is that it is close to the previous residence
   -Conducting market research in the area of the area to be developed (radius 5km)
   -Looking at other competitors around the area development location
3) The reason for choosing the Cububur apartment is the integrated LRT station
   -Developing integrity support infrastructure to the station (connecting roads etc.)
   -Make the design as comfortable as possible for the integration of the Area to the station
4) The desired apartment area unit is 1 BR (30-40 m2)
   -In line with Price, pressing COGS so that selling price can go down
5) How to pay soft cash (installments in stages> 4 years)
   -Cooperate with a bank that offers many benefits
   -Setting up a cashflow plan strategy with enlarged softcash payers> 4 years
6) The desired price is 300-400 million
   -In line with Unit area, looking for optimization so that Price 300-400 gets 1 BR units

2. Determine Technical Response

After determining the technical response or technical response of the company in an effort to improve the quality of service that exists today. The next step is to determine or create a correlation matrix.

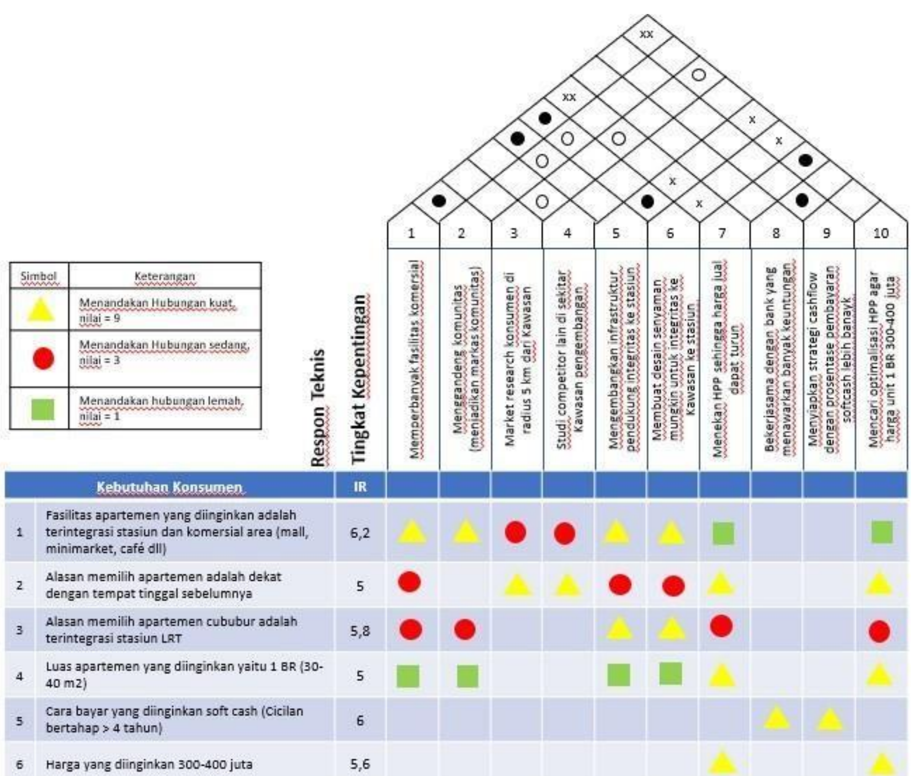
Table 17. Correlation matrix



Symbol	Definition
•	Very Strong Positive Influence
○	Positive Influence Is Strong
(Blank)	No Effect
x	The Negative Influence Is Strong enough
xx	The Negative Influence Is Very Strong

3. Determine Relationship Matrix

Table 19. Relationship matrix



4.Calculation of Technical Aspect Weight Value

The calculation of the weight value for technical aspects is a calculation carried out to find out which technical aspects are considered the most influential or important and need to be a priority by the company in an effort to improve the quality of existing services today. The weight value from the technical aspect can be divided into two types, namely the weight value of absoluteimportance and one more, namely relative importance. The value of absolute importance is a valuethat can indicate a technical aspect whether it is really needed in an effort to improve a service attribute or not. Meanwhile, relative importance is the number in the form of cumulative percent. As for finding these two values, the following formula can be used.

Table 20. Technical aspect matrix

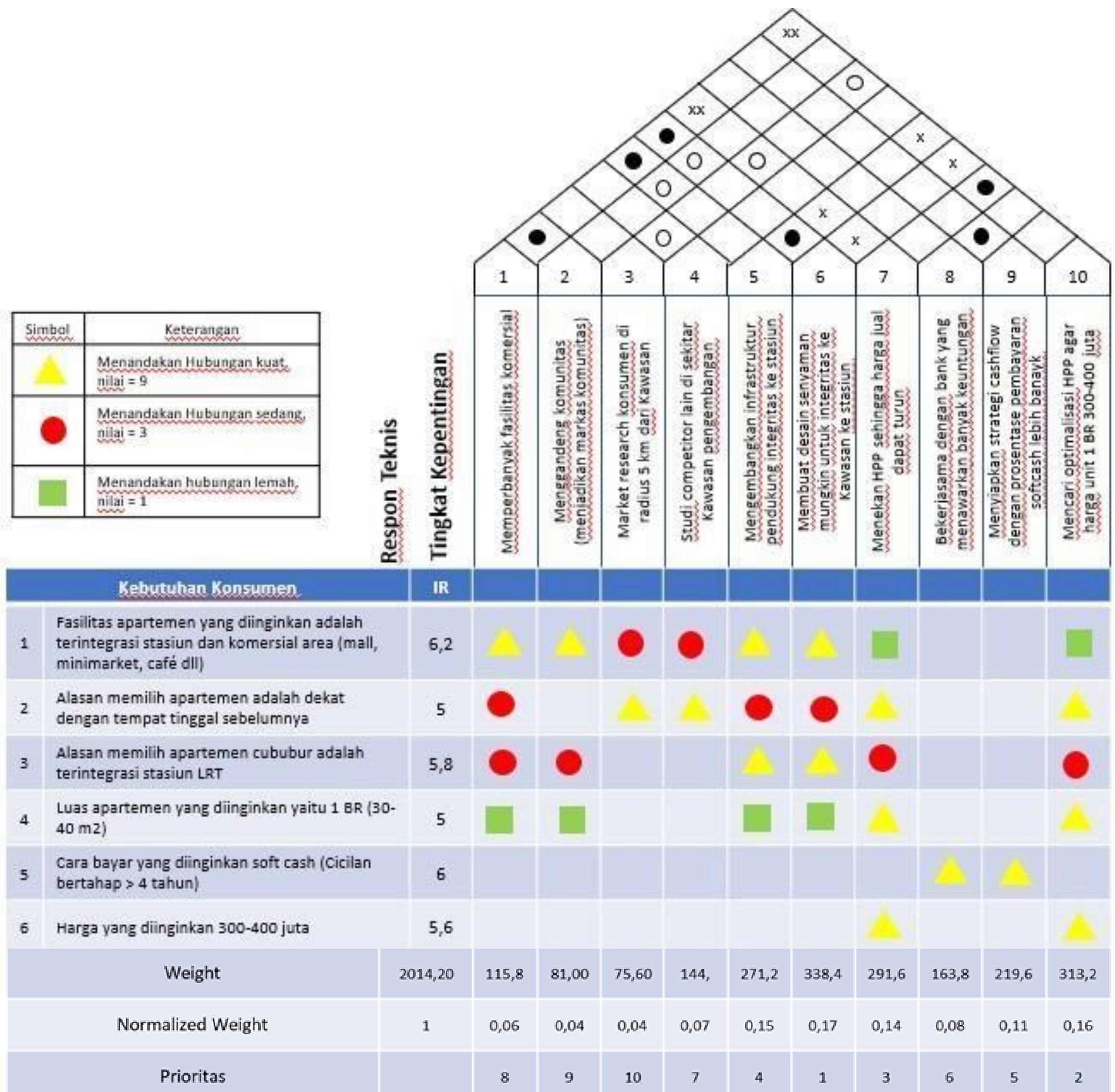


Table 20. Technical aspect weight value

No	Technical Response	IW	AIW	Priority
1	Increase commercial facilities	115,80	0,06	8
2	Enabling communities in the region	81,00	0,04	9
3	Conducting market research in the area to be developed (radius 5km)	75,60	0,04	10
4	Looking at other competitors around the area development location	144,00	0,07	7
5	Developing an integrity support infrastructure to the station	271,20	0,13	4
6	Make the design as comfortable as possible for the integration of the Area to the station	338,40	0,17	1
7	Pressing the HPP so that the selling price can go down	291,60	0,14	3
8	Cooperate with a bank that offers many benefits	163,80	0,08	6
9	Prepare a cash flow plan strategy with an enlarged percentage of soft cash payers> 4 years	219,60	0,11	5
10	Looking for optimization so that Price 300-400 gets 1 BR units	313,20	0,16	2

Based on the calculation of the weight value for the technical aspects which includes the calculation of the value of absolute importance and also the calculation of the value of relative importance, it is known that there are at least several technical aspects that deserve priority and priority in the effort to improve and improve the quality of existing features and services.

4. CONCLUSION

It can be concluded that the results of the **Analitycal Hierarchy Process (AHP)** method based on 4 attributes (Facility, Unit area, Price and how to pay) resulted in the priority of Area development with the first order of **TOD with the concept of Mixed Use**.

Based on the QFD analysis using the House of Quality, there are several technical aspects that deserve to be prioritized and prioritized in efforts to improve and improve the quality of existing features and services in order of priority, namely (1). Make the design as comfortable as possible for the integration of the area to the station, (2). Looking for optimization so that the priceof 300-400 gets the unit, (3). Pressing HPP so that the selling price can be optimized and adjusted to a price that is relatively acceptable and absorbed by the market, (4). Developing the integrity support infrastructure to the station (connecting roads etc.), (5). Prepare a cash flow plan strategy with an enlarged percentage of soft cash payers> 4 years.

5. REFERENCES

Akao, Y. (1990). *QFD Integrating costumer requiremens into product design*. USA: Productivity Press.

Apriani, N., Ukkas, M.I. dan Yusnita, A. (2012). *Sistem Pendukung Keputusan Pemilihan Perumahan di Samarinda Menggunakan Metode AHP Berbasis Web*

Bolleter, dan Ramalho C.E (2020). *Transit-Oriented Development (TOD) and Its Problems. Greenspace-Oriented Development*: 13-39.

Calthorpe, P. (1993). Transit-Oriented Development Design Guidelines, Calthorpe Associate

Carlton, I. (2009). *Histories of Transit-Oriented Development: Perspective on the Development of the TOD Concept.*

Cervero, R. (2004). Transit-Oriented Development in The United States: Experiences, Challanges, and Prospects. TCRP Report 102. Washington: Transportation Research Board.

Cervero, R. (2006). *Public Transport and Suistainable Urbanism* : Global Lessons.

Childers, D.L. (2014). Advancing urban sustainability theory and action: Challenges and opportunities. *Landscape and Urban Planning,* 125.

Cohen, L. (1995), *Quality Function Deployment: How To Make QFD Work For You*, Addison-Wesley Publishing Company.

Nugeraha, D. (2017). *Sistem Penunjang Keputusan*. Yogyakarta : Garudhawaca.

Djati, S. (2003). *Pengertian quality function deployment*. Retrieved Februari 03, 2003, from http://www.wordpress.com.

Foley, R.C. dkk. 1972. *Dairy Cattle Principles, Practices, Problems, Profits*. LEA & Febiger. Philadelphia

Harold, A. L. (1975). *The Delphi Method: Techniques and Applications*. Mass: Adison-Wesley.

Hasibuan, H.S., Soemardi, T.P., Koestoer, R. dan Moersidik, S. (2014). *The Role of Transit Oriented Development in constructing urban environment sustainability, the case of Jabodetabek, Indonesia*.

Indradjati, P.N. (2019). Konsep dan Prinsip Pengembangan Kawasan Berorientasi Transit/Transit Oriented Development: *Buletin Penataan Ruang*, 21-26.

Javadiana, M., Shamskooshkia, H. dan Momeni, M. (2011). *Application of sustainable urban development in environmental suitability analysis of educational land use by using AHP and GIS in Tehran.*

Jayanti, T.B. (2017). *Kajian Eksisting Kawasan Stasiun Manggarai terhadap Rencana Penataan Kawasan Berbasis TOD*, Temu Ilmiah Ikatan Peneliti Lingkungan Binaan Indonesia 6.

Joshi, R,. Joseph Y., Patel K. and Darji V. (2017). *Transit-Oriented Development* : Lessons from International Experiences.

Kenworthy, J and Newman, P. (1999) *Sustainability and Cities*: Overcoming Automobile Dependence. Island Press. Washington, D.C.

Knowles, R.D. (2019). I*ntroduction to transit Oriented Development and Suistainable Cities: Economics, Community and Methods*. Transit Oriented Development and Suistainablecities: 1–10.

Knowles, R.D. and Ferbrache, F. (2019). *Transit Oriented Development and Sustainable Cities*. Edward Elgar Publishing.

Mansoer, H.H. (1989). *Pengantar Manajemen Pendidikan*. Jakarta : Proyek Pengembangan Lembaga Pendidikan Tenaga Kependidikan.

Muwahidin, N.H. dan Muta'ali, L. (2019). *Strategi Pengembangan Kawasan Transit Oriented Development (TOD) di Kota Bekasi*.

Petkar, A.S and Hamand, S.S (2015). *Transit Oriented Development*, April.

Pirrone, C. (2014). Sustainable development of territories: The freedom approach and its consequences for attractiveness policies. *Geographie Economie Societe*, 16(3):275-296.

Pradana, F. (2012). *Penggunaan Metode AHP dalam kajian strategi Transportation Demand Management (TDM)*.

Sirait, J.H.M. (2020).*Konsep Pengembangan Kawasan Kota. Jurnal Perencanaan & Pengembangan Wilayah*, Vol.4 No.3. Wahana Hijau.

Stupishin, L.U. (2014). The Use of the Investment Potential for Planning Suistainable Cities. Advanced Materials Research. *Trans Tech Publication*. 919-921, pp 1582-1585.

Sun, Y., Gladstone, L. and Taplin, J.H. (2016). *Hype or hope*: Boomtown and Beyond.

Taylor, B.W. 2014. *Introduction to Management Science*, Sains Manajemen. Jakarta: Salemba Empat.

ANALYSIS OF CUSTOMER RELATIONSHIP MANAGEMENT PROCESS THROUGH BUSINESS PROCESS MANAGEMENT AND PROCESS MINING (CASE STUDY : TREASURE DATA PROJECT OF AUTO2000 HEAD OFFICE)

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ABSTRACT

As a real concrete step to improve sales performance, Auto2000 has carried out various marketing activities. Not only focusing on attracting new customers, Auto2000 also has a project to optimize customer database especially from resigned salespeople called Treasure Data. However, based on the result evaluation conducted by Marketing Division of Auto2000 Head Office in the period of January-November 2020, the conversion rate of repeat orders generated from Treasure Data project was only 0,02%, this number creates a fairly high gap with the Key Performance Indicator (KPI) which should be 5%.

This research is focusing on the analysis to the flow process of Treasure Data utilization on Auto2000's website-based internal mobile phone application called Sales Activity Management (SAM) through the theoretical approach of Business Process Management (BPM) and process mining with case study methodology and quantitative analysis. The process begins with the collection of event log data for each Treasure Data activity on SAM which then becomes input for process mining in Process Diamond.

The purpose of this analysis is to see the patterns that most salespeople do when utilizing Treasure Data on SAM and whether there are deviations or potentials to improve the process so the Key Performance Indicator (KPI) of repeat orders can be achieved. At the end of the research, this analysis is expected to provide a positive insight for Auto2000 to re-engineer the process in order to generate maximum repeat orders through Treasure Data.

Keywords: Treasure Data, Business Process Management, Process Mining.

1. INTRODUCTION

One of the senior players in the automotive industry that is well known, especially by the people of Indonesia, is Auto2000. Stated on the company's official website, the company with the full name PT. Astra International Tbk. - Toyota Sales Operation is a sales service network, maintenance, repair, and supply of Toyota spare parts with management that has been fully handled by PT. Astra International Tbk. Currently Auto2000 is the largest Toyota retailer in the world with 126 branches spread across almost all of Indonesia.

Beside focusing on generating sales through efforts to attract new customers, Auto2000 also has a project to optimize their current customer database, especially customer database from resigned salespeople. The project is called Treasure Data, which is a customer database utilization process that is owned by Auto2000 but it is not well maintained because the salesperson who used to handle these customers has resigned. Without this project, Auto2000 could potentially lose revenue through repeat orders from these customers.

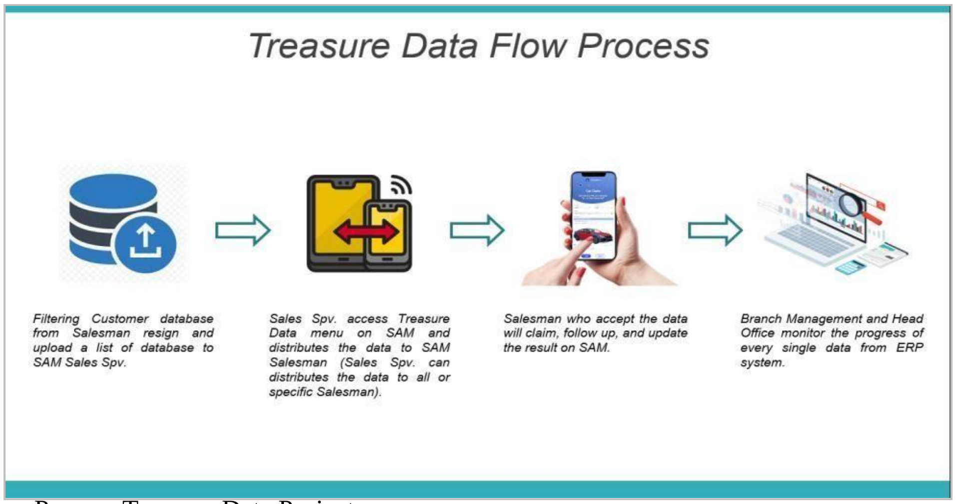


Figure 1.1 Flow Process Treasure Data Project
Source : PT. Astra International Tbk. – Toyota Sales Operation (2020)

Figure 1.1 shows the flow of Treasure Data utilization process on SAM. The process begins with automatic filtering by system for customer data that has no relationship with the existing salesperson. These data will be uploaded to SAM sales supervisor regularly. Sales supervisor who receives the data will get a notification on SAM to open the "Treasure Data" menu and see in detail the history of each data such as who was the last salesperson who handled the customer, the last unit purchased, etc. The reason why the data is not uploaded directly to SAM salesperson is because the sales supervisor is considered to have more authority to assess which salespeople are eligible to receive the data.

Furthermore, sales supervisor must distribute Treasure Data to active salesperson. Sales supervisor can choose whether to distribute to all salesperson under his team or specific to one particular salesperson. If the sales supervisor chooses to distribute data to more than one salesperson, then the mechanism is first come first serve. The salesperson who is the fastest to claim the data will automatically make the data disappear from other SAM salesperson. This process aims to ensure that the follow-up activity will only be carried out by one salesperson only so that it does not disturb the customers.

Salesperson who receives data will get a notification on SAM and must immediately claim, follow up, and update the results in the "result status" section on SAM. Basically, the results will be divided into two, which is "deal" or "drop". However, before reaching that point, there will be a journey of follow up activity for each customer data. All results for each data entered by the salesperson in the "result status" menu on SAM can be monitored in detail by Auto2000 Head Office and Branch Management (Branch Head & Sales Supervisors) through an internal ERP system called the Toyota Dealership Management System (TDMS).

Based on result evaluation carried out of Treasure Data project during January-December 2020 carried out by Marketing Division Auto2000 Head Office, approximately 91,000 data were uploaded to SAM to be utilized by the salesperson. From all of these data, repeat order generated were only 255 or about 0.02%. If you look at the conversion rate, there is a fairly high gap with the Key Performance Indicator (KPI) of this project which is a 5%. Departing from this problem, it is necessary to carry out further analysis to find the root cause of the problem and suggestions for improvement so that the KPI of Treasure Data project can be achieved in the future.

2. METHOD

This study focuses on the analysis of the flow process of using Treasure Data on SAM with the aim of generating repurchase or repeat order. The purpose of this analysis is to see how the patterns that most salespeople do when utilizing Treasure Data on SAM and whether there are deviations or the potential to improve the process so that the KPI of repeat order can be fulfilled. This research using Business Process Management (BPM) theoretical approach and process mining with a case study methodology and quantitative analysis.

Rosing (2015) provides a definition of BPM as a discipline that involves a combination of modeling, automation, implementation, control, measurement, and optimization of business activity flows in an appropriate combination to support company goals, encompass organizational & system boundaries, and involve employees, customers and partners inside and outside the company. On the other hand, Van Der (2011) defines process mining as a set of techniques in the field of process management that support business process analysis based on event logs. The event log itself is a process of recording history in the form of transactions or audit trail on an information system tool as evidence of an ongoing transaction.

During process mining, special algorithms are applied to the event log data to identify trends, patterns, and details contained in the event logs recorded by the system. Process mining aims to increase efficiency and process understanding. The term process mining also refers not only to techniques for finding process models, but also business process suitability and performance analysis based on event logs.

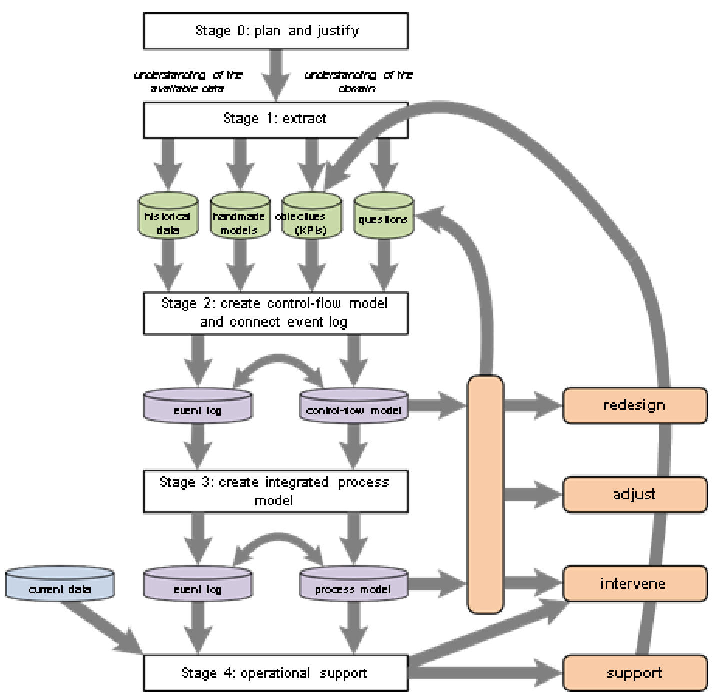


Figure 2.1 Process Mining Manifesto Source : Wil van der Aalst (2011)

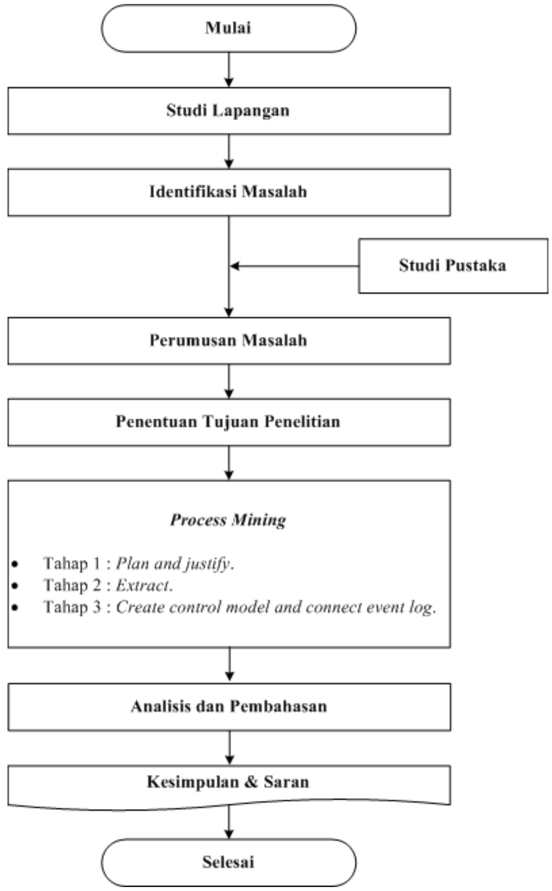
In order to analyze with the process mining approach, the author will collect event log data for each Treasure Data activity, starting from being uploaded to SAM sales supervisor, distributed to SAM salespeople, claiming and being followed up by the salesperson, to the final drop/deal result. This event log will be the initial data as input for processing on ProcessDiamond application. Process Diamond itself is a business process analytics platform for process mining with the aim of encouraging digital transformation and creating operational excellence

Various benefits can be obtained from process mining, such as knowing how a process is running, whether the process is in accordance with the designed model, or knowing at what stage a process is slowing down. In addition, process mining is also able to predict the number of delays and design more appropriate model to solve problems.

This study using process mining approach to analyze the salesperson's flow process in utilizing Treasure Data feature on SAM. Aalst (2011) introduces a process mining manifesto in the form of a five stages L lifecycle model as shown in **Figure 2.1** where this research refers to three of the five stages in carrying out process mining. The three stages of process mining that will be carried out in this study are as follows:

- **Stage 1 : Plan and justify.**
  In this stage, the research is focused on the customer database utilization of resigned salespeople on SAM (Treasure Data project). First, it will be determined what questions will be answered from the process mining that will be carried out. In this study, process mining was carried out on the basis of questions about "how is the flow process of sales supervisors and salespeople in utilizing Treasure Data on SAM?" The resulting answer will be the basis for analyzing the root cause of the problem and producing suggestions for improvement through Business Process Management approach to Treasure Data Project so the KPI achievement of repeat orders can be better.
- **Stage 2 : Extract.**
  In this stage, a field study is carried out to find out the big picture of Treasure Data process as a whole. In addition, data collection is also carried out such as project KPI and event logs from each Treasure Data utilization activity on SAM. The event log data starts from when Treasure Data is uploaded to SAM sales supervisor, distributed to SAMsalesmen, claimed and followed up by the salesperson, until the final drop/deal results.
- **Stage 3 : Create control flow model and connect event log.**
  The last stage is to build a model of the event log data that has been collected and to analyze normal and deviant paths in Treasure Data utilization process by salespeople on SAM. This analysis involves the lead time variable because there is timestamp data for each Treasure Data utilization activity recorded in the event log data. The results of this process mining will be the basis for analyzing the root cause of the problem and generating ideas for improvements to Treasure Data project so that KPI of repeat orders can be achieved.

This research is included in case study research. As a case study, the data collected comes from various sources and the results of the study only apply to the cases investigated. Furthermore, Arikunto (1986) argues that this method is carried out intensively, in detail, and in depth on a particular object. In this study, the object that is observed in depth is Treasure Data project in Marketing Division Auto2000 Head Office. The following is a flow chart of the research process :



3. EXPECTED RESULT & DISCUSSION

The results of process mining will be the basis for further analysis to find the root cause of the problem and create improvement ideas through Business Process Management approach using Kaizen Methodology and involving experts in related functions in Auto2000 to get valid and comprehensive solution with the final result in the form of a Kaizen Plan for Treasure Data project. The following is the analysis stages:

a. Root cause analysis

The root cause analysis was carried out using why-why diagram method. The why-why diagram itself is a tree diagram to find the cause or internal potential improvement from a problem by asking "why" on each of the causal factors until it cannot be answered anymore. The final result of each "why" question that can be answered is defined as the root cause of the problem for which then to find a needed solution.

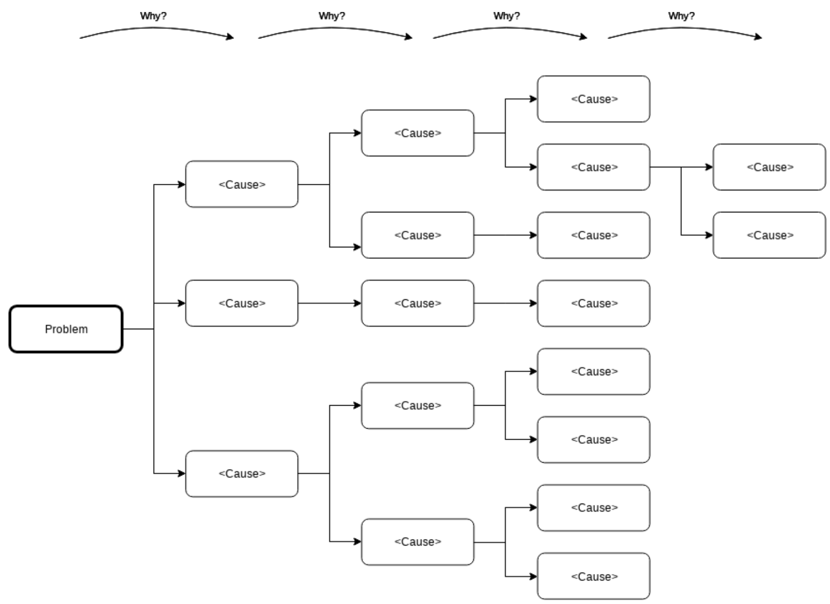


Figure 3.1 *Why-Why Diagram*
Source : *Visual Paradigm Online* (2021)

b. Countermeasure analysis

After finding several root cause of problem, the next process is to find a countermeasure or solution to each of these root cause through discussions with the Department Head and Division Head of related functions to produce appropriate and comprehensive solutions.

The solutions will then be mapped using cost benefit diagram in order to know which solution provides the greatest positive benefit with the least development costs. Themapping process is carried out based on discussion with the functions involved in it. For example, if the solution is system development, then the IT team will be involved to provide information about the estimated effort and cost of developing the system.

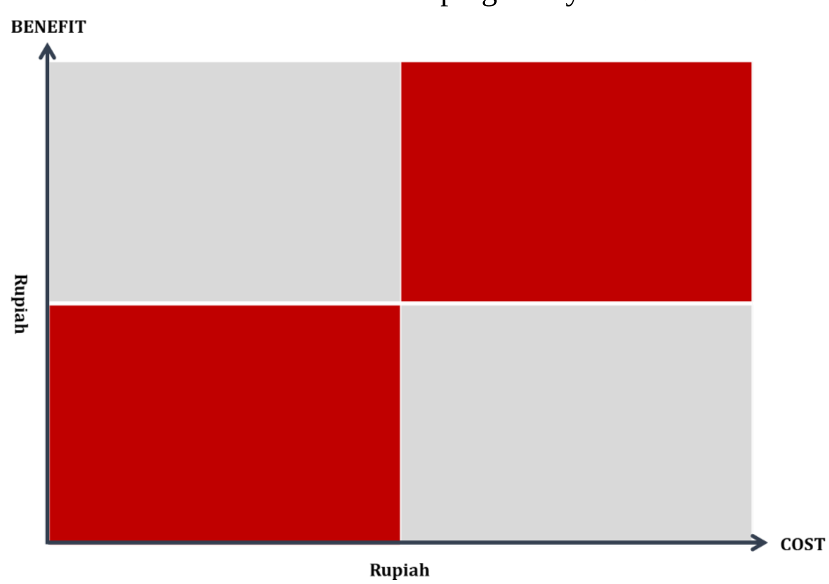


Figure 3.2 *Cost Benefit Diagram*
Source : *CBA Builder* (2021)

c. Kaizen plan

The best solution from the cost benefit diagram will be the final result of the analysis and discussion process in the form of a kaizen plan aimed for further development of the Treasure Data project with the following detailed information obtained based on discussions with related functions:

Table 3.1 Format *Kaizen Plan*

Solution	Devl.	Piloting	Expansion	Cost	KPI	PIC
Solution A	mm-yyyy	mm-yyyy	mm-yyyy	Rp,-	KPI A	Dept. A
Solution B	mm-yyyy	mm-yyyy	mm-yyyy	Rp,-	KPI B	Dept. B
Solution C	mm-yyyy	mm-yyyy	mm-yyyy	Rp,-	KPI C	Dept. C
Solution D	mm-yyyy	mm-yyyy	mm-yyyy	Rp,-	KPI D	Dept. D

4. CONCLUSION

This research contributes to provide an overview of how users utilizing digital tools in a process automation project especially in the automotive industry. At the end of the research, it is hoped that this analysis will provide a positive insight for Auto2000 to re-engineer the process in order to generate maximum repeat orders through Treasure Data. The expected results from these observations are flow process mapping, improvement suggestions, and evaluation of results with business KPIs in the form of total potential sales (suspect/prospect) and generated repeat orders.

5. REFERENCE

Aalst, Wil MP. van Der. (2011) *Process Mining: Discovery, Conformance and Enhancement of Business Processes.* Berlin Heidelberg: Springer Verlag.

Coussement, K., Benoit, D. F., & Poel, D. V. (2015). *Preventing customers from running away! Exploring generalized additive models for customer churn prediction. In M. Dato-on (Ed.). The sustainable global marketplace. Developments in marketing science: Proceedings of the academy of marketing science*. Cham: Springer.

Cherni, J., Martinho, R., & Ghannouchi, S. A. (2019). *Towards Improving Business Processes based on preconfigured KPI target values, Process Mining and Redesign Patterns*. Procedia Computer Science, 279-284.

Daly, C. & Freeman, T. 1997. *The Road of to Excellence: Becoming a Process-Based Company (The CAM-Process Management Guide)*. Institute of Management Accountants, CAM-I.

Davenport, T. H. 1993. *Process innovation: reengineering work through information technology*. Harvard Business Press.

Dumas, M., La Rosa, M., Mendling, J., & Reijers, H. A. 2013. *Fundamentals of Business Process Management*. (M. Dumas, M. La Rosa, J. Mendling, & H. A. Reijers, Eds.). Berlin Heidelberg: Springer Berlin Heidelberg. Retrieved from https://doi.org/10.1007/978-3-662- 56509-4_10

Elhadjamor, E. A. & Ghannouchi, S. A. (2019). *Analyze in Depth Health Care Business Process and Key Performance Indicators using Process Mining*. Procedia Computer Science, 610-617.

ER, M. & Astuti, H. M. (2014). *A Case Study on Process Mining Implementation in Modelling Supply Chain Business Process: A Lesson Learnt*. 6th International Conference on Operations and Supply Chain Management, Bali.

ER, M. 2018. *Business Process Management: Konsep & Implementasi*. Yogyakarta: CV Andi Offset.

ER, M. Astuti, H. M., & Nastiti, A. (2015). *Analysis of Customer Fulfilment with Process Mining: A Case Study in a Telecommunication Company*. Procedia Computer Science, 588–596.

ER, M. Zayin, S. O., & Pamungkas, F. J. (2017). *ERP Post Implementation Review with Process Mining: A Case of Procurement Process*. Procedia Computer Science 124, 216–223.

Harmon, P. 2015. The Scope and Evolution of Business Process Management. *Handbook on business process management 1: introduction, methods, and information systems* (pp. 37-80). Berlin, Heidelberg: Springer-Verlag.

Kumar, V. & Reinartz, W. 2012. *Customer Relationship Management: Concept, Strategy, and Tools*. Springer.

Roldan, J. J., Crespo, E., Barrio, A. M., Tapia, E. P., & Barrientos, A. (2019). *A training system for Industry 4.0 operators in complex assemblies based on virtual reality and process mining*. Robotics and Computer Integrated Manufacturing, 305-316.

Rosing, M. von, Scheel, H. von, & Scheer, A.-W. 2015. *The Complete Business Process Handbook: Body of Knowledge from, Process Modelling to BPM, Volumen I* (1st ed.). San Fransisco, CA, USA: Morgan Kaufmann Publishers Inc.

Statements on Management Accounting No. 4NN. 2000. *Implementing Process Management for Improving Products and Services*. Institute of Management Accountants.

Weske, M. 2007. *Business Process Management: Concepts, Languages, Architectures*. Berlin, Heidelberg: Springer-Verlag.

FORECASTING MATERIAL NEEDS FOR ELECTRICITY DISTRIBUTION AT PLN UP3 PAMEKASAN

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ABSTRACT

Currently, PLN is becoming more selective in providing services, however, quality of services remains a priority. Therefore, material requirements planning is very important to accelerate the customer's electrical connection. This case study aims to forecast material requirements at PT PLN (Persero) UP3 Pamekasan. UP3 Pamekasan has the highest number of queues compared to others. The main cause of service delays is the insufficient supply of materials. There are two methods used in this research, exponential smoothing and Artificial Neural Network (ANN), where the predictor variables used are the value of connected power, electricity consumption, electricity rates, electrification ratio, and the population of the Madura Islands. Demand categories are grouped into 169 categories differentiated by material requirements. The optimal forecasting method is obtained by iterating and comparing the RMSE and MAPE values of each method. RMSE and MAPE values analysisshow that the ANN method has a better level of accuracy than the exponential smoothing method with an average MAPE value of 0 - 15%. Forecasting results show electricity demand for 450 VA and 900 VA still dominate but show a downward trend. It happens because the value of the electrification ratio is still 84%. Meanwhile, the downward trend is due to an increase in the electrification ratio due to daily electricity connection. Demand for power upgrade is predicted to increase, in line with the existence of the 3T (Frontier, Outermost, Disadvantaged) areas that have been eliminated. Also, a comparison between actual application data for January 2021, forecasting the company version, and forecasting using the proposed method, shows that the proposed method has a MAPE value that is 2% lower than the MAPE value from the existing method. The ANN method can be an alternative method of forecasting demand, but it is only recommended for short termforecast.

Keywords: Forecasting, Material, Neural Network, Exponential Smoothing.

1. INTRODUCTION

The pandemic covid-19 affected various economic sectors. Including the impact on the decline in electricity sales. PLN cash flow has slowed down. Therefore, PLN is currently becoming more selective in providing services, however, the quality of service cannot be reduced. It is very important to carry out optimal planning so that there is no stockout or even overstock which has an impact on company losses. So that all demand can be fulfilled according to the standard level agreement and the number of waiting lists can be suppressed, as well as ensuring that the use of the budget becomes more effective, the authors calculate the main distribution material requirements. The method used to predict the demand is the Artificial Neural Network method and exponential smoothing, where the independent variables used as predictors are the amount of connected power, power consumption, average electricity rates, electrification ratio, and population of the Madura Islands. The results of demand forecasting translated into the total material requirements based on the bill of material for each category of demand.

2. LITERATURE REVIEW

According to Maman A. Djauhar I (1986), forecasting is predicting events that will occur in the future and aim to minimize the risks that may occur due to decisions taken by not eliminating uncertainty factors. Meanwhile, according to Lalu Sumayang (2003), forecasting is an objective calculation using past data to determine something in the future. Based on this definition, it can be said that forecasting is an activity to predict something in the futureusing past data that aims to minimize the risks that may occur.

Many types of forecasting are disseminated based on several aspects. Based on the time aspect, there are three types of forecasting according to Heizer and Reder, 1996, that is :

1. Forecasting in the short term, where the forecasting period is less than three months,
2. Forecasting in the medium term, where this forecasting has a period of between three months to three years,
3. Forecasting in the Long term, where the forecasting is more than three years.

Based on the nature of the forecast, forecasting can be divided into two types:

1. Qualitative Forecasting
   Qualitative forecasting is forecasting which is carried out regarding past qualitative data based on the knowledge and experience of the perpetrators. There are twomethods included in the qualitative method, namely the explorative method and the normative method.
2. Quantitative Forecasting
   Quantitative forecasting is forecasting which is carried out regarding historical quantitative data in the previous period. In doing quantitative forecasting, three conditions must be met, that is :
   - There is information about the state of the past,
   - Existing information can be quantified in the form of numeric/numeric data,
   - In several aspects, it can be assumed that the pattern of the past will continue in the future.

In quantitative forecasting there are two models, that is :

- Time series model, where this model is based on the use of analysis of the relationship between variables to be estimated with time variables, which iscalled a time series. This periodic l series mode consists of several methods, namely Exponential Smoothing and Moving Average, Regression, and Box - Jenkins.
- Causal model, where the model is based on the pattern analysis of the linkages between variables (causal)

3. METHODOLOGY

3.1 Double Exponential Smoothing Method with Two Parameters

A double exponential smoothing method with two parameters is used when demand is influenced by the trend but not influenced by season. According to Makridakis, Wheelwright, and Hyndman (1998), this method smoothens the trend value with different parameters from the parameters used in the original series. To forecast demand in the next period, it is necessary to know the forecast level/value of the new smoothing and its trend stimulation. Here is the formula for knowing the level forecast and trend estimation :

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1}) \tag{2-1}$$

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1} \tag{2-2}$$

In formula (2-1), the smoothing value for period t requires data demand for period t, the smoothing value for the previous period, and the value of the previous trend. After knowing the smoothing value for period t, we can get the t-trend value (formula 2-2). If the forecast level and its trend estimate have been obtained, then the real demand forecasting in period p can be obtained with the following formula:

$$\hat{Y}_{t+p} = L_t + pT_t \tag{2-3}$$

Keterangan :
L_t : level estimate
Y_t : demand in period t
T_t : trend estimation for
period t $\hat{Y}_{t+p}$: forecast for future
period p
p : the period of demand forecast
α : smoothing weight factor or smoothing constant for the level (0 <α
<1) p : weight factor smoothing or constant for trend (0 <β <1)

3.1 Artificial Neural Network

Neural Network is a physical circular nervous system that can acquire, store and use the knowledge that has been gained from experience. ANN represents the human brain in carrying out certain tasks. Neural Network was created by Waffen McCulloh and Walter Pits in 1943 by formulating a mathematical model of human brain cells. This method using the computer in processing some information. Three elements that play an important role in ANN, that is :

1. Network architecture and the relationships between neurons,
2. Learning algorithms that function for the use of finding weights - network weights,
3. The activation function used.

Neural Network consists of several neurons that are connected and function to transfer the information that you want to convey. The information will be stored as weight. The following is an illustration of the Neural Network Structure which can be seen in Figure 1.

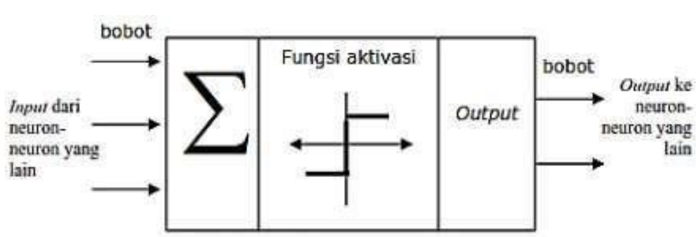

Figure 1 Neural Network Structure

Neural Networks have several advantages of ability and property in processing information, which are nonlinearity, input-output mapping, adaptive, evidential response, contextual information, fault tolerance, VLSI (Very Large Scale Integrated) Implementability, Uniformity of Analysis and Design. and Neurobiological Analogy.

3.2.1 Multilayer Neural Network Architecture

This network consists of three-layer, that is the input layer, the output layer, and the hidden layer. This network can solve more complex problems than the Single Layer Network but it takes longer. The following is an explanation of the three layers of this network.

1. Input Layer
   The number of layers of this network is only one layer which consists of several numbers of neurons. The neuron starts from the first input neuron to the n^{th} input neuron. The input layer describes things that will carry out the training process on a Neural Network.
2. Hidden Layer
   The hidden layer is a layer that lies between the input layer and the output layer. The number of layers of this network is one layer to n layers which consists of several numbers of neurons. These neurons start from the first hidden neuron to the n^{th} hidden neuron. In determining the number of neurons in the hidden layer, there are several best practices or rules of thumb that can be used. Based on the opinion of Haykin (1999), the number of neurons in the hidden layer which ranges from 2 to 9 neurons can already give good results in a network, but basically, the number of neurons from the hidden layer used can be infinite.
3. Output Layer
   The output layer is almost the same as the input layer. The number of layers of this network is only one layer which consists of several numbers of neurons. These neurons start from the first output neuron to the n^{th} output neuron. The number of neurons in the output layer depends on the type and performance of the network itself.

3.2.2 Activation Function

The activation function is a function that will convert an input value into a specific output value. In the Neural Network, the information will be sent to the neurons via input with a certain initial weight. This information will be processed by a propagation function which will add up the values of all incoming weights. Functions that are commonly used are:

1. Binary Step Function
   Binary functions convert input units, where the value of the variable is continuous which results in the output value is binary (i.e. 1 or 0) or bipolar (1 or 1).
2. Signum Function Binary
   Converts the input of a continuous variable to an output of 1,0, or -1.
3. Sigmoid Function Binary
   This function is used for neural networks that are trained using the backpropagation method. The binary sigmoid function has a value in the range of 0 to 1. Therefore this function is often used for neural networks that require output values that are located in the interval 0 to 1.
4. Hyperbolic Tangent Binary
   This function will carry the input value using the hyperbolic tangent sigmoid formula. The maximum output value of this function is 1 and the minimum is -1.

5. Linear Derivative Binary
   Linear functions have the same output value as the input value. y = x. This function is usually used in the input unit to give the initial value for each unit price.

3.2.3 Backpropagation Method

Backpropagation is an Artificial Neural Network method that uses the Supervised Learning algorithm and is usually used by perceptrons with many layers to change the weights that are linked with neurons in the hidden layer. The backpropagation method consists of several layers, namely as follows:

1. Input Layer
   The input layer is 1 layer consisting of input neurons, starting from the first input neuron to the n^{th} input neuron. In this case, the input layer will represent the conditions that will conduct training on the network.
2. Hidden Layer
   The hidden layer consists of several hidden neurons ranging from the initially hidden neuron to the n^{th} hidden neuron. In the Hidden layer, several method rules can be used to determine the number of hidden layer neurons ranging from N + 1 for a multilayer perceptron neural network, and a value of about 2N on a bridged multilayer perceptron neural network. So it can be concluded that the number of hidden neuronsn up to 2n can produce good results in the network, but basically, the number of hidden neurons used can amount to infinity.
3. Output Layer
   In general, it is almost the same as the input and hidden layers, the output layer is one layer consisting of output neurons starting from the first output neurons to the n^{th} output neurons. The number of output neurons depends on the type and performance of the neural network itself.

In the Artificial Neural Network Backpropagation method, there are 3 stages in the training process, namely as follows:

- Feedforward of the input
- Calculation and backpropagation
- Adjustment of weight values based on output error.

The backpropagation algorithm will use the error value from the output to change the weight value. However, to get this error value, it is necessary to do the feed-forward process first.

3.3 Evaluation of Forecasting Methods

It is necessary to do an evaluation process in modeling the forecasting process to determine the performance of the forecasting methods that have been carried out. The test is carried out to find out the errors that exist in the forecasting model made with two measurements,namely as follows:

- Mean Square Error (MSE)
  Mean Square Error (MSE) measures the accuracy of the forecast by averaging the square value of the resulting error. The formula for calculating MSE is as follows:

Mean Squared Error $:MSE = \frac{\Sigma(x_i - f_i)^2}{n}$ (2-17)

MSE means the average of the squared error, where x_i is the actual data and f_i is the predicted value, and n is the number of observations.

- Mean Absolute Percentage Error (MAPE)
  Mean Absolute Percentage Error (MAPE) is a parameter that is often used in forecast evaluation. MAPE represents the error value of forecasting in percentage units. The MAPE value is obtained through the following calculations:

Mean Absolute Percentage Error : $MAPE = \sum \frac{\frac{|Aktual - Forecast|}{aktual} \times 100\%}{n}$ (2-

18) Where :

MAPE : Mean Absolute Percentage
Error *N* : The number of periods
Actual : Actual data
Forecast : forecasting
results

The following is a comparison of the level of accuracy of the forecasting results based on the MAPE value, shown in table 1.

Table 1 Level of Accuracy based on MAPE Value

MAPE	Interpretation
<10%	Very Good
10% - 20%	Good
21% - 50%	Enough
>50%	Bad

4. ANALYSIS

4.1 Determination Analysis of Forecasting Methods

The stages of data processing are data processing using the double exponential smoothing method, data processing using the artificial neural network method, and calculating the accuracy parameters of the forecasting method using the root mean square error and mean percentage error. Before data processing, the authors conducted several preliminary tests to determine the characteristics of the data to be processed. The initial test conducted was testingthe distribution assumptions and plotting data. Testing this distribution needs to be done to further narrow the selection of the forecasting method, whether to use a method that requires using a probabilistic distribution or a method that does not require using a probabilistic distribution. In the case study of forecasting material needs at PT PLN (Persero) UP3 Pamekasan, the demand population data is unknown, so testing needs to be carried out to confirm thedistribution of the sample again. In this case, the project is the entire application for the East Java Region, while the term sample is intended to define the application in the PT PLN (Persero) UP3 Pamekasan area. Normal distribution testing is done using the Shapiro Wilk test. The test was chosen because it is suitable for testing small amounts of data, that was less than 50 data. In

addition to the Shapiro Wilk test, the author also uses the statistical values of skewness and kurtosis, as well as the QQ plot. Based on the test results, it is known that both the dependent variable/predictor and the dependent variable have not fulfilled the normal distribution assumption. After it is known that the overall data has not met the assumption test, the authors plot the demand data to find out whether the demand is following trend pattern, horizontal pattern, cyclical pattern, or seasonal pattern. Through this data plotting stage, it is known that the demands are very volatile, not stationary, and show a trend influence on the demand category 450
- 5,500 VA, but do not show any seasonal patterns in the overall demand data. This can be correlated with the condition of PLN UP3 Pamekasan which is still included in the 3T area category (Disadvantaged, Outermost, and Frontier). The characteristic of the 3T area, in general, is the inadequate network availability so that it has not reached all remote areas. This has an impact on the types of business and industrial investment in the region, so that the amount of demand for the industry/business category with power above 10,600 VA is fairly small, with growth that cannot be accurately predicted. Besides, the 3T area is dominated by demand for the households R1 450 VA and R1 900 VA tariff groups, where the tariff groups are subsidized household rates, which naturally tend to decrease in number over time (reflected in the plotting data.). Meanwhile, the tariff group of R1M 900 VA and above tends to increase due to the trend of improving the economy and lifestyle of the local community after electricity reaches the regions.

Based on the trend of data patterns, data processing is then carried out using the double exponential smoothing method, because this method is suitable for data that is influenced by trends. The double exponential smoothing method uses 2 smoothing constants, which are intended to minimize errors due to fluctuating data. Apart from these methods, an artificial neuralnetwork method was also carried out. The ANN method was chosen because of its ability to map patterns on input and patterns on output. ANN is a method that focuses on the learning process, where ANN can identify patterns in the historical data used. ANN is tolerant of many types of data and can identify a data pattern that is incomplete or noisy. In the case of prediction based on time series, ANN can study temporary patterns in data in the past time series, so that ANN can make predictions on time series data properly and by the demand patterns at PT PLN which tend to fluctuate.

At the data plotting stage, we can also see the types or categories of demand that have not had historical data for the last 3 years. The types of demand that do not have historical data are then eliminated because at this time quantitative forecasting cannot be carried out. There are 35 independent variables/demand categories issued from data processing. Special treatment is needed to follow up on these 35 types of requests, namely by analyzing trends in customers' electrical energy usage. The energy usage analysis will show the potential customer can offer to make a power upgrade. The procurement of special materials for proactive marketing itself is adjusted to the company's investment budget ceiling and financial and technical feasibility studies for potential customers. Basically, for 35 types of demand that do not have historical data,PLN UP3 Pamekasan needs to analyze energy used and make financial and technical studies as a basis for selecting customers who will be offered a new installation service or power upgrade offer.

The results of calculating the root mean square error generally show the superiority of the ANN method's accuracy compared to exponential smoothing. Based on the comparison of RSME, the result shows that there are 2 types of requests for Y93 and Y162 that are more optimal using the exponential smoothing method, although, when compared to using the MAPE parameter, the ANN method overall shows better performance. In terms of value, the percentage of the MAPE value for the two types of requests is still classified as very good because it is less than 10% so that forecasting can be done using the exponential smoothing method or ANN. The two variables predicted by using the exponential smoothing method are power demand with an extension with the capacity of 164,000 VA and Power Upgrade requests with the capacity of 53,000 VA power. The difference in forecasting methods for each type of demand is very possible because there are differences in customer characteristics based on the connected power. Of course, the pattern of demand for power of 450 VA to 5,500 VA which is dominated by household users will be different from the pattern of demand for power from 10,600 VA to 197 kVA which is dominated by customers with business or industrial interests. The differences in these characteristics then affect the patterns and methods that will be suitableto be used for forecasting. In the 3T area itself, the growing business and industrial climate havenot developed too fast, so there will be high uncertainty in projections. Historical data for 3 years which shows the number of requests can be said to be insufficient to be used for projections because it only shows that there are 1 or two requests in 1 year, even 2 years, due to the experimental process of data processing using the forecasting method, showing the value of the RMSE parameter and MAPE is very good.

4.2 Analysis and Discussion of Forecasting Results

In forecasting materials, projected material requirements cannot be done separately, but must be adjusted to the needs of each specific customer demand. Therefore, before calculating material requirements, forecasting of demand is first carried out. There are 169 types of demand category. All demands cannot be put together or counted together because they have different material component requirements both in terms of type and quantity.

After determining the optimal method for all types of demand Y1 to Y169, the next step is to forecast demand. By the pattern in historical data, the demand projection still shows the same pattern. Demand is dominated by range connection power between 450 VA to 5,500 VA prepaid with the highest composition being the connection with JTM expansion, then in the second place connection with low voltage network expansion (JTR), and the last is without expansion. An expansion of medium voltage network (JTM) for low-voltage connection is still needed in the UP3 Pamekasan area, because the distance between population centers in the Madura Islands is quite far, especially in the islands around Madura Island where there is no electricity network.

The next step, after obtaining the projected value of demand, is to calculate the material requirements for each demand category. The amount of material needed is obtained by multiplying the number of needs for 1 customer with the projected number of customers. At the end of the study, the authors made a comparison between the results of forecasting the demand made by the company with the forecasting results carried out by the ANN method and exponential smoothing. Based on comparisons using data for the period January 2021, it can be seen that the forecasting is slightly better than the existing method. This is indicated by theMAPE value of the proposed method which is 2 % lower than the MAPE value of the existing method. Therefore, the proposed method can be an alternative method of forecasting demand at PT PLN (Persero) UP3 Pamekasan in the planning stages.

Table 2 Comparison Between Existing Method and Proposed Method

Demand Category	Realization Demand in Januari 2021	Forecast Value using Existing Method		Forecast Value using ANN & Double Exponential Smoothing	
		Pred	MAPE	Pred	MAPE
New Installment with no expansion (1 phase)	3.383	1.817	39%	2.606	37%
New Installment with no expansion (3 phase)	14	3		23	
New Installment with low voltage expansion (1 phase)	1.253	1.294		1.281	
New Installment with low voltage expansion (3 phase)	20	19		18	
New Installment with medium voltage expansion (1 phase)	900	661		1.332	
New Installment with medium voltage expansion (3 phase)	10	21		20	
Power Upgrade	1.070	1.128		1.220	

5. CONCLUSION

The ANN method is a method that is adaptive to changes in data patterns. ANN's method can identify patterns in the historical data used. ANN is tolerant of many types of data and can identify a data pattern that is neither sticky nor noisy. However, the ANN method also has disadvantages in numerical operations. The ANN method lacks precision for processing large amounts of numerical data. ANN works based on a given input data pattern. The precision of forecasting depends on determining the training and testing samples, as well as the number of hidden layers and neurons in them to determine the weight of each input. So for implementation at the company level, the ANN method is only recommended for forecasting in the short term. The use of ANN to make predictions can be done at least every 3 months to update predictions according to market conditions or demand patterns. This short-term forecast is under the policies of PT PLN (Persero) during the pandemic period to face the economic crisis.

The ANN method has a flexible architecture. In its implementation, forecast evaluation in each period must be done if the ANN method is used. ANN architectural modifications can also be done if necessary, by modifying the number of hidden layers or using a different number of hidden layer neurons to obtain better forecasting results for each forecast period. Also, after the forecasting is carried out, the ordering of materials to vendors is not only calculated based on the results of the forecasting but also the remaining queues that have not been served in previous periods are added, so that the connection queue does not get longer. By evaluating and improvingthe ANN method architecture at the end of the forecast period, PLN UP3 Pamekasan will be able to obtain more accurate forecast results and obtain the architecture that best suits the demand patterns in the region.

6. REFERENCES

Amrin. (2016). *Neural Network Backpropagation Comparative Analysis and Multiple Linear Regression for Level Forecasting*. *Ii* (2), 1–6. Jakar ta: Journal of Computer Engineering AMIK BSI.

Anggun, I. (2016). *Forecasting Electric Power Sales in the Industrial Sector at PT PLN (Persero) Distribution East Java*. Surabaya: ITS Statistics Major.

Bahagia, SN (2006). *Inventory System.* Bandung: ITB Press.

Bowerman, BL, O'Connell, RT, Koehler, AB, (2005). *Forecasting, Time Series, And Regression, 4th Edition*. California: Duxbury Applied Series.

General Manager of PT PLN (Persero) Distribution of East Java. *(2013). The decision of the General Manager of PT P LN (Persero) Distribution of East Java concerning the Implementation of Distribution Network Construction of PT P LN (Persero) Distribution of East Java*. (2013). Surabaya: PT PLN (Persero) Distribution of East Java

Hanke, JE & Wichers, DW (2005). *Business Forecasting Eight Edition*. New Jersey: Pearson Prentice Hall.

Hiroaki, Y. (2008). *Power demand forecast: The study on optimal electric power development in Java-Madura-Bali in the Republic of Indonesia. The 2nd Workshop Program. PJB Head Office.*

I Nyoman Pujawan, ME (201 7). *Supply Chain Management.* Surabaya: ANDI Yogyakarta

Jacob, M., Neve s, C., & Vukadinović Greetham, D. (2010). *forecasting and Assessing the Risk of Individual Electricity Peaks*.

Kuncoro, AH, & Dalimi, R. (2007). *Long-term load forecasting on the Java-Madura-Bali electricity system using artificial neural network method. P resented at the International Conference on Advances in Nuclear Science and Engineering in Conjunction with LKSTN 2007* (pp. 177 - 181)

Kurniawan, B. (2018). *Forecasting Bitcoin Price Using Back- Propagation Neural Network*. Surabaya: ITS Information Systems Department

Lewis, D . (1997). *Demand Forecasting and Inventory Control*. Cambridge: Woodhead Publishing Ltd.

Makridakis, S., Wheelwright, S., & Hyndman, RJ (1997). *Forecasting: Methods and Applications, 3rd Ed*. John Wiley & Sons.

McNeil, MA, Karali, N., & Letschert, V. (2019). *Forecasting Indonesia's electricity load through 2030 and peak demand reductions from appliance and lighting efficiency*. *Energy for Sustainable Development Journal*, *49*, 65–77.

Mufaidah, I., et al. (2017). *Forecasting of PND Frozen Shrimp Demand Using Artificial Neural Network Method (ANN) Backpropagation* .). Jember: Journal of Agrotechnology, Jember University

Nezhad Haj Ali Irani, F., Reza Noruzi, M., Papavasileiou, EF, Lyons, ST, Ferrell, OC, Harrison, DE, Ferrell, L., Hair, JF, Carter, SP, Dudley, W., Lyle, DS, Smith, JZ, Batarliene, N., Čižiuniene, K., Vaičiute, K., Šapalaite, I., Jarašuniene, A., Daswati, Yudiaatmaja, F.,… Hirekhan, M. (2017). Issn1412 - 8683 29. *Procedia - Social and Behavioral Sciences*, *IV* (2), 29–38.

Ningrum, TC (2016). *Forecasting the Amount of Rice Procurement and Rice Inventory at Perum Bulog, East Java Divre*. Surabaya: ITS Information Systems Department.

Pakaja, F., & Naba, A. (2015). *Artificial Neural Networks and Certainty Factors. Neural Networks*, 6 (1), 23–28.

PLN (State Electricity Company) (2017 *). PLN 2017–2026 Electricity Supply Business Plan (RUPTL)* http://www.djk.esdm.go.id/pdf/Coffee%20Morning/April%202017/ Presentation% 20 RUPTL% 202017-2026.pdf.

Pradipta, R . (2018). *Application Of Backpropagation Neural Network For Forecasting Global Steel*. Surabaya: Department of Information Systems ITS.

Pratomo, S., & Dayawati, RN (2009). *Evolving Artificial Neural Network in Stock Forecasting Case Implementation Of Time Series Method Using Evolving Artificial Neural Network In Stock Forecasting.* Telkom University, Faculty of Informatics Engineering.

Purnomo, A . (2018). *Forecasting Indonesian Composite Index With Artificial Neural Network*. Surabaya: ITS Information Systems Department.

Ramadhan, A., Advisor, D., & Statistics, J. (2016). *Forecasting Electricity Sales (KWH) Industrial Sector PT PLN (Persero) Distribution of East Java, Surabaya West Area Using Exponential Smoothing*. Surabaya: ITS Statistics Department.

Rinda, NP (2017). *The number of Tuberculosis Patients Forecasting in Malang District Using ARIMAX Method*. http://repository.its.ac.id

Seymour, L., Brockwell, PJ, & Davis, RA (1997). *Introduction to Time Series and Forecasting*. In *Journal of the American Statistical Association* (Vol. 92, Issue 440).

Simon Haykin., *Neural Networks - a Comprehensive Foundation*. Prentice-Hall, New Jersey, 2nd edition, 1999. ISBN 0-13 -273350-1

Singh, S., Hussain, S., & Bazaz, MA (2018). *Short term load forecasting using artificial neural network. 2017 4th International Conference on Image Information Processing, ICIIP 2017, 2018-January, 159–163.*

Sustrova, T. (2016). *A Suitable Artificial Intelligence Model for Inventory Level Optimization*. *Trends Economics and Management*, *10* (25), 48.

ACCURACY ANALYSIS OF CIGARETTE DISTRIBUTION OFFICE LOCATION SELECTION USING SPATIAL POINT PROCESS

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ABSTRACT

The location selection of business facilities is very influential on the success of an organization, especially in cigarette companies that have national market segmentation. Determining the location of this distribution office is important because it will affect long-term business decisions. The location of the distribution office will affect the reach to the consumer area and the costs incurred. This study aims to examine the most appropriate criteria in selecting the distribution office of an international affiliated cigarette company. The object of this research is the distribution area offices in East Java, Indonesia, which are spread over several zones. The research method uses a quantitative approach, with data obtained through company databases and location identification studies. Then the data is processed using Spatial Point Pattern (SPP) analysis which will capture the significancy of the selection factor of office locations in the poisson process model. It is expected that from the results of this study, the company can select locations that are accurate on target and contribute to the continuity of its business. The results of the intensity homogeneity analysis showed that the distribution office location distribution of the company is a homogeneous poisson process, which is influenced by the same factors. From the results of parameter estimation, it is found that among other factors, the factor that plays the significant role is availability of infrastructure and strategic location.

Keywords: distribution office location, spatial point process.

1. INTRODUCTION

The business location factor affects the differences in the level of organizational success and differences in organizational strengths and weaknesses. In a competitive situation, location factors can be critical factors which make it very important. In order for a business to be run to compete effectively, the business location must be strategic and easy to reach. The choice of location for a company will affect the risks and benefits of the company as a whole, considering that location greatly affects both fixed and variable costs, both in the medium and long term. Transportation costs can reach 25% of the selling price of the product, depending on the product and the type of production or service provided. Thus, it can be said that a quarter of the company's total revenue may be needed only to cover the cost of transporting service products out of and into the business location (Heizer et al., 2017). The decision to place a business location will be determined by supply variables (land, labor and capital costs, labor and technological characteristics), demand variables (market size and market accessibility) and agglomeration economies. Selecting the right business location means avoiding as many negative effects as possible and finding the location that has the most positive factors. Once an organization determines the location of its business to operate in a certain area, it will incur many costs and are difficult to reduce (Mota & Brandão, 2013). Several researchers considered several important factors including agglomeration economies, industry specialization index, labor, fiscal conditions, transportation infrastructure, and land development characteristics (Bhat et al., 2014). The business location facility factor and the allocation of customers to be served from the operating facilities have a strong economic, environmental and social impact. Although decisions on facility location issues may have varying effects on these impacts, the simultaneous consideration of these effects in the early stages of decision making for facility location selection and business location network plans has attracted the attention of researchers in the area of facility location decision making (Anvari & Turkay, 2017).

Zandiatashbar et al (2019) consider location factors, facility density factors and sustainable aspects in selecting business locations with high technology facilities using descriptive statistical methods and Anova (Zandiatashbar et al., 2019). Nurzukhrufa et al (2019) surveyed a questionnaire on class a multifunctional office consumers in Surabaya, and it was found that among various indicators, proximity to public facilities, noise, and building age were 3 indicators of the causes of dissatisfaction (Nurzukhrufa et al., 2018). Mota and Brandão (2011) present a count data modelfor determining business location by considering the factors of land prices, labor and capital costs, labor and technology characteristics, market size and accessibility (consumers) and the agglomeration economy (Mota & Brandão, 2013). Anvary and Turkay (2017) present a decision support framework for the problem of facility location with an emphasis on sustainability aspects by taking into account social, economic and environmental factors (Anvari & Turkay, 2017).

This study conducted in East Java Distribution Area, Indonesia. From the review of various location selection factors, the selected factors aim to maximize company benefit, especially for cigarette companies whose activities require warehouses and distribution offices in each of the areas that are their business scope. The research problems that will be examined in this study are:

1. What is the distribution pattern of the distribution office point location based on the intensity homogeneity analysis?
2. What factors influence significantly the selection of the distribution office location?
3. What is the implications of significant factors to the distribution office placement policy?

2. METHODS AND MATERIALS

2.1 Methods

In the current era, some researchers take spatial aspects into their analysis of business location determination. Rahman and Kabir (2019) used a questionnaire survey and spatial analysis using a GIS tool for selecting locations to place manufacturing facilities (Rahman & Kabir, 2019). Bhat et al (2014) present a multivariate spatial model for determining company location (Bhat et al., 2014). Sabater et al (2011) present a discrete spatial choice model with the Non-Homogeneous Poisson Process (NHPP) (Alamá-Sabater et al., 2011). Based on a review of previous research, it can be concluded that spatial data analysis is important in determining the location of business facilities. Based on a review of previous research, it can be concluded that spatial data analysis is important in determining the location of business facilities. From the summary of researchers in the past 10 years, there are at least four researchers (Foued 2021, Rahman and Kabir 2019, Bhat et al 2014, Sabater 2011) who consider spatial data in their analysis. Although the four researchers above combined statistical methods with spatial analysis, only Foued (2021) integrated spatial data into his modeling in the same stage as multivariate statistical analysis. While the other threeresearchers (Rahman and Kabir 2019, Bhat et al 2014, Sabater 2011) combined spatial analysis, but in a separate process from the multivariate statistical analysis stage. This study takes a position to participate in the study of the location of business facilities spatially using the spatial point pattern approach, where a probabilistic statistical analysis will be presented that integrates the poisson process with an intensity analysis of the office points as the object being reviewed. This approach has never been carried out by researchers in this field before, with the existence of this research is expected to fill the theoretical gap.

Spatial point pattern is a random pattern of points in d-dimensional space, with the number of dimensions equal to or more than two (Baddeley et al., 2015). Spatial point pattern is used as a statistical model to analyze the point distribution pattern, where the point represents the location of a research object. An important role of this method is to identify spatial trends in point intensity. Statistical analysis of point spatial layouts can reveal important features (Baddeley & Turner, 2006). Some researchers use this method to examine patterns in the field of ecology (Law et al., 2009), study the distribution of earthquake events (Ogata, 1998), find out extreme symptoms in the field of climatology (Sang & Gelfand, 2010) and determine the factors of drinking water facilities damage (Nugroho & Iriawan, 2019). Analysis of the distribution pattern in this case is the main focus that is important to study in spatial point patterns. The Poisson Point Process can be used as an approach to the spatial point process if it assumes that there is no interaction between one point location and another.

Poisson Point Process is divided into two types: non-homogeneous point process and homogeneous point process (Baddeley & Turner, 2006). The Poisson distribution is a type of distribution of the number of events at a certain time interval or in a certain area. These events depend on a certain time interval or a certain area, where the results of observations are in the form of discrete data and between events are mutually independent. In this study, it is assumed that the location between one location and another has no interaction, so it qualifies to use the spatial poisson point process method. Data variables are displayed in the form of a pixel image. The method used in this research is the smoothed kernel for point pattern. This method is used for the density function, which calculates the convolution of the isotropic gaussian kernel from the sigma standard deviation with the point mass at each data point at x location. Convolution is conducted by multiplying the pixel image to the next pixel by the matrix. The kernel smoother is usually a small matrix value used in image convolution (Xia & Ludwig, 2016). From the pixel image intensity, the homogeneity test in the Poisson process is carried out to determine whether the intensity of the observed point pattern is categorized in the homogeneous point pattern or the non-homogeneous point pattern (Baddeley et al., 2015).

2.2 Materials

The research variables that proposed in this study consist of response and covariate variable. Response variable proposed in this study is the number of office location point with a certain latitude and longitude geographical coordinate. The data will be displayed visually as a planar pointpattern then transformed into a pixel image display (Baddeley & Turner, 2005). The covariate variables proposed in this study is the strategic location, building readiness, infrastructure, safety and security, exposure and commercial which displayed as pixel images or marks point patterns (Baddeley & Turner, 2005). The distribution zone boundary is used as the grid of model density, where the covariate variable is transformed into a pixel image and then extracted into 6 grids, based on the number of distribution zone (Moser et al., 2015). Research variables and data structures in this study are shown in table 1 and table 2.

Table 1. Research Variables

Variables	Scale	Description
Y	Ratio	Number of distribution office points
X1	Ratio	Strategic Location
X2	Ratio	Building Readiness
X3	Ratio	Infrastructure
X4	Ratio	Security and Safety
X5	Ratio	Exposure
X6	Ratio	Commercial

Table 2. Data Structure

Grids	*Y*	*X1*	*X2*	*X3*	*X4*	*X5*	*X6*
1	*Y1*	*X1.1*	*X1.2*	*X1.3*	*X1.4*	*X1.5*	*X1.6*
2	*Y2*	*X2.1*	*X2.2*	*X2.3*	*X2.4*	*X2.5*	*X2.6*
3	*Y3*	*X3.1*	*X3.2*	*X3.3*	*X3.4*	*X3.5*	*X3.6*
4	*Y4*	*X4.1*	*X4.2*	*X4.3*	*X4.4*	*X4.5*	*X4.6*
5	*Y5*	*X5.1*	*X5.2*	*X5.3*	*X5.4*	*X5.5*	*X5.6*
6	*Y6*	*X6.1*	*X6.2*	*X6.3*	*X6.4*	*X6.5*	*X6.6*

The data analysis process proposed in this study as follows:

1. Analyse the characteristics of office location patterns.
2. Conduct the goodness of fit test.
3. Conduct the homogeneity of intensity test.
4. Develop spatial poisson point process model
5. Estimate model parameters using the Bayesian method
6. Make conclusions and recommendations from the results of the analysis.

To estimate parameters, the Bayesian algorithm used as follows:

1. Form the probability function.
2. Determine the prior distribution that depends on the frequentist result.
3. Form a posterior distribution based on the prior distribution.
4. Form full conditional posterior distribution for estimated parameters.
5. Perform an iterative process of estimating parameters using Gibbs sampling, meet irreducible, repetitive, and aperiodic characteristics.
6. Determine the best model parameters.

3. RESULTS AND DISCUSSION

3.1 Goodness of fit test

The goodness of fit test using the Anderson-Darling method was conducted to determine the suitability of poisson distribution as a pattern approximation. Based on the test results in Table 3, the statistical value is 0.30354, while the critical value obtained is 0.51962 using an alpha of5%. It is found that the data distribution pattern of office location points can be approached as a poisson distribution pattern and meets the poisson process criteria.

Table 3. Goodness of fit test result

Statistic Value	Alpha	Critical Value
0.30354	0.05	0.51962

3.2 Pattern of office point locations

Figure 1 shows visually that office point locations in East Java have ahomogeneous pattern with a central peak pattern. The intensity homogeneity test using the chi-square method was carried out to determine whether the office distribution was homogeneous or non-homogeneous poisson process type. The test results in Table 4 provide information that the chi-square statistical value is 2.2676 and the p-value is 0.378 using an alpha of 5%. It is found based on the test result that the office point location pattern is categorized into homogeneous poisson process. By this result, it is also found that there is no need to conduct a mixture identification analysis.

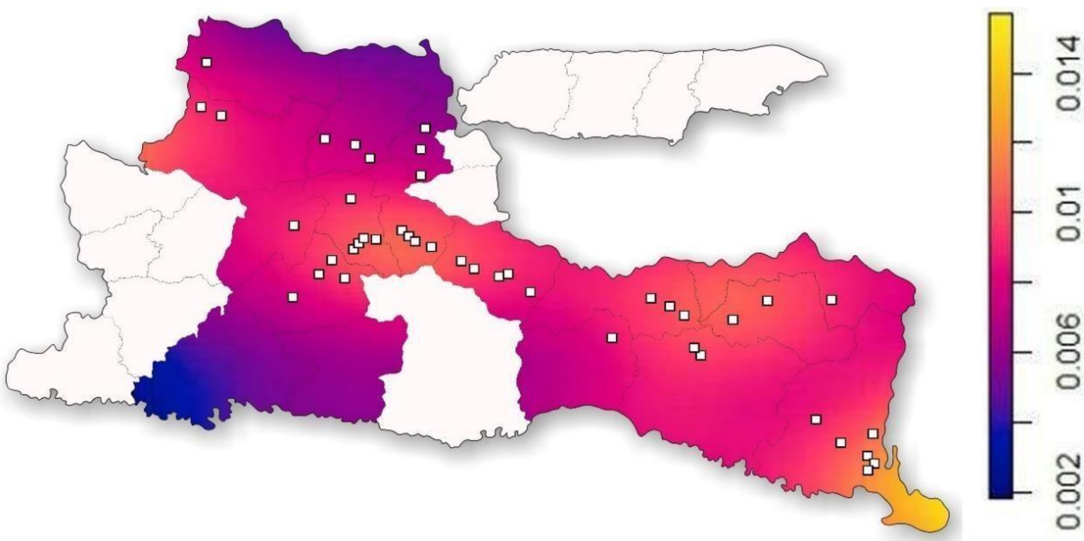

Figure 1. Intensity of office point location (in each km^2)

Table 4. Homogeneity of intensity test result

Statistic Value	Alpha	p-value
2.2676	0.05	0.378

3.3 Homogenous poisson point process model

The posterior distribution is used to obtain the estimation of model parameters, where the Markov Chain Monte Carlo (MCMC) is used as an approximation. The results obtained have to meet the nature of irreducible, aperiodic, and recurrent which can be seen from the results of history plots, autocorrelation, and kernel density. Based on Table 5, it can be seen that only Beta 0, Beta 1 (strategic location) and Beta 3 (infrastructure) parameters are significant in the model. This is because the credible interval of the two variables does not exceed 0 (zero). The most significant parameter in the model is Beta 3 (infrastructure).

Table 5. Estimation parameter result

Parameter	Mean	Standard Deviation	2.5%	Median	97.5%
Beta 0	1.76	0.3035	0.7327	1.346	1.924
Beta 1	-0.2465	0.2020	-0.436	-0.2477	-0.0362
Beta 2	-0.00842	0.4371	-0.862	-0.008057	0.8498
Beta 3	0.66855	0.3346	0.3696	0.6992	0.9867
Beta 4	-0.09718	0.4289	-0.9384	-0.096	0.7417
Beta 5	0.004588	0.3951	-0.7746	0.006345	0.7725
Beta 6	0.06714	0.3119	-0.5419	0.06666	0.6781

The Poisson regression model for homogeneous point pattern is as follows:

$$\lambda = \exp(\beta0 + \beta1\ X1 + \beta2\ X2 + \beta3\ X3 + \beta4\ X4 + \beta5\ X5 + \beta6\ X6) \quad (1)$$

which :

λ : Office location intensity

β : Poisson regression parameter

X : Predictor variable

With the results of parameter estimation that only shows Beta 0, Beta 1 and Beta 3 as significant parameters, the equation (1) becomes:

$$\lambda = \exp(1.76 - 0.2465\ X1 + 0.66855\ X3) \quad (2)$$

Where the relationship between the Beta 1 parameter (strategic location) and office location intensity is negative, which means that the shorter the distance to the market outlet, the higher the selection accuracy of the location. Meanwhile, the relationship between Beta 3 (infrastructure availability) and office location intensity is positive, where the higher the availability score of a location, the more accurate the location will be to select. The poisson regression parameter value in equation (2) also shows that the most significant parameter in the model is the availability of infrastructure.

The availability of infrastructure is also a support in making decisions regarding business facilities. This is in line with research work by Foued (2021), Huang et al. (2020), and Alama-Sabater et al. (2019) which found that the infrastructure variable as a significant factor that influences decision making in placing industrial facilities. If we observe at the exploration of the covariate variable in Figure 2 where there is a slight gap between the northern and southern regions, in a condition where the northern coastal areas have lower availability of supporting infrastructure than the central and southern regions, the company prefers to place distribution offices more towards the middle and south which have better availability. There is a possibility because, in contrast to other products, such as food and textiles in Foued (2021), cigarette products have a larger range and threshold. So that the placement of a location that is slightly further from the outlet (but still within the range of an adequate distance), is still possible rather than placing a location close to the outlet but is not supported by the existence of a water network, electricity, and telecommunications networks that are sufficient for operations. The act of expanding the distribution area can be chosen by the company to overcome this. For example, the location of the Gresik distribution office not only serves the Gresik Regency and Gresik City areas but also servesthe Lamongan Regency area. Because finding a distribution office located in the Lamongan Regency area that has the availability of supporting infrastructure is more difficult than expanding the Gresik distribution area which only risks increasing operations to reach outlets in Lamongan Regency. This also means that the choice of a location that has adequate infrastructure takes precedence over a location that is closest to the outlet.

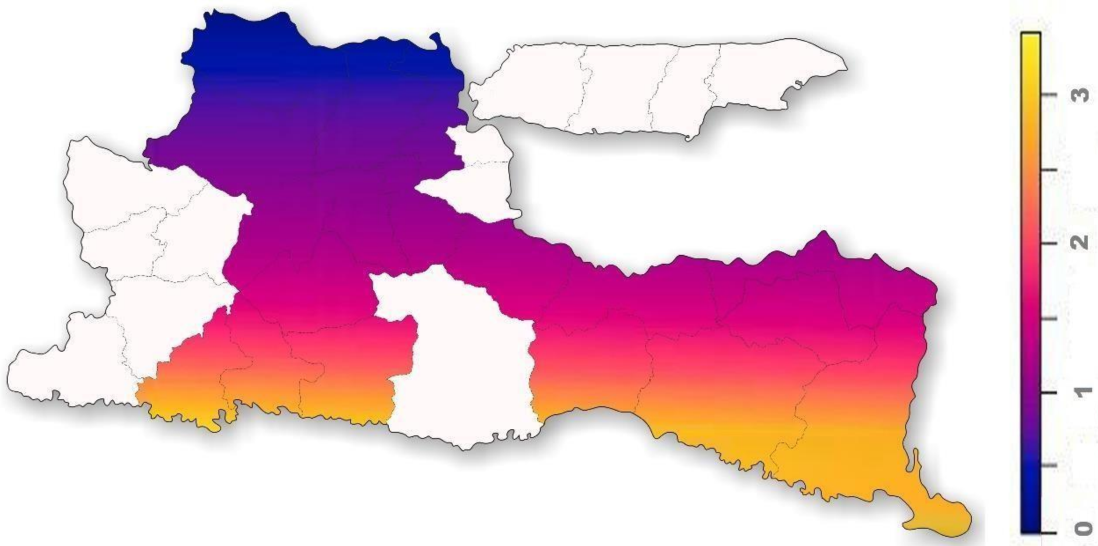

Figure 2. Score gradation of infrastructure availibility (in 1 to 4 scale)

It becomes very important for future research by exploring the factors of selecting business facilities with an emphasis on factors outside of this study. Where other factors are not considered in this study, but hypothetically have a significant influence in the selection of the location of business facilities. Several other factors such as rent term and conditions, accessibility, human and labor resources, agglomeration and economic conditions, market or consumer conditions, population, social, cultural, and environmental conditions, operational costs, the climate of competition and competitors and government factors, regulation and politic stability can be an influencing factor in the placement of distribution office facilities has been considered by researchers in the past 10 years. As we know, the determination of the distribution area for cigarette products must be taken by considering the market and consumer conditions, and it would be more logical to place the distribution office at the center of gravity for areas that have significant market demand. The competition condition factor and competitors are also considered to influence because when the market share of cigarette products is saturated in a certain area, the placement of the distribution office located in that region becomes ineffective in marketing activities. Local government regulations view the position of cigarette products concerning the health of their residents in their governance area, and it will be more effective if the placement of distribution offices is aimed at supporting outlet locations in areas with good regulatory support for the cigarette industry.

4. CONCLUSIONS

Based on the analysis that has been done, the following conclusions are obtained:

1. Based on the intensity homogeneity analysis and distribution suitability analysis, it was found that the distribution pattern of office location points follows the homogeneous poisson process rule, which means that the distribution is influenced by the same factors.
2. Based on the results of the parameter estimation carried out, the results show that the distribution pattern of office location points is influenced by factors of strategic location and

factors of infrastructure availability.

3. Based on poisson regression modeling, it can be concluded that the shorter the distance to the farthest outlet, the higher the selection accuracy will be. Meanwhile, the higher the availability score of a location, the more precise the location point will be to choose. The weight of the infrastructure variable has a greater influence than the variable weight for strategic location. This also means that companies prefer locations that have adequate infrastructure to locations that are closest to outlets.
4. This study also recommends further research to further explore the factors of selecting business facilities with an emphasis on factors outside of this study. Several other factors such as term and conditions of rent, accessibility, human and labor resources, agglomeration and economic conditions, market or consumer conditions, population, social, cultural, and environmental conditions, operating costs, competitors and government factors, regulation,and political stability can become influencing factors in the placement of distribution office facilities has been considered by researchers in the past 10 years.

5. REFERENCES

Alamá-Sabater, L., Artal-Tur, A., & Navarro-Azorín, J. M. (2011). Industrial location, spatial discrete choice models and the need to account for neighbourhood effects. *Annals of Regional Science*. https://doi.org/10.1007/s00168-010-0383-7

Anvari, S., & Turkay, M. (2017). The facility location problem from the perspective of triple bottom line accounting of sustainability. *International Journal of Production Research*. https://doi.org/10.1080/00207543.2017.1341064

Baddeley, A., Rubak, E., & Turner, R. (2015). Spatial Point Patterns. In *Spatial Point Patterns*. https://doi.org/10.1201/b19708

Baddeley, A., & Turner, R. (2005). spatstat: An R package for analyzing spatial point patterns. *Journal of Statistical Software*. https://doi.org/10.18637/jss.v012.i06

Baddeley, A., & Turner, R. (2006). Modelling Spatial Point Patterns in R. In *Case Studies in Spatial Point Process Modeling*. https://doi.org/10.1007/0-387-31144-0_2

Bhat, C. R., Paleti, R., & Singh, P. (2014). A Spatial multivariate count model for firm location decisions. *Journal of Regional Science*. https://doi.org/10.1111/jors.12101

Heizer, J., Render, B., & Munson, C. (2017). The Strategic Importance of Location. In *Operations Management: Sustainability and Supply Chain Management*.

Law, R., Illian, J., Burslem, D. F. R. P., Gratzer, G., Gunatilleke, C. V. S., & Gunatilleke, I. A. U.N. (2009). Ecoogical information from satial patterns of plants: Insights from point process theory. *Journal of Ecology*. https://doi.org/10.1111/j.1365-2745.2009.01510.x

Moser, M. B., Rowland, D. C., & Moser, E. I. (2015). Place cells, grid cells, and memory. *Cold Spring Harbor Perspectives in Biology*. https://doi.org/10.1101/cshperspect.a021808

Mota, I., & Brandão, A. (2013). The determinants of location choice: Single plants versus multi-plants. *Papers in Regional Science*. https://doi.org/10.1111/j.1435-5957.2011.00401.x

Nugroho, W., & Iriawan, N. (2019). Effect of the leakage location pattern on the speed ofrecovery in water supply networks. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/1402/2/022023

Nurzukhrufa, A., Setijanti, P., & Dinapradipta, A. (2018). Factors Influencing Rental Office Selections (Case Studies: Class A Rental Offices Multifunction in Surabaya). *International Journal of Scientific and Research Publications (IJSRP)*. https://doi.org/10.29322/ijsrp.8.7.2018.p7942

Ogata, Y. (1998). Space-time point-process models for earthquake occurrences. *Annals of the Institute of Statistical Mathematics*. https://doi.org/10.1023/A:1003403601725

Rahman, S. M. T., & Kabir, A. (2019). Factors influencing location choice and cluster pattern of manufacturing small and medium enterprises in cities: evidence from Khulna City of Bangladesh. *Journal of Global Entrepreneurship Research*. https://doi.org/10.1186/s40497-019-0187-x

Sang, H., & Gelfand, A. E. (2010). Continuous spatial process models for spatial extreme values. *Journal of Agricultural, Biological, and Environmental Statistics*. https://doi.org/10.1007/s13253-009-0010-1

Xia, G., & Ludwig, S. A. (2016). Object-tracking based on particle filter using particle swarm optimization with density estimation. *2016 IEEE Congress on Evolutionary Computation, CEC 2016*. https://doi.org/10.1109/CEC.2016.7744317

Zandiatashbar, A., Hamidi, S., & Foster, N. (2019). High-tech business location, transportation accessibility, and implications for sustainability: Evaluating the differences between high- tech specializations using empirical evidence from U.S. booming regions. *Sustainable Cities and Society*. https://doi.org/10.1016/j.scs.2019.101648

SUPPLIER SELECTION USING INTEGRATED AHP FUZZY TOPSIS AND MULTI CHOICE GOAL PROGRAMMING (A CASE STUDY IN SHOES MANUFACTURING COMPANY)

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ABSTRACT

Supplier is one part of supply chain that has a role in the continuity of the company. The role of the supplier is to supply the needs of raw materials or services for production or other requirement with the aim that the production or operational activities of company can run smoothly. Supplier selection and order allocation is a strategic decision in procurement especially if the suppliers supply raw materials directly to production activities so thataccuracy in selecting and managing suppliers can improve the company's competitiveness and customer satisfaction. The research focuses on one of the shoe manufacturing companyin Indonesia that produce formal and casual leather shoes. The company experienced delays in one of the raw materials, disrupting the production process where the supplier has a lower performance compared to other raw material suppliers. It is necessary to select the right suppliers within multi-criteria decision making consist of qualitative and quantitative criteria and optimize order allocation in the multiple-sourcing problem. The purpose of this research is to provide an overview of selecting suppliers and order allocation by using AHP fuzzy TOPSIS method and integrate it to the MCGP model. The AHP is applied to weight main criteria and sub-criteria while triangular fuzzy number is used to avoid uncertainty and vagueness of judgement from decision makers. There are 9 main criteria and 17 sub-criteria that have been agreed by experts in the company. The criteria are code of conduct, quality, delivery, cost, technical capability, performance, facilities, flexibility and warranty. Based onthe calculation using fuzzy TOPSIS method, supplier S2 is the best supplier with highest score and optimal order each supplier is obtained by using MCGP.

Keywords: Supplier Selection, Multi Criteria Decision Making, AHP, Fuzzy TOPSIS, Order Allocation, MCGP.

1. INTRODUCTION

Supplier selection and order allocation are strategic decisions in procurement. Estimated 70% of product costs in manufacturing industry came from the cost of raw materials and components. Thus, the accuracy in selecting and managing suppliers determine the success of the company due to increase company competitiveness, bring benefits in reducing purchase costs,increase customer satisfaction, improve product quality and minimize potential risks that will occur (Chopra and Meindl, 2013, Pujawan and Mahendrawathi, 2017, Monczka et al., 2009).

Indonesian footwear products are an important component of the country's economy, which accounted for 2.8 percent of the total non-oil and gas exports of the processing industry in

2019 (statistics.kemendag.go.id, access date 5 December 2020). Indonesia exported 427 million pairs of footwear in 2019, which is the third largest of all countries in the world. Indonesia's footwear exports have grown by an average of 11.2 percent over the past decade which constitutes 3.3 percent of global footwear exports (The World Footwear Yearbook, 2020). This research refers to a shoe manufacturing company in Indonesia that required thermoplastic polyurethane (TPU) outsoles from its suppliers which have been delayed in delivery and disrupted production plans.

Chen and Chao (2012) described two aspects in selecting suppliers, criteria used for suppliers evaluation and the method for selecting suppliers. Each company has its own criteria in selecting suppliers tailored to the needs and interests of the company. Dickson (1966) identified 23 criteria for selecting suppliers based on a survey conducted on 273 purchasing agents, while Weber (1991) obtained 11 criteria related to the Just In Time (JIT) concept after reviewing 74 literatures and Muralidharan (2002) shared nine supplier criteria accompanied by sub-criteria in the bicycle manufacturing case study. Kahraman (2015) argued that multi-criteria decision making is a field of research to solve complex problems involving various criteria and conflicted objectives. The decision maker evaluates a set of alternatives to select the best alternative andthen ranks them from best to worst. Integration of AHP (Analytic Hierarchy Process) and TOPSIS (Technique For Others Preference by Similarity to Ideal Solution) methods was a hybrid approach to solve multi-criteria decision making problems.

The AHP allowed evaluation to be carried out based on weighted objectives through criteria by pair wise comparisons and having the ability to detect inconsistencies.The TOPSIS produces a decision matrix based on qualitative data. Evaluation assessments carried out by experts contain imprecision and subjectivity, furthermore it is necessary to convert them into fuzzy numbers in order to solve the uncertainty of human thinking. The advantages of the AHP fuzzy TOPSIS method are able to solve and simplify supplier evaluation and selection problems and tends to remain consistent if there are additions or changes of new alternatives (Azizi et al., 2015, Kumar et al., 2018, Oroojeni et al., 2020). The integration of the AHP-TOPSIS method is the most popular hybrid approach used in supplier selection problems (Ghorabaee et al, 2017).The TOPSIS method can be used to rank suppliers besides being flexible, systematic and suitable for multi-criteria problems involving the subjectivity of decision makers or problems with uncertainty (Boran et al., 2009).

2. METHOD

2.1 Analytic Hierarchy Process (AHP)

The AHP method has been adopted to solve supplier selection problem. This method was introduced by Saaty (1980). Some of well-known research on supplier selection with the AHP single approach method for example Chan et al (2008) who use the fuzzy AHP method to address global supplier selection and Lee (2009) who examined green supplier evaluation based on fuzzy AHP in high technology industries. The main characteristic of AHP is the used of pair wise comparisons matrix expressed on a numerical scale described in table 1 where the element values are assigned by decision makers or experts.

Table 1. Saaty Scale Definition (1980)

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
Intensity of importance	**Definition**	**Explanation**
3	Somewhat more important	Experience and judgement slightly favor one over the other
5	Much more important	Experience and judgement strongly favor one over the other
7	Very much more important	Experience and judgement very strongly favor one over the other
9	Extremely more important	The evidence favoring one over the other is of the highest possible affirmation
2,4,6,8	Intermediate scores	

The steps of AHP can be constructed in following detail (Chi and Trinh, 2016):

1. Construct hierarchy decision model
2. Construct the pair wise comparation matrix

$$A_{nxn} = \begin{array}{c} A_1 \\ A_2 \\ \vdots \\ A_n \end{array} \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

3. Construct the normalized decision matrix

$$c_{ij} = {a_{ij}}\Big/{\sum_{i=1}^{n} a_{ij}} \quad (2)$$

With i=1, 2, 3... n, j= 1, 2, 3... n

4. Construct the weighted normalized decision matrix

$$w_i = \sum_{j=1}^{n} {c_{ij}}\Big/{n} \quad (3)$$

5. Calculate Eigenvector and row matrix

$$E = {N^{th} rootvalue}\Big/{\sum N^{th} rootvalue} \quad (4)$$

$$Row\ matrik = \sum_{j=1}^{n} a_{ij} \bullet e_{j1} \quad (5)$$

6. Calculate the maximum Eigenvalue

$$\lambda_{max} = {\text{Row matrix}}\Big/{E} \quad (6)$$

7. Calculate the consistency index (CI) and the consistency ratio (CR)

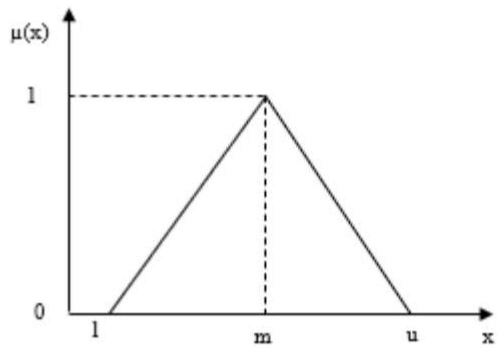
$$CI = {(\lambda_{max} - n)}\Big/{(n-1)} \quad (7)$$

$$CR = {CI}\Big/{RI} \quad (8)$$

If CR > 0.1 than the pair wise comparation matrix must be repeated until CR <= 0.1

2.2 Fuzzy TOPSIS

The concept of fuzzy logic was introduced by Zadeh (1965) for the first time. Fuzzy means vague, fuzzy thinking has a value of fuzziness so that a value can be either true or false simultaneous. Fuzzy logic is associated with uncertainty which is a natural of human being, making it possible to make calculations with vague information (Kannan et al., 2015). The most frequently fuzzy number used is the Triangular Fuzzy Number (TFN), the TFN membership function is consist of three points as shown in figure 1 Ã = (l, m, n).



$$\mu_{A^{\sim}}(x) = \begin{cases} 0, \ x < l \\ \frac{x-l}{m-l} \ l < x < m \\ \frac{u-x}{u-m}, l < x < x \\ 0, u < x \end{cases}$$

l: lowest value or bottom limit

m: middle value

u: highest value or upper limit

Figure 1. Triangular Fuzzy Number

Linguistic variables in rating assessment of supplier selection presented in table 2.

Table 2. Linguistic Variables for Rating Assessment of Supplier (Rouyendegh & Saputro, 2014)

Linguistic Variable		**TFN**
Very Poor	VP	(0,0,1)
Poor	P	(0,1,3)
Medium Poor	MP	(1,3,5)
Fair	F	(3,5,7)
Medium Good	MG	(5,7,9)
Good	G	(7,9,10)
Very Good	VG	(9,10,10)

Yoon and Hwang (1981) introduced the TOPSIS method as a more accurate and reliable approach to multi-criteria decision analysis involving qualitative data containing subjectivity from decision makers due to differences in experience, knowledge and assessment. The TOPSIS method is based on the idea that the optimal solution should have the closest distance from the ideal positive solution and the furthest from the negative ideal solution using Euclidian distance. The TOPSIS method is applied to the process of supplier selection for example research conducted by Memari et al (2019) with the object of automotive catalyst converter manufacturing company. Some studies compared TOPSIS methods with other methods such as ANP, DEMATEL, AHP, it was found that the TOPSIS method provides more consistent and more efficient results to choose alternative suppliers (Büyüközkan and Ifi, 2012, Lima Junior et al, 2014).

The fuzzy TOPSIS can be constructed in following detail:

1. Identify the number of alternatives available, the criteria used and the number of experts.
2. Select the linguistic variable to determine the rating of each supplier

3. Perform aggregation of assessment rating each alternative under the criter

$$\tilde{x}_{ij} = \frac{1}{k}\left(\tilde{x}_{ij}^{1} + \tilde{x}_{ij}^{2} + \cdots + \tilde{x}_{ij}^{k}\right); i = 1,2,\ldots,m; j = 1,2,\ldots,n \tag{9}$$

4. Construct fuzzy decision matrix

$$\tilde{D} = \begin{vmatrix} C_1 & C_2 & \ldots & C_n \\ \tilde{x}_{11} & \tilde{x}_{12} & \ldots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{vmatrix} \tag{10}$$

i=1,2,…,m;j=1,2,…,n

5. Construct normalized fuzzy decision matrix

$$\tilde{R} = \left[\tilde{r}_{ij}\right]_{mxn}, i = 1,2,\ldots,m; j = 1,2,\ldots,n \tag{11}$$

$$\tilde{r}_{ij} = \left(\frac{l_{ij}}{u_j^*}, \frac{m_{ij}}{u_j^*}, \frac{u_{ij}}{u_j^*}\right) \; dimana \; u_j^* = max u_{ij}, \in G1 \tag{12}$$

$$\tilde{r}_{ij} = \left(\frac{u_j^*}{u_{ij}}, \frac{u_j^*}{m_{ij}}, \frac{u_j^*}{l_{ij}}\right) \; dimana \; u_j^* = min\, u_{ij}, \in G2 \tag{13}$$

G1 is beneficial criteria, maximum value is preferred and G2 is non beneficial criteria minimal value is preferred.

6. Construct weighted normalized fuzzy decision matrix

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{mxn}, i = 1,2,\ldots,m; j = 1,2,\ldots,n \tag{14}$$

$$\tilde{v}_{ij} = \tilde{r}_{ij}\, \tilde{w}_j, i = 1,2,\ldots,m; j = 1,2,\ldots,n \tag{15}$$

7. Calculate the distance of each alternative from fuzzy positive ideal solutions (FPIS) and fuzzy negative ideal solutions (FPIN)

$$S^{+} = (\tilde{v}_1^{+}, \tilde{v}_2^{+}, \ldots, \tilde{v}_n^{+}) \tag{16}$$

$$S^{-} = (\tilde{v}_1^{-}, \tilde{v}_2^{-}, \ldots, \tilde{v}_n^{-}) \tag{17}$$

$$\tilde{v}_n^{+} = max\{v_{ij}\} \; dan \; \tilde{v}_n^{-} = min\{v_{ij}\}$$

8. Calculate the distance FPIS (d^+) and FPIN (d^-)

$$d(A_1, A_2) = \sqrt{\frac{1}{3}\left[(l_1 - l_2)^2 + (m_1 - m_2)^2 + (u_1 - u_2)^2\right]}$$

$$d_i^{+} = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^{+}), i = 1,2,\ldots,m \tag{18}$$

$$d_i^{-} = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^{-}), i = 1,2,\ldots,m \tag{19}$$

9. Calculate the closeness coefficient CCi and determine rank of alternatives

$$CC_i = \frac{d_i^{-}}{(d_i^{-} + d_i^{+})}, i = 1,2,\ldots,m \tag{20}$$

The higher CC_i the higher rank of supplier

2.3 MCGP

Multi Choice Goal Programming (MCGP) is used for multi-objective decision that allow decision makers to set aspiration levels. The use of MCGP is to help decision makers to determine the appropriate level of aspiration so that it can be obtained a viable potential area (Chang, 2008). The result of Cci from the previous stage will be used as input to the decision variable Xi. The steps of MCGP can be constructed in following detail:

1. Decision variable
   Xi number of supplier orders i
   Yi is a binary integer, a value of 1 if the order is supplied by supplier i and a value of 0 if it is not supplied.
2. The objective function is the minimization of the total number of deviations based on the equation
   $Min\ Z = d_1^+ + d_1^- + d_2^+ + d_2^- + d_3^+ + d_3^- + d_4^+ + d_4^- + e_1^+ + e_1^- + e_2^+ + e_2^- + e_3^+ + e_3^- + e_4^+ + e_4^-$
   a. Determine the goal and constraint to minimize the total purchasing cost
   $Min\ Z_1 = \sum_{i=1}^{n} C_i X_i + O_i Y_i + d_1^- - d_1^+ \geq g_{1min}\ or\ g_{1max}$ (21)
   b. Determine the goal and constraint to maximize the total purchase value
   $Min\ Z_2 = \sum_{i=1}^{n} CC_i X_i + d_2^- - d_2^+ \geq g_{2min}\ or\ g_{2max}$ (22)
   c. Determine the goal and constraint to minimize the number of tardiness
   $Min\ Z_3 = \sum_{i=1}^{n} p_i X_i + d_3^- - d_3^+ \geq g_{3min}\ or\ g_{3max}$ (23)
   d. Determine the goal and constraint to minimize defective raw material
   $Min\ Z_4 = \sum_{i=1}^{n} q_i X_i + d_4^- - d_4^+ \geq g_{4min}\ or\ g_{4max}$ (24)
   e. Determine the goal and constraint to minimize return cost
   $Min\ Z_5 = \sum_{i=1}^{n} r_i X_i + d_5^- - d_5^+ \geq g_{5min}\ or\ g_{5max}$ (25)
   f. Define demand constraint
   $\sum_{i=1}^{n} X_i = D$ (26)
   g. Define capacity constraint
   $X_i \leq S_i Y_i\ ,\ i = 1,2,\dots,n$ (27)
   h. Specifies non negative and binary boundaries
   $X_i \geq 0\ and\ integer;\ i = 1,2,\dots,n$ (28)
   $Y_i = 0\ or\ 1\ ;\ i = 1,2,\dots,n$ (29)

Parameter:
d_i^+, d_i^- : Minimum and maximum deviation of goal j
e_i^+, e_i^- : Minimum and maximum deviation of goal $y_i - g_{imax/min}$
g_i: Aspiration level of experts
C_i: Price of raw material suppliers i
O_i: Cost of ordering suppliers i
p_i: Rate of delivery delay of raw materials for supplier i
q_i: Rate of delivery defect of raw materials for supplier i
r_i: Cost of returning the supplier's defective product i
D: Demand
S_i : Capacity of suppliers i

3. RESULT AND DISCUSSION

3.1 Result of AHP Fuzzy TOPSIS

In order to fulfill the demand for TPU outsole, the company has 4 suppliers, S1 and S2 located in Indonesia, S3 and S4 located overseas. There are 5 experts involved in the procurement process of TPU outsole came from the department of purchasing, planning, quality control and quality assurance. The proposed new criteria were obtained from five existing criteria added with new criteria based on the research of Dickson (1996), Weber (2001), Muralidharan (2002) and input from experts in shoe the company. There are nine main criteria and seventeen sub-criteria were concluded based on the agreement of the experts as figure 2.

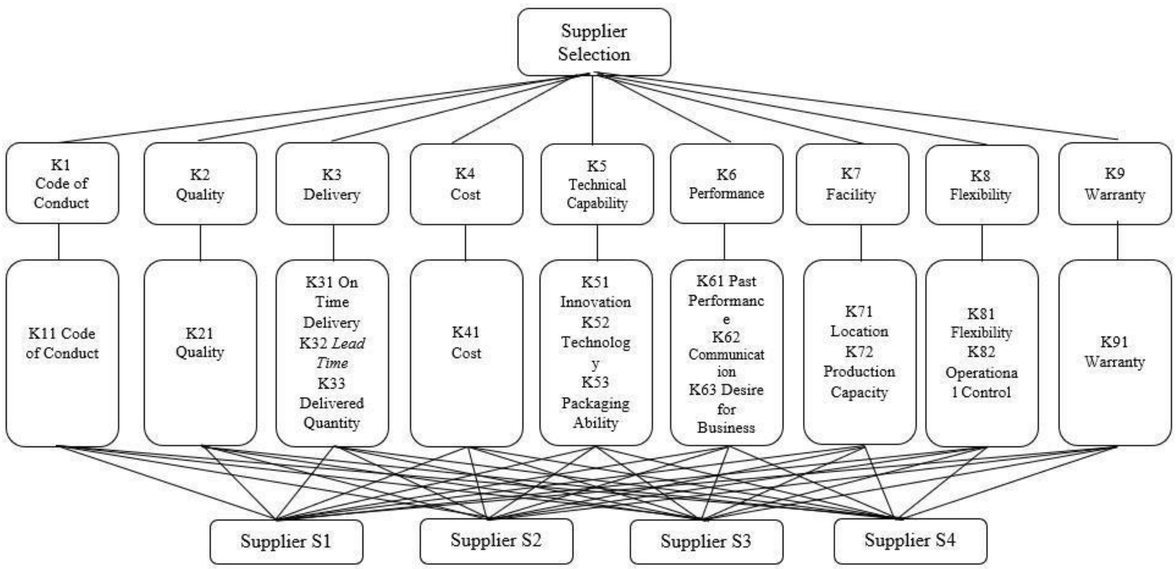


Figure 2. Hierarchy Decision Model with Main Criteria and Sub-criteria

The weight of the main criteria and sub-criteria is obtained from questionnaires against five respondents with pair wise matrix assessment using the AHP method and calculated byExpert Choice^{TM} software described in figure 3 and 4. The highest criteria weight is code of conduct (0.36) followed by quality (0.175), delivery (0.118), facilities (0.102) and technicalcapabilities (0.077) while the criteria with the lowest weight are performance (0.036) and flexibility (0.04).

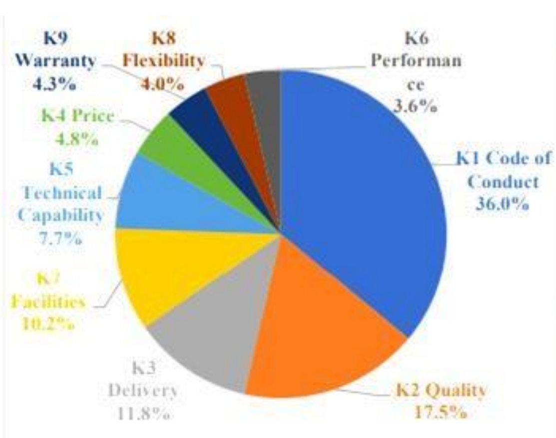


Figure 3. Weight percentage of main criteria

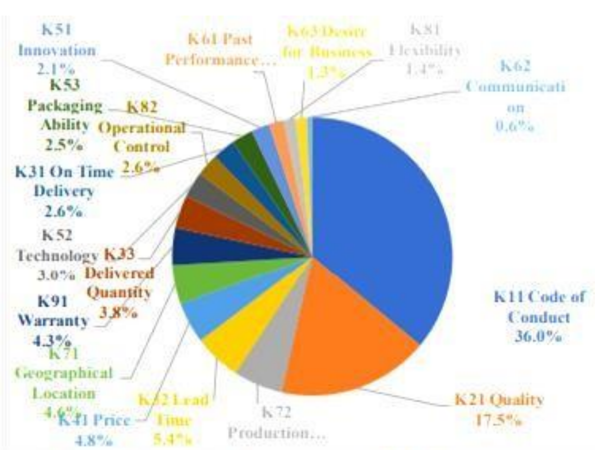


Figure 4. Weight percentage of sub-criteria

Based on data collection and assessment of supplier rating on each sub-criteria each expert, fuzzy TOPSIS performed by aggregating fuzzy rating and weight of sub-criteria from previous AHP stage presented by table 3.

Tabel 3. Normalized Fuzzy Decision Matrix

No	Sub-criteria	Supplier												Weight
		S1			S2			S3			S4			
K11	Code of Conduct	0.82	0.96	1.00	0.74	0.92	1.00	0.62	0.82	0.96	0.62	0.82	0.96	0.360
K21	Quality	0.86	0.98	1.00	0.78	0.94	1.00	0.62	0.82	0.96	0.62	0.82	0.96	0.175
K31	On Time Delivery	0.67	0.88	1.00	0.67	0.88	1.00	0.63	0.84	0.98	0.55	0.76	0.94	0.026
K32	Lead Time	0.50	0.70	0.88	0.74	0.92	1.00	0.58	0.78	0.94	0.54	0.74	0.90	0.054
K33	Delivered Quantity	0.70	0.90	1.00	0.70	0.90	1.00	0.70	0.90	1.00	0.70	0.90	1.00	0.038
K41	Price	0.42	0.62	0.82	0.66	0.86	0.98	0.54	0.74	0.92	0.74	0.92	1.00	0.048
K51	Innovationon	0.90	1.00	1.00	0.82	0.96	1.00	0.62	0.82	0.96	0.58	0.78	0.94	0.021
K52	Technology	0.90	1.00	1.00	0.78	0.94	1.00	0.58	0.78	0.94	0.58	0.78	0.94	0.030
K53	Packaging Ability	0.70	0.90	1.00	0.70	0.90	1.00	0.70	0.90	1.00	0.66	0.86	0.98	0.025
K61	Past Performance	0.74	0.92	1.00	0.70	0.90	1.00	0.62	0.82	0.96	0.54	0.74	0.92	0.017
K62	Communication	0.58	0.78	0.94	0.74	0.92	1.00	0.66	0.86	0.98	0.50	0.70	0.90	0.006
K63	Desire for Business	0.66	0.86	0.98	0.90	1.00	1.00	0.70	0.90	1.00	0.62	0.82	0.96	0.013
K71	Location	0.78	0.94	1.00	0.78	0.94	1.00	0.58	0.78	0.94	0.42	0.62	0.82	0.046
K72	Production Capacity	0.50	0.70	0.90	0.70	0.90	1.00	0.62	0.82	0.96	0.58	0.78	0.94	0.057
K81	Flexibility	0.34	0.54	0.74	0.74	0.92	1.00	0.54	0.74	0.92	0.58	0.78	0.94	0.014
K82	Operational Control	0.62	0.82	0.94	0.74	0.92	1.00	0.62	0.82	0.96	0.58	0.78	0.94	0.026
K91	Warranty	0.67	0.88	1.00	0.67	0.88	1.00	0.63	0.84	0.98	0.63	0.84	0.98	0.043

The data is weighted, further performed FPIS and FPIS and calculated distance of each alternative presented in table 4.

Table 4. Rank of alternative supplier

Supplier	d^+	d^-	Cci	Rank
S1	0.17	0.31	0.65	2
S2	0.16	0.32	0.67	1
S3	0.25	0.26	0.51	3
S4	0.26	0.25	0.50	4

Sensitivity analysis conducted to find out the effect of parameters due to inequality the weight of sub-criteria and experts assessment using 11 case scenarios taking into account as following in table 5.

Table 5. Sensitivity Analysis using 11 Cases Scenarios

No	Expert, Sub-criteria	S1	S2	S3	S4	Rank
Case 1	A1,A2,A3 - K11,21, 32, 61, 62, 63, 72, 81	0.68	0.66	0.51	0.48	S4<S3<S2<S1
Case 2	A3,A4, A5 - K11,21, 32, 61, 62, 63, 72, 81	0.73	0.69	0.51	0.51	S4,S3<S2<S1
Case 3	A2,A3, A4 - K11,21, 32, 61, 62, 63, 72, 81	0.66	0.67	0.49	0.46	S4<S3<S1<S2
Case 4	All Expert - K11,21, 32, 61, 62, 63, 72, 81	0.67	0.68	0.50	0.49	S4<S3<S1<S2
Case 5	A1,A2,A3 - K31, 33, 41, 51, 52, 53, 71, 82, 91	0.59	0.67	0.51	0.52	S3<S4<S1<S2
Case 6	A3,A4, A5 - K31, 33, 41, 51, 52, 53, 71, 82, 91	0.61	0.65	0.53	0.52	S4<S3<S1<S2
Case 7	A2,A3, A4 - K31, 33, 41, 51, 52, 53, 71, 82, 91	0.61	0.68	0.53	0.50	S4<S3<S1<S2
Case 8	All Expert - K31, 33, 41, 51, 52, 53, 71, 82, 91	0.61	0.67	0.53	0.52	S4<S3<S1<S2
Case 9	A1,A2,A3 - all sub-criteria	0.65	0.66	0.51	0.49	S4<S3<S1<S2
Case 10	A3,A4, A5 - all sub-criteria	0.68	0.69	0.51	0.50	S4<S3<S1<S2
Case 11	A2,A3, A4 - all sub-criteria	0.65	0.67	0.50	0.47	S4<S3<S1<S2

The result of CCi from table 5 visualize into radar graph as figure 4. It was obtained that supplier S2 get 10 times the highest thus can be concluded that supplier S2 is consistent as the most preferred suppliers and S4 suppliers is the most disliked suppliers consistently.

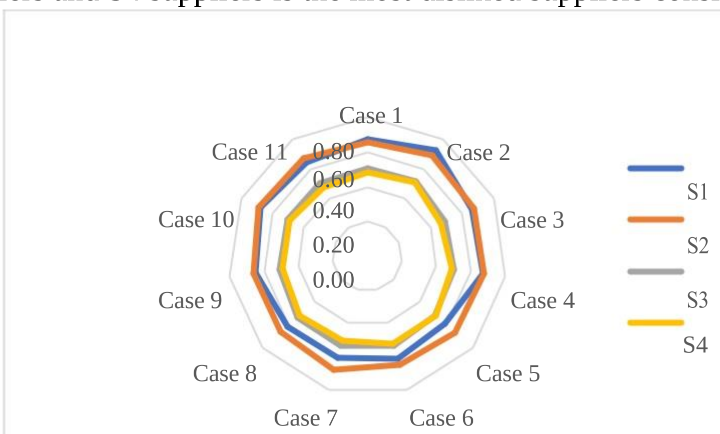


Figure 4. Sensitivity Analysis on Supplier Rating

3.2 Result of MCGP

Allocating orders of each suppliers determined with MCGP using Lingo program as following formulated model:

$$Min\ Z = d_1^- + d_2^+ + d_3^- + d_4^- + e_1^+ + e_1^- + e_2^+ + e_2^- + e_3^+ + e_3^- + e_4^+ + e_4^-$$

$$Min\ Z_1 = \sum_{i=1}^{n} C_i X_i + O_i Y_i + d_1^- = y_1$$

The purchasing manager estimated the total purchase does not exceed USD 2,000,000 and expected to make savings with the total expected purchase cost of USD 1,950,000. The price per unit of raw materials is USD 2.3 (supplier S1), USD 2.25 (supplier S2), USD 2.18 (supplier S3) and USD 2.33 (supplier S4). Purchasing value each order expected USD 162,500

$$2.3X_1 + 162{,}500Y_1 + 2.25X_2 + 162{,}500Y_2 + 2.18X_3 + 162{,}500Y_2 + 2.33X_4 + 162{,}500Y_2 + d_1^- = y_1$$

$y_1 - e_1^+ + e_1^- = 1{,}950{,}000$
$1{,}950{,}000 \leq y_1 \leq 2{,}000{,}000$
CCi value from calculation integrated into model.
$Min\ Z_2 = \sum_{i=1}^{n} CC_i X_i + d_2^- = y_2$
$0.65X_1 + 0.67X_2 + 0.51X_3 + 0.5X_4 + d_2^- >= 162{,}500$
Percentage tardiness each supplier integrated into model. Expected tardiness min 4% and max 7%
$Min\ Z_3 = \sum_{i=1}^{n} p_i X_i + d_3^- - d_3^+ \geq g_{3min}\ atau\ g_{3max}$
$0.06X_1 + 0.05X_2 + 0.08X_3 + 0.08X_4 + d_3^- \geq y_2$
$y_2 - e_2^+ + e_2^- = P_{min} D$
$y_2 - e_2^+ + e_2^- = 0.04.851{,}000$
$P_{min} D \leq y_2 \leq P_{max} D$
$0.04.851{,}000 \leq y_2 \leq 0.07.851{,}000$
$Min\ Z_4 = \sum_{i=1}^{n} q_i X_i + d_4^- \geq y_3$
Percentage defective material each supplier integrated into model. Expected defective percentage min 0.5% and max 2%
$0.02X_1 + 0.02X_2 + 0.03X_3 + 0.03X_4 + d_4^- \geq y_3$
$y_3 - e_3^+ + e_3^- = Q_{min} D$
$y_3 - e_3^+ + e_3^- = 0.005.851{,}500$
$Q_{min} D \leq y_3 \leq Q_{max} D$
$0.005.851{,}500 \leq y_3 \leq 0.02.851{,}500$

$Min\ Z_5 = \sum_{i=1}^{n} r_i X_i + d_5^- \geq g_{5min}$
Return cost each each supplier integrated into model. Expected min cost return material min 0.02 and max 0.04.
$0.01X_1 + 0.01X_2 + 0.07X_3 + 0.09X_4 + d_4^- - d_4^+ \geq y_4$
$y_4 - e_4^+ + e_4^- = r_{min} D$
$y_4 - e_4^+ + e_4^- = 0.02 * 851{,}000$
$r_{min} D \leq y_4 \leq r_{max} D$
$0.02 * 851{,}000 \leq y_4 \leq 0.03 * 851{,}000$
$\sum_{i=1}^{n} X_i = D$
$X_1 + X_2 + X_3 + X_4 = 425{,}000$
$X_i \leq S_i Y_i\ dimana\ i = 1,2,\dots,n$
$X_1 \leq 150{,}000.\,y_1$
$X_2 \leq 300{,}000.\,y_2$
$X_3 \leq 200{,}000.\,y_3$
$X_4 \leq 250{,}000.\,y_4$
$X_i \geq 0\ and\ integer;\ i = 1,2,\dots,n$
$Y_i = 0\ or\ 1\ ;\ i = 1,2,\dots,n$

Lingo software used to solve the model. The optimal solution X1 (S1) =150,000, X2 (S2) = 300,000, X3 (S3) = 200,000 and X4 (S4) = 201,000. The goal is satisfied and it was obtained total cost purchasing is 1,924,330.

4. CONCLUSION

This research integrated supplier selection problem solving using AHP fuzzy TOPSIS method and allocation order problem solving using MCGP method in multiple sourcing environment. The AHP method is used to determined the weight of each main-criteria and sub-criteria. The fuzzy triangle number is used to solve the uncertainty of human nature and the

TOPSIS method is implemented to obtain supplier rankings, supplier with highest rank is consideres as most preferable supplier. The closeness coefficients of each supplier is used as an input into the MCGP model to determine order allocation.

The main criteria and sub-criteria in this study were obtained from pre-existing criteria added by input from experts in shoe manufacturing company and previous studies. Nine main criteria and seventeen sub-criteria were concluded based on the agreement of the experts, then the pair wise comparation matrix was carried out using the AHP method and data processing with the Expert Choice^{TM} software. It was found that the main criteria are code of conducts (0.36), quality (0.175), delivery (0.118), facilitiy (0.102), technical capability (0.077), cost (0.048), warranty (0.043), flexibility (0.04) and performance (0.036).

Evaluation and supplier selection was carried out using the fuzzy TOPSIS method where the experts assess each supplier using linguistic variables which are then processed using Microsoft Excel software. Based on data processing, it was found that S2 supplier was the best supplier by achieving the closeness coefficient CCi of 0.67. The second ranked supplier is S1(CCi 0.65), followed by the third rank S3 (CCi 0.51) and finally S4 (CCi 0.5). Then a sensitivity analysis was conducted to investigate the effect of criteria weight and expert assestment on supplier ranks. Based on 12 scenarios, it is found that supplier S2 achieves 6 times the highest yield of proximity coefficient, so it can be concluded that supplier S2 is the most preferred supplier and supplier S4 is the least preferred supplier.

This paper refer to multiple sourcing problem where there is no single supplier that can meet the needs of a manufacturing company, thus the distribution of order for each supplier is needed, in this case using the MCGP method to enable experts to achieve many objective functions. The objective function such us minimize procurement costs, minimize delivery time and maximize the total value of purchases with limited capacity and demand. CCi values are integrated into the MCGP model. The model was solve using Lingo software and it was obtained order allocation is X1 (S1) =150,000, X2 (S2) = 300,000, X3 (S3) = 200,000 dan X4 (S4) = 201,000. The goal is satisfied and it was obtained total cost purchasing is 1,924,330.

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6. REFERENCES

Azizi, A., Aikhuele, D. O., & Souleman, F. S. (2015). A Fuzzy TOPSIS Model to Rank Automotive Suppliers. *Procedia Manufacturing*, *2*(February), 159–164.

Boran, F. E., Genç, S., Kurt, M., & Akay, D. (2009). A multi-criteria intuitionistic fuzzy group decision making for supplier selection with TOPSIS method. *Expert Systems with Applications*

Büyüközkan, G., & Ifi, G. (2012). A novel hybrid MCDM approach based on fuzzy DEMATEL, fuzzy ANP and fuzzy TOPSIS to evaluate green suppliers. *Expert Systems with Applications*

Chan, F. T. S., Kumar, N., Tiwari, M. K., Lau, H. C. W., & Choy, K. L. (2008). Global supplier selection: A fuzzy-AHP approach. *International Journal of Production Research*, *46*(14)

Chang, C. Ter. (2008). Revised multi-choice goal programming. *Applied Mathematical Modelling*, *32*(12), 2587–2595

Chen, C. T., Lin, C. T., & Huang, S. F. (2006). A fuzzy approach for supplier evaluation and selection in supply chain management. *International Journal of Production Economics,*

Chen, Y. H., & Chao, R. J. (2012). Supplier selection using consistent fuzzy preference relations. *Expert Systems with Applications*, *39*(3), 3233–3240.

Chi, H. T. X., & Trinh, D. H. N. (2016). Supplier selection by Using AHP-TOPSIS and Goal Programming-A case Study in Casumina Rubber Company-Vietnam. *MATEC Web of Conferences*, *68*, 6–10.

Chopra, S., & Meindl, P. (2013). *Supply Chain Management, 5th Edition*.

Dickson, G. W. (1966). An Analysis Of Vendor Selection Systems And Decisions. *Journal of Purchasing*.

Ghorabaee, M. K., Amiri, M., Zavadskas, E. K., & Antucheviciene, J. (2017). Supplier evaluation and selection in fuzzy environments: A review of MADM approaches. *Economic Research-Ekonomska Istrazivanja*

Hwang, C. L., & Yoon, K. (1981). Multiple attribute decision making: Methods and applications.Springer-Verlag.

Kahraman, C., Onar, S. C., & Oztaysi, B. (2015). Fuzzy Multicriteria Decision-Making: A Literature Review. *International Journal of Computational Intelligence Systems*, *8*(4)

Kannan, D., De Sousa Jabbour, A. B. L., & Jabbour, C. J. C. (2014). Selecting green suppliers based on GSCM practices: Using Fuzzy TOPSIS applied to a Brazilian electronics company. *European Journal of Operational Research*, *233*(2), 432–447.

Lee, A. H. I., Kang, H. Y., Hsu, C. F., & Hung, H. C. (2009). A green supplier selection model for high- tech industry. *Expert Systems with Applications*, *36*(4), 7917–7927.

Lima Junior, F. R., Osiro, L., & Carpinetti, L. C. R. (2014). A comparison between Fuzzy AHP and Fuzzy TOPSIS methods to supplier selection. *Applied Soft Computing Journal*

Memari, A., Dargi, A., Akbari Jokar, M. R., Ahmad, R., & Abdul Rahim, A. R. (2019). Sustainable supplier selection: A multi-criteria intuitionistic fuzzy TOPSIS method. *Journal of Manufacturing Systems*, *50*(September 2018), 9–24.

Monczka, R. M., Handfield, R. B., Giunipero, L. C., & Patterson, J. L. (2009). Purchasing and Supply Chain Management (ISBN: 9780324381344). In *Learning*.

Muralidharan, C. (2002). *A Multi-Criteria Group Decisionmaking*. 22–35.

Pujawan, I, N., Mahendrawathi. (2017). Supply Chain, Management 3rd Ed. Penerbit Guna Widya, Surabaya.

Oroojeni Mohammad Javad, M., Darvishi, M., & Oroojeni Mohammad Javad, A. (2020). Green supplier selection for the steel industry using BWM and fuzzy TOPSIS: A case study of Khouzestan steel company. *Sustainable Futures*, *2*, 100012.

Rouyendegh (Babek Erdebilli), B. D., & Saputro, T. E. (2014). Supplier Selection Using Integrated Fuzzy TOPSIS and MCGP: A Case Study. *Procedia - Social and Behavioral Sciences*, *116*, 3957–3970.

Saaty, T. L. (1990). How to make a decision: The analytic hierarchy process. *European Journal of Operational Research*, *48*(1), 9–26.

Weber, C. A., Current, J. R., & Benton, W. C. (1991). Vendor selection criteria and methods. *European Journal of Operational Research*, *50*(1), 2–18

DESIGN OF SUPPLIER SELECTION OF PURPLE PASSION FRUIT OF SYRUP INDUSTRIES SME

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ABSTRACT

One way to stay competitive in the market is to increase customer satisfaction by offering better quality products than competitors. Raw materials are among the ones that have a major impact in supporting product quality, especially in the food and beverage industry. CV. X is an SME engaged in passion fruit syrup industry and is one of the pioneers in the establishment of passion fruit syrup manufacturing industry in South Sulawesi, since 1961. Passion fruit syrup is made from processed purple passion fruit, which is susceptible to plant parasites, compounded with its harvest season that is only in certain months. The problem that is often faced by CV. X, is the lack of supply of the main raw material, namely the purple passion fruit caused by single supplier system implemented by CV.X. The owner of CV. X is considering implementing multiple sourcing to meet customer needs. As CV. X is very selective in maintaining products‟ quality, it needs to identify the criteria that comply with the company standards regarding purple passion fruit as the raw material to be used in evaluating and selecting multiple suppliers. This research focusses on designing the proposed criteria to evaluate the potential suppliers of purple passion fruit using the integration of Delphi technique and Step-Wise Weight Assessment Ratio Analysis (SWARA) method. The purpose of thisstudy is to design a list of criteria and sub-criteria to evaluate the suppliers of purple passion fruit in the syrup beverage industry SME using the Delphi technique, as well as the weighting and ranking of priorities for each evaluation criteria and sub-criteria using the SWARA method. This research proposes 6 main criteria namely quality, price, service, delivery, warranty & claims policy, and management & operation. And also 22 sub criteria including standard physical characteristics on purple passion fruit.

Keywords: Evaluation Criteria, Purple Passion Fruit, Supplier Selection, Delphi, SWARA

1. INTRODUCTION

In maintaining and improving product quality, the company strives to optimize supply chain processes that often involve cooperation between economic actors outside the company including cooperation with suppliers of raw materials. Raw materials are among the major impacts in supporting the quality of products, especially in the food and beverage industry. Because food and beverage processing is basically a business with the main raw materials derived from plants and plantation products (Wibowo, Prihatminingtyas, and Susanto 2014). Fulfillment of good quality raw materials is certainly inseparable from the role of suppliers as the main actors. Raw materials are generally supplied by one or several different suppliers. In conditions where the company has several different suppliers on one type of raw materials, of course it will have different quality of raw materials. According to Jain et al., (2018) Suppliers that provide low quality raw materials for the production of a product, in this case food and beverage products that are actually sold to the end customer will have lower quality, so as to affect the company's reputation in the eyes of consumers and will negatively affect the business.

CV. X is an SME engaged in the passion fruit syrup beverage industry and one of the pioneers of the establishment of passion fruit syrup industry one of the fruits in Makassar South Sulawesi since 1961. Problems often encountered by CV. X is the lack of supply of the main raw material that is purple passion fruit caused by CV. X has been implementing a single supplier system that only comes from CV. X's garden. With only one supplier cv owner has difficulty to fulfill the order if the passion fruit harvest from his garden is insufficient. Therefore, CV owners need supplies from suppliers outside of their own gardens and do not currently have a supplier selection system.

Boran et al. (2009) in Gama, Alves, and Oliveira (2020) confirms to get a good supplier, it takes a process to get suppliers with quality products or raw materials, at the right price, at the right time, and in the right amount. In this research will be carried out development in designing proposed criteria to evaluate prospective suppliers of purple passion fruit raw materials in the SME syrup beverage industry CV. X to evaluate suppliers by using MCDM method integration approach. Determination of evaluation criteria and sub-criteria in this studyby adopting and modifying the criteria contained in some literature research used as other consideration criteria for supplier evaluation, such as in the research model conducted by Alfaris & Qurtubi, (2019) which uses dickson criteria (1966) then entering the quality sub-criteria related to the physical characteristics of raw materials to comply with the standards of their company evaluation criteria. Similarly, quality criteria in this study will also be added several sub criteria of physical characteristics of purple passion fruit for supplier evaluation of literature.

Because of the many criteria in supplier evaluation and to choose criteria that are in accordance with the standards of the company's evaluation criteria, therefore it takes someopinions from experts in the company related to the procurement of raw materials and the selection of suppliers to choose which criteria are important and in accordance with the standards of their company evaluation criteria. , This research will also adopt previous research conducted by Karabasevic et al., (2017) through the integration of Delphi's technical approach and step-wise weight assessment ratio analysis (SWARA) method as the basis for development indifferent scopes. In this integrated approach, Delphi technique is a method that considers the opinions of experts and is used to replace some of the initial steps of the SWARA method, or rather it is said to replace the steps related to the determination of the list of evaluation criteria (Karabasevic et al., 2017). Decision makers in the company will be given a set of criteria and sub-criteria for supplier selection to be evaluated according to the standards of their company evaluation criteria, then given the weighting of interests for the criteria that have been determined that will be used by the company to evaluate and rank potential suppliers later in their selection process.

2. LITERATURE STUDY

2.1 Delphi Method

Delphi's method began in a series of experiments conducted in the 1950s by the RAND Corporation. The goal is to establish techniques to obtain the most accurate and precise consensus from a group of experts (Dalkey and Helmer, 1963) in (Okoli and Pawlowski 2004). The Delphi method is an iterative or repetitive procedure that uses a collection of questionnaires interspersed with suggestions or feedback to collect and filter the assessments of experts. The questionnaire is to reflect situations, ideas, alternatives, or predictions. Based on the results of the previous questionnaire will be developed for the creation of the next questionnaire. When the research question is resolved, then the mechanism will stop: for example, theoretical saturation is achieved when consensus is reached, or when sufficient knowledge and information has been shared(Garatti et al. 2002).

There are several processes or procedures that must be passed in the delphi, Linstone and Turoff method process (1975) in Skinner et al. (2015) dividing the Delphi method procedure into four stages, namely as follows:

Stage 1: explore the subject under discussion. Each individual may contribute providing additional relevant information if necessary.

Stage 2: an understanding of how the group sees an issue (i.e., where members agree or disagree, what is a relative term such as interests, desires, feasibility, etc.).

Stage 3: If there is substantial disagreement, then analyze it to determine the underlying cause of the disagreement and evaluate it

Stage 4: Final assessment is carried out after all previously obtained data is evaluated and the evaluation has been given back to the panelists.

Then the 4 phases are broken down and categorized into three main stages, namely the exploration stage, the distillation stage, and the utilization stage

2.2 Step-Wise Weight Assessment Ratio Analysis (SWARA) Method

Step-wise Weight Assessment Ratio Analysis (SWARA) is one of the new methods in Multi Criteria Decision Making (MCDM). SWARA was first introduced by Keršuliene et al., (2010) to evaluate and weight the criteria. Keršuliene et al., (2010) said that the main titur of the SWARA method is the ability to engage the opinions of experts or interest groups about the ratio of attribute significance in their weighting process. In contrast to the famous AHP method, Stanujkic et al. (2015) in Karabasevic et al., (2017) also specifically emphasizes the advantages of the SWARA method over AHP, which is largely due to the relatively smaller number of pairwise comparisons n-1, which is why the SWARA method is much easier to implement. The steps of the SWARA method are summarized in Işik and Adali, (2016) following (Keršulienė and Turskis, 2011; Zolfani and Saparauskas, 2013; Zolfani and Banihashemi, 2014) as follows:

Step 1: Decision criteria are determined and each decision maker ranks all criteria from the best to the worst based on their own knowledge and experience. Aggregate rankings are determined by the total score given by the decision maker for each criterion. The criteria are denoted by C_j ($j = 1, 2, .., n$). C_1 and C_n are the best and worst criteria taking into account aggregate rankings.

Step 2: Each decision maker determines the comparative importance of the criteria taking into account aggregate rankings. Then calculated the average value of comparative interests (s_j). For example s_1 indicates the average comparative importance (s_j)between the first (previous) and second important criteria (after).

Step 3: The coefficient of each criterion (k_j)is calculated as follows:

$$k_j = \begin{cases} 1 & \text{if } j = 1 \\ s_j + 1 & \text{if } j > 1 \end{cases} \quad \text{..(1)}$$

Step 4: The weight of each criterion (w_j)is found to be:

$$w_j = \begin{cases} 1 & \text{if } j = 1 \\ \dfrac{w_{j-1}}{k_j} & \text{if } j > 1 \end{cases} \quad \text{..(2)}$$

Step 5: The weight (w_j) found in the previous step is divided by the amount. The result is the final weight of each criterion (q_j).

$$q_j = \frac{w_j}{\sum w_j} \quad \text{..}(3)$$

3. RESULTS AND DISCUSSION

3.1 Designing Criteria and Sub Criteria Evaluation

Stages of designing criteria and sub-criteria by collecting and selecting criteria and sub-criteria on the evaluation of suppliers of purple passion fruit raw materials in the SME passion fruit syrup beverage industry through a literature review of previous research related to criteria in supplier evaluation. The selection of criteria and sub-criteria is based on several previous studies that also discuss evaluation criteria in general, especially on SME objects, including Dickson (1966), Weber et al. (1991), Banaeian et al., (2015), Anggrahini et al. (2018), Ramlan et al.(2016), and Taufik et al., (2014), and Hutabarat et al. (2016) discussing the standards of physical characteristics in purple passion fruit. The criteria and sub-criteria used in the previous researchare different, so in this study, the selection of appropriate criteria and sub-criteria will be used by the company in the supplier evaluation process.

Table 1. Summary of proposed main criteria in supplier evaluation of literature review

No.	**Criteria**	**Dickson (1966)**	**Weber et al. (1991)**	**Banaeian *et al.*, (2015)**	**Anggrahini et al. (2018)**	**Ramlan et al. (2016)**
1.	Quality	√	√	√	√	√
2.	Price	√	√	√	√	√
3.	Service	√	√	√		√
4.	Delivery	√	√	√	√	√
5.	Warranty and claim policy	√			√	
6.	Operations manajement	√	√			√

There are 6 main criteria namely quality, price, service, delivery, warranty & claims policy, and management &operation. The main criteria are then used to group the sub-criteria to be used in supplier evaluation.

Table 2. Summary of proposed sub criteria in supplier evaluation of literature review

Criteria	**Sub Criteria**		**Reference**
Quality	K1	Physical characteristics of purple passion fruit:` - Weight: 42.6-60.4 gr - Color : Dark Purple - Aroma : Distinctive flavor of passion fruit - Shape : Not perfectly	Hutabarat et al. (2016)
	K2	Supplier's ability to be consistent with	Taufik et al., (2014),

		quality standards	Anggrahini et al. (2018)
	K3	Low fruit defect rate	Taufik et al., (2014), Ramlan et al. (2016)
	K4	Packaging quality when delivering fruit	Dickson (1966), Banaeian et al., (2015)
Price	H1	Suitability of passion fruit offer price with market price	Dickson (1966), Weber et al., (1991), Banaeian et al., (2015), Taufik et al., (2014), Anggrahini et al. (2018), Ramlan et al. (2016)
	H2	Payment method (term)	Taufik et al., (2014)
	H3	Discounted price of passion fruit	Anggrahini et al. (2018)
	H4	Shipping transportation costs	Anggrahini et al. (2018), Banaeian et al., (2015), Ramlan et al. (2016), Taufik et al., (2014) , ,
Service	L1	Fulfillment of capacity (quantity) of passion fruit supply	Dickson (1966), Weber et al. , , (1991), Banaeian et al., (2015), Taufik et al., (2014), Anggrahini et al. (2018), Ramlan et al. (2016)
	L2	Fast response & easy communication with suppliers	Dickson (1966), Banaeian et al., (2015), Taufik et al., (2014), Anggrahini et al. (2018), Ramlan et al. (2016) , ,
	L3	Attitude & impression of suppliers in the purchasing process	Dickson (1966), Banaeian et al., (2015), Taufik et al., (2014),, Ramlan et al. (2016)
	L4	Follow-up of the purchasing process according to the procedure	Dickson (1966), Banaeian et al., (2015), Ramlan et al. (2016) ,
Delivery	P1	On-time delivery	Dickson (1966), Weber et al. , , (1991), Banaeian et al., (2015), Taufik et al., (2014), Anggrahini et al. (2018), Ramlan et al. (2016)
	P2	Flexibility on delivery time and number of orders	Dickson (1966), Weber et al. (1991), Banaeian et al., (2015), Taufik et al., (2014), Anggrahini et al. (2018) ,
	P3	Frequency (history) of shipment of passion fruit	Dickson (1966), Weber et al. (1991), Taufik et al., (2014)
	P4	Types of transportation	Dickson (1966), Weber et

			al. (1991), Taufik et al., (2014), Banaeian et al., (2015) ,
Warranty & claim policy	G1	Supplier response to low quality passion fruit claims	Dickson (1966), Banaeian et al., (2015), , Anggrahini et al. (2018), Ramlan et al. (2016)
	G2	Low quality or defective passion fruit replacement compensation	Dickson (1966), Banaeian et al., (2015), Taufik et al., (2014),, , Anggrahini et al. (2018), Ramlan et al. (2016)
	G3	Passion fruit delivery warranty	Dickson (1966), Banaeian et al., (2015), Taufik et al., (2014),, , Anggrahini et al. (2018), Ramlan et al. (2016)
	G4	Provide supply assistance in case of emergency	Taufik et al., (2014)(Ramlan et al. 2016)(Ramlan et al. 2016)(Ramlan et al. 2016)(Ramlan et al. 2016)(Ramlan et al. 2016)
Operations manajement	M1	Good reputation in supplier scope	Dickson (1966), Weber et al. (1991), Banaeian et al., (2015), Taufik et al., (2014), Ramlan et al. (2016) ,
	M2	Geographical location between company and supplier	Dickson (1966), Weber et al. (1991), Banaeian et al., (2015), Ramlan et al. (2016) ,
	M3	Certification and completeness of purchase documents and fruit checking	Dickson (1966), Anggrahini et al. (2018), Taufik et al., (2014) ,
	M4	Standard use of equipment	Dickson (1966), Weber et al. (1991), Banaeian et al., (2015), Taufik et al., (2014)

Quality sub-criteria were also included as supporters in the supplier evaluation decision making of some of the literature adopted and modified in this study, such as Dickson (1966), Weber et al., (1991), Banaeian et al., (2015), Anggrahini et al., (2018), Ramlan et al., (2016), and Taufik et al., (2014), the standard physical characteristics of purple passion fruit by Hutabarat et al,. (2016), for supply capacity in anggrahini et al., (2018) research will be included in the service or service sub criteria as conducted in ramlan et al. research (2016). From the merger of several studies, 24 sub-criteria were also obtained for supplier evaluation and each sub-criterion was grouped based on the definition of the appropriate criteria.

3.2 Delphi Method Round 1

It requires several experts who understand or are directly involved in the procurement of raw materials and production in the SME passion fruit syrup beverage industry. In this study, the selected expert experts were parties from SME CV. X who has knowledge and experience in raw material procurement and production in CV. X. The experts who played the role of filling out the questionnaire amounted to three people.

Delphi Round 1 questionnaire results found a shrinkage in the number of sub-criteria from 24 to 21 sub-criteria. Some sub-criteria that do not fit as a sub-criteria supplier evaluation based on interviews to experts, namely (K2) The ability of suppliers to be consistent with quality standards, (H1) Conformity of passion fruit offer price with market price, and (P3) Frequency (history) of passion fruit delivery. In addition, there is one new sub-criterion added by experts, namely on the quality criteria of adding sub-criteria (K5) Maturity level estimated at 50%-70%. With the addition of one sub-criterion, the total sub-criteria becomes 22 which then becomes the materialfor Delphi round 2 questionnaire.

3.2 Delphi Method Round 2

Delphi Round 2 questionnaire using Delphi Round 1 questionnaire. There are 6 criteria and 22 sub-criteria that are the results of Delphi Round 1 questionnaire which is the material for Delphi Round 2 questionnaire. Experts are expected to provide a level of importance using a 7- point Likert scale, ranging from a scale of 1 which means it is not very important to a scale of 7 which means it is very important. Then done consensus calculation using statistical analysis usedto determine whether the existing instrument has consensus or not. The first measure when the answer or assessment of all experts has a standard deviation <1.5 then the assessment is declared consensus. The second measure when the answer or assessment of all experts has an interquartile range of <2.5 then the assessment is declared consensus (Giannarou and Zervas, 2014). From the results of the Delphi round 2 questionnaire consensus calculation for 6 main criteria and 22 sub- criteria stated to have reached consensus from experts because the standard deviation is <1.5 and interquartile range <2.5.

3.3 Weighting Criteria and Sub Criteria

Delphi Round 2 questionnaire results containing the importance of each criteria and evaluation sub-criteria using 7 points of likert scale and then from the criteria and sub-criteria are carried out group weighting using Stepwise Weight Assessment Ratio Analysis (SWARA) method to find out which criteria and sub criteria to prioritize. Table 3 shows the results of group weighting calculations for quality criteria using the Stepwise Weight Assessment Ratio Analysis (SWARA) method. The first stage is the existing sub-criteria ranked based on the initial rating using the initial prefence of each expert respondent using 7 points likert scale. The next stage is to get an Sj value, each expert respondent determines the comparative importance of the criteria taking into account the aggregate ranking. This value can also be calculated by ranking the mean value and then dividing the mean value between the second important criteria (after it) or the smaller and the first (previous) or larger, for example K4/K3 = 6,667/7,000 = 0.952 (Korol and Spyridou 2020). The first criterion is not calculated because there is no comparison with the previous criteria. The next stage is the calculation of the coefficient of each criterion (Kj) by adding the number 1 to the value of each Sj if j > 1, then perform the calculation of the weight of each criterion (Wj) for j > 1 by dividing between the previous criteria weight (Wj) with the new or subsequent criteria coefficient (Kj), for example K3/K4 = 1,000/1,952 = 0.512. The last stage is the weight (Wj) found in the previous step divided by the sum, for example the sum of Wj is 1,924, then K3/∑ Wj = 1,000/1,924 = 0.520. The resultis the final weight of each criterion (Qj).

Table 3. Weighting quality criteria using SWARA

Code	Quality Criteria	Respondents			Mean	Sj	Kj	Wj	Qj	Rank
	Sub Criteria	**1**	**2**	**3**						
K3	Low fruit defect rate	7	7	7	7,000	-	1,000	1,000	0,520	1
K4	Packaging quality when delivering fruit	7	7	6	6,667	0,952	1,952	0,512	0,266	2
K5	Maturity level estimated at 50%-70%	6	5	7	6,000	0,900	1,900	0,270	0,140	3
K1	Physical characteristics of purple passion fruit: ⌋ Weight: 42.6-60.4 gr ⌋ Color : Dark Purple ⌋ Aroma : Distinctive flavor of passion fruit ⌋ Shape : Not perfectly rounded	5	6	5	5,333	0,889	1,889	0,143	0,074	4
Sum								**1,924**	**1,000**	

Table 4. Weighting price criteria using SWARA

Code	Pricing Criteria	Respondents			Mean	Sj	Kj	Wj	Qj	Rank
	Sub Criteria	**1**	**2**	**3**						
H4	Shipping transportation costs	5	5	7	5,667	-	1,000	1,000	0,561	1
H3	Discounted price of passion fruit	6	4	6	5,333	0,941	1,941	0,515	0,289	2
H2	Payment method (term)	5	4	6	5,000	0,938	1,938	0,266	0,149	3
Sum								**1,781**	**1,000**	

Table 5. Weighting service criteria using SWARA

Code	Service Criteria	Respondents			Mean	Sj	Kj	Wj	Qj	Rank
	Sub Criteria	**1**	**2**	**3**						
L1	Fulfillment of capacity (quantity) of passion fruit supply	7	7	7	7,000	-	1,000	1,000	0,521	1
L3	Attitude & impression of suppliers in the purchasing process	6	7	7	6,667	0,952	1,952	0,512	0,267	2
L4	Follow-up of the purchasing process according to the procedure	5	6	7	6,000	0,900	1,900	0,270	0,140	3
L2	Fast response & easy communication with suppliers	5	5	7	5,667	0,944	1,944	0,139	0,072	4
Sum								**1,920**	**1,000**	

Table 6. Weighting delivery criteria using SWARA

Code	Delivery Criteria	Respondents			Mean	Sj	Kj	Wj	Qj	Rank
	Sub Criteria	**1**	**2**	**3**						
P1	On-time delivery	7	7	7	7,000	-	1,000	1,000	0,554	1
P4	Types of transportation	6	7	7	6,667	0,952	1,952	0,512	0,284	2
P2	Flexibility on delivery time and number of orders	5	4	6	5,000	0,750	1,750	0,293	0,162	3
Sum								**1,805**	**1,000**	

Table 7. Weighting warranty criteria & claim policy using SWARA

Code	Warranty Criteria & Claims Policy	Respondents			Mean	Sj	Kj	Wj	Qj	Rank
	Sub Criteria	**1**	**2**	**3**						
G3	Passion fruit delivery warranty	7	6	7	6,667	-	1,000	1,000	0,513	1
G1	Supplier response to low quality passion fruit claims	5	5	7	5,667	0,850	1,850	0,541	0,277	2

G2	Low quality or defective passion fruit replacement compensation	5	6	6	5,667	1,000	2,000	0,270	0,139	3
G4	Provide supply assistance in case of emergency	4	6	6	5,333	0,941	1,941	0,139	0,071	4
Sum								**1,950**	**1,000**	

Table 8. Weighting management & operation criteria using SWARA

Code	**Operation Management Criteria**	**Respondents**			**Mean**	**Sj**	**Kj**	**Wj**	**Qj**	**Rank**
	Sub Criteria	**1**	**2**	**3**						
M3	Certification and completeness of purchase documents and fruit checking	6	7	7	6,667	-	1,000	1,000	0,513	1
M1	Good reputation in supplier scope	6	6	6	6,000	0,900	1,900	0,526	0,270	2
M4	Standard use of equipment	5	5	6	5,333	0,889	1,889	0,279	0,143	3
M2	Geographical location between company and supplier	4	5	6	5,000	0,938	1,938	0,144	0,074	4
Sum								**1,949**	**1,000**	

4. CONCLUSION

To overcome the problem of lack of raw materials and difficulty to fulfill orders if the passion fruit harvest from the garden is insufficient. CV. X‟s owner need supplies from suppliers outside of their own gardens and do not currently have a supplier selection system. This research carried out development in designing proposed criteria to evaluate prospective suppliers of purple passion fruit raw materials in the SME syrup beverage industry CV. X to evaluate suppliers through the integration of Delphi's technical approach and step-wise weight assessment ratio analysis (SWARA) method from adopt previous research conducted by Karabasevic et al., (2017) as the basis for development in different scopes.

The selection of criteria and sub-criteria is based on several previous studies that also discuss evaluation criteria in general, especially on SME objects and the standards of physical characteristics in purple passion fruit. Thereare 6 main criteria namely quality, price, service, delivery, warranty & claims policy, and management & operation and 24 sub-criteria were also obtained for supplier evaluation and each sub-criterion was grouped based on the definition of the appropriate criteria. Delphi Round 1 questionnaire results found a shrinkage in the number of sub- criteria from 24 to 21 sub-criteria. Some sub-criteria that do not fit as a sub-criteria supplier evaluation based on interviews to experts, namely (K2) The ability of suppliers to be consistent with quality standards, (H1) Conformity of passion fruit offer price with market price, and (P3) Frequency (history) of passion fruit delivery. In addition, there is one new sub-criterion added by experts, namely on the quality criteria of adding sub-criteria (K5). With the addition of one sub-criterion, the total sub-criteria becomes 22. Delphi Round 2 questionnaire results containing the importance of each criteria and evaluation sub-criteria using 7 points of likert scale and then from the criteria and sub-criteria are carried out group weighting using Stepwise Weight Assessment Ratio Analysis (SWARA) method.

5. REFERENCES

Alfaris, M. F., and Qurtubi. (2019). “Priority Proposal in Selecting Fresh Fruit Bunch Suppliers Using Analytical Hierarchy Process (AHP) and Weighted Scoring Model.” *IOP Conference Series: Materials Science and Engineering* 598(1).

Anggrahini, Dewanti, Imam Baihaqi, and Putri Candra Anggani. (2018). “Supplier Selection Framework For Dairy Industry in Indonesia.” *Proceedings of the International Conference on IndustrialEngineering and Operations Management* 2018-March (2015): 2917–26.

Banaeian, Narges, Hossein Mobli, Izabela Ewa Nielsen, and Mahmoud Omid. (2015). “Criteria Definition and Approaches in Green Supplier Selection – a Case Study for Raw Material and Packaging of Food Industry.” *Production and Manufacturing Research* 3(1): 149–68. http://dx.doi.org/10.1080/21693277.2015.1016632.

Dickson, G.W. (1966). An analysis of vendor selection systems and decisions. Journal of Purchasing. Volume 2, Issue 1 (Winter 1966), p. 5.

Gama, Nathália, Carlos Alberto Alves, and Paulo Sergio Oliveira. (2020). “Suppliers Selection in Restaurants: Application of Delphi and Fuzzy AHP Methods.” 0924: 94–106.

Garatti, Marco, Roberto Costa, Stefano Crespi Reghizzi, and Erven Rohou. (2002). „The Delphi Method for Graduate Research‟, *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 2327 LNCS, pp. 93–105. doi: 10.1007/3-540-47847-7_10.

Giannarou, Lefkothea, and Efthimios Zervas. (2014). “Using Delphi Technique to Build Consensus in Practice.” *International Journal of Business Science and Applied Management* 9(2): 65–82.

Hutabarat, Rina Christina, Rasiska Tarigan, Susilawaty Barus, and Fitriana Nasution. (2016). “Karakterisasi Morfologi Dan Anatomi Markisa F1 Di Kebun Percobaan Berastagi.” *Jurnal Hortikultura* 26(2): 189.

Işik, A. Tuş, and E. Aytaç Adali. (2016). “A New Integrated Decision Making Approach Based on SWARA and OCRA Methods for the Hotel Selection Problem.” *International Journal of Advanced Operations Management* 8(2): 140–51.

Jain, Naveen, Vinay Surendra Yadav, H. K. Narang, and A. R. Singh. (2018). “Supplier Selection through Attractive Criteria: A Fuzzy Kano Based Integrated MCDM Approach.” *Proceedings of the International Conference on Industrial Engineering and Operations Management* 2018-March (1966): 1695–1704.

Karabasevic, Darjan et al. (2017). “An Approach to Criteria Weights Determination by Integrating the DELPHI and the Adapted SWARA Methods.” *Management:Journal of Sustainable Business and Management Solutions in Emerging Economies* 22(3): 15.

Keršuliene, V., Zavadskas, E. K. and Turskis, Z. (2010). „Selectionofrationaldisputeresolutionmethodby applying new step–wise weight assessment ratio analysis (SWARA)‟, *Journal of Business Economics and Management*, 11(2), pp. 243–258. doi: 10.3846/jbem.2010.12.

Korol, Tomasz, and Anastasia Spyridou. (2020). “Examining Ownership Equity as a Psychological Factor on Tourism Business Failure Forecasting.” *Frontiers in Psychology* 10(January): 1–9.

Okoli, Chitu, and Suanne D. Pawlowski. (2004). “The Delphi Method as a Research Tool: An Example, Design Considerations and Applications.” *Information and Management* 42(1): 15–29.

Ramlan, Rohaizan, Engku Muhammad Nazri Engku Abu Bakar, Fatimah Mahmud, and Hooi Keng Ng. (2016). “The Ideal Criteria of Supplier Selection for SMEs Food Processing Industry.” *MATEC Web of Conferences* 70.

Skinner, Richard; Nelson, R. Ryan; Chin, Wynne W.; and Land, Lesley. (2015). "The Delphi Method Research Strategy in Studies of Information Systems,"Communications of the Association for Information Systems: Vol. 37, Article 2. DOI: 10.17705/1CAIS.03702

Taufik, Riyan, Yeni Sumantri, and Ceria Tantrika Farela. (2014). “Penerapan Pemilihan Supplier Bahan Baku Ready Mix Berdasarkan Integrasi Metode AHP Dan TOPSIS (Studi Kasus Pada PT Merak Jaya Beton, Malang).” *Jurnal Rekayasa dan Manajemen Sistem Industri* 2(5): 1067–76.

Weber, C., Current, J.R., & Benton, W.C. (1991). Vendor selection criteria and methods. European Journal of Operational Research.

Wibowo, Sandy Budi, Budi Prihatminingtyas, and R Y Susanto. (2014). "The Development of Food and Beverage Industry Based on People Economic into Good Local Industry." *Online)* 5(23). www.iiste.org.

SUPPLIER SELECTION IN PT PELOPOR TEKNOLOGI IMPLANTINDO WITH THE INTEGRATION OF DEMATEL, ANP AND TOPSIS METHOD

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ABSTRACT

A manufacturing company, PT Pelopor Teknologi Implantindo, in its operational activities to meet the needs of implant raw materials and medical devices in collaboration with suppliers, both manufacturers and distributors. The company places more emphasis on short-term attributes such as low costs but is also considering establishing long-term relationships and the possibility of product development collaborations with several suppliers. Based on the case mentioned, this study aims. First, select a supplier for 316L material using the method DEMATEL (Decision Making Trial and Evaluation Laboratory), ANP (Analytic Network Process) and TOPSIS (Technique for Others Reference by Similarity to Ideal Solution) from suppliers that match the needs and objectives of the company. Second, identifying the interplay between the DEMATEL - ANP method and identifying criteria using the TOPSIS method. Data collection was carried out through observers and interviews to determine the important variables in the selection of the 316L raw material supplier to categorize them intogroups and criteria. Gradually, Questionnaires I and II were used to obtain group consensus and important criteria in selecting suppliers of raw materials in the 316L scrab. Criteria and processed using the Analytical Network Process (ANP) method with the help of Microsoft Excel software and Super Decisions. Meanwhile, TOPSIS considers two of them, the distance between the positive ideal solution and the negative ideal solution by using relative proximity to the positive one. From comparisons of relative distances, alternative priority arrangements. In this future research will get priority factors on the criteria in selecting suppliers of raw materials Scrab 316L. Based on the research conducted, it is hoped that with these 3 methods, DEMATEL, ANP and TOPSIS will be able to solve the problem of selecting a 316L raw material supplier in PT Pelopor Teknologi Implantindo.

Keywords: SUPPLIERS SELECTION, DEMATEL, ANP AND TOPSIS.

1. INTRODUCTION

The fulfillment of raw material for scrab 316L at PT. Pelopor Teknologi Implantindo supplied by more than one supplier. This is done to maintain the availability of materials for the smooth running of the production process. Evaluation of suppliers at PT. So far, Implantindo Pioneer Technology has been applied only from the perspective of the assessment criteria for the reduction of payment, quality. The required supplier reliability is of course not only reflected in suppliers who are able to supply cheap, quality and timely materials, but also must be able to provide optimal service, both in terms of smooth communication and information, responsiveness, and providing convenience in the transaction process. Therefore, companies need to conduct performance evaluations. Implementation of evaluation at PT. Implantindo Technology pioneers carried out using the same weight criteria. Weighting the assessment criteria is very important because it can show the priority of each performance indicator, so that it can facilitate the management involved in making a decision. Supplier performance evaluation system at PT. Implantindo Technology Pioneer makes it possible to do this by using a number of performance assessment criteria that are interrelated among the evaluation criteria. This is because, PT. Pelopor Teknologi Implantindo is a large company that has quite complex interests in its strategic relationship with suppliers. Based on the company's condition, the company needs a Multi Criteria Decision Making (MCDM) method could be accommodate the linkages between existing criteria.

The MCDM method that is right for use in decision making applications in supplier performance evaluation is the integration of DEMATEL and ANP and applies TOPSIS method. DEMATEL can be used to determine the linkages that occur between supplier performance evaluation criteria. In addition, DEMATEL can also be used to find and analyze the dominant criteria in a system (Tzeng, 2007). ANP is a method that can be used to MCDM problems. The ANP method is able to improve AHP weaknesses to accommodating linkages between criteria or the alternative options in the supplier performance evaluation process. With the ANP method, priority weights will be obtained on all the criteria used in evaluating supplier performance. The results of this weighting can be used as input in the final assessment stage of all alternative suppliers based on identified criteria. Meanwhile, TOPSIS is a basic concept of Multi Attribute Decision Making (MADM) which provides alternatives between the shortest distance and the longest distance from the positive to the negative ideal solution.

2. METHOD

2.1 DEMATEL

DEMATEL was developed in 1972-1976 by the Battelle Memorial Institute as a science and humanitarian program implementation. This method can solve the dependency problem between complex criteria (Lee, 2013). In its development, the DEMATEL method has becomeone of the best methods that can be used to determine the causal relationship between factors (Tzeng, 2007). This is supported by the statement by (Wu, 2009), that this method is devoted to showing the visualization of the structure of the relationship in a complex matrix. When acompany evaluates its implementation, it will find many criteria that must be considered. From these criteria, then a very common problem arises, namely the effect of the relationship between the criteria. Therefore, to make overall improvements in a business unit, it is necessary to identify the relationship between the effects of each criterion so that the criteria will have the greatest influence (Lee, 2013). This statement is the basis for the author to use this method to assist in selecting the right criteria.

2.2 ANP

ANP is a mathematical-theory-based method that allows to cope with interrelated factors (dependence) systematically and the feedback also. This method is one of the decision making with a basis on the multiple criteria or MCDM developed by Thomas L. Saaty. This method is a new approach to qualitative methods which is a continuation of the previous method, namely the Analytic Hierarchy Process (AHP) (Tanjung, 2013). In general, research with a qualitative approach only describes the findings in the field without conducting a deeper synthesis. Moreover,when compared to the AHP method, ANP could help to compare more objectively, predict ability more accurately, and the outcomes are more stable. ANP is more general than AHP which is used in multi-criteria decision analysis. AHP is a hierarchical-decision problem solving to set a certain level of hierarchy, while ANP is a non-hierarchical approach that deals with a network approach (Tanjung, 2013).

2.3 TOPSIS

TOPSIS is one of the Multi Criteria Decision Making (MCDM) category method, which has several alternatives for decision-making, especially Multi Attribute Decision Making (MADM) (Widiyanti, 2013). The basic concept of MADM which provides alternatives between the shortest distance and the longest distance from the positive to the negative ideal solution.

3. RESULT & DISCUSSION

In the latest literature, whether DEMATEL and ANP methods could be integrated. By deriving the degree of dependence between criteria in DEMATEL, the outcomes could help ANP for normalizing the unweighted-supermatrix (Hsu, 2012). ANP calculates the relative weights of criteria, resulting the degree of interdependence as mutual values. While DEMATEL has no mutual values on its level of interdependence, which has a similarity to the real problems that needto be solved (Yang, 2011). To dealing with this incapacity of calculating relative weights in ANP, it can be done by calculating the total relationship matrix in DEMATEL, which can be more profitable (Vujanovic, 2012). Meanwhile, the TOPSIS method could help to complete morepractical decision making, because this method are more understandable, compute more efficiently, and the capacity to calculate decision alternatives and relative performance. In addition, the selection of alternatives is easy to take, where alternatives that have a higher valueare higher to be chosen (Juliyanti, 2011).

The DEMATEL method has five main stages (Özer Uygun, 2014), which are as follows:
Stage 1: Creating a Direct Relationship Matrix
In this step, a direct relationship matrix will be made using four levels of comparison scale, namely 0 to 4 described 0 as no effect, 1 as low effect, 2 as moderate effect, 3 as high effect, 4 very high effect. Previously, it was necessary to calculate the number of each column and row from matrix A which then looked for the maximum value to enter the formula.
Stage 2: Normalize of the relationship matrix directly
Using matrix A, normalize the relationship with matrix D directly obtained using the following formulation

$$D = z \times A \quad \text{...........(2.1)}$$

$$Z = \min \left\{ \frac{1}{\max i \sum_{j=1}^{n} aij}, \frac{1}{\max j \sum_{t=1}^{n} aij} \right\} \quad \text{...........(2.2)}$$

Stage 3 Calculate the Total Matrix T
The total relationship of the identity matrix (T Matrix) can be acquired as follows:

$$T = D + D^2 + D^3 + \ldots + D^h$$
$$= D(I + D + D^2 + \ldots + D^{h-1}) \, [(I-D)(I-D)^{-1}]$$
$$= D\,(I - D^h)(I - D)^{-1}$$
$$I = D\,(I - D)^{-1}, \; h \to \infty, \; D^h = [0]_{n \times n} \quad \text{...........(2.3)}$$

Stage 4: Calculating and determining of the dispatcher (vector D) and the receiver (vector R)
Total of columns and rows is represented by separating as vector D and vector R. Then the vector (D + R) is referred to as "prominence" horizontally. This vector is created to add both D and R which concludes the importance of criterion. Besides, there is also a vector (D-R) which is referred to as a "relation" into a cause and effect group. The above can then be formulated as follows:

$$T = [tij]_{n \times n} \qquad i,j = 1,2,3,\ldots, n \quad \text{...........(2.4)}$$

D= [ri] n x 1 = $[\sum_{j=1}^{n} tij]$n x 1 = [tj]n x 1.. .... (2.5)

R= [sj] nx1 = $[\sum_{i=1}^{n} tij]$ 1 x m = [tj]n x 1.. .... (2.6)

Stage 5: Obtain the impact-diagraph map

From the value obtained from the total relationship matrix, each value provides information on how much influence the criterion group i with criterion j is. So that if you only relyon the results from the total relationship matrix, there will be difficulties in determining decision making. Therefore, it is necessary to determine the threshold for the level of influenced to ensure that the impact-diagraph map has a few T matrix elements exceeding the threshold value. This threshold value is usually determined by an expert. The map of impact diagraph can be derived by outlining the values (D + R) and (D-R) so that information can be obtained to make decisions. TheDEMATEL method can complement the ANP method because the determination of the interdependence relationship between groups of several factors is more objective. Combining the DEMATEL and ANP methods is very helpful for solving dependence and feedback problems and making it more accurate and able to describe the real situation (Chen K. Y., 2011).

The decision making with ANP as follows:

1. Developing a problem structure and a linkage model, determining the desired objectives, criteria based on control criteria, and alternative options. If there are similar elements, then they have to be grouped into the same component.
2. Comparing matrix layer ANP to make a comparison for each level between all elements in pairs. The outcome will be converted to the matrix A.Calculating the weight of the element. After completing the comparison, vector W known as the eigenvector is calculated using the formula:

$$A.w = \lambda\, max.\, W$$

Where A is the comparison matrix and is the largest eigenvalue of A. The eigenvector is the priority weight of a matrix which is going to be used in the super matrix.

4. Calculating the consistency ratio that should be below or equal to 10 percent. If this value is bigger than 10, then the decision data has to be one percent. Practically, consistent is not possible. In the consistency of matrix, practically $\lambda\, max = n$, , the matrix not every the variation of itwill bring about a change in value. Deviation is i$\lambda\, max$ from n the ConsistencyIndex (CI). The CI value will not be meaningful if there is a standard to state whether the CI shows a consistent matrix. (Thomas, 2008) In his book provides a benchmark by making a random comparison of 500 samples. Saaty argues that a matrix resulting from random comparisons is an absolutely inconsistent matrix. From the random matrix, the Consistency Index value is also obtained, which is called the Random Index (RI). By comparing CI and RI, a contrast is obtaining to establish the Consistency Ratio (CR) that represent the level of consistency of a matrix.
5. Making Supermatrix, which is the priority vector obtained from the comparison in pairsbetween alternatives, criteria, clusters. There are three stages consisting Unweighted Supermatrix, Weighted Supermatrix, and Limit Supermatrix (Limmiting Supermatrix).

a. Unweighted Supermatrix stage

Unweighted Supermatrix is made by comparing in pairs between alternatives, criteria, clusters by entering the priority vector (eigenvector) of the column into matrix related to the cell.

b. The Weighted Supermatrix Stage

The weighted supermatrix is made by multiplying all the unweighted supermatrix elements in the appropriate cluster matrix value, so that each column has the sum of one.

c. Limit Matrix Stage

Furthermore, to obtain limmiting supermatrix, weighted supermatrix is increased in weight, which is done by multiplying several times the supermatrix by itself. When the weights for each column have the same value, then the limiting supermatrix is obtained.

In using the TOPSIS method, there are procedures that must be done (Vahit Kaplanog, 2013), including:

1. Normalizing decision matrix.
2. Developing a weighted normalizing decision matrix.
3. Establishing the positive and negative ideal solutions matrix.
4. Computing the separation of measure.
5. Measuring the value of alternatives between the shortest distance and the longest distance from the positive to the negative ideal solution.
6. Establishing the preference value in every alternative.
7. The alternatives decision matrix D obtained to be evaluated based on the criteria.
8. With xij state the process of the calculating for the ith alternative to the j-attribute.

4. CONCLUSION

The criteria and sub-criteria for selecting a sustainable supplier are obtained from several literature reviews conducted on research on supplier selection at PT Pelopor Teknologi Implantindo. From several criteria and subcriterias submitted to the expert there are 8 criteria and 16 sub-criteria that have been confirmed by the expert. Based from results of the integration of theDEMATEL, ANP and TOPSIS methods obtained later will know the rank of the supplier.

5. ACKNOWLEDMENTS

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6. REFERENCES

Chen, K. Y. (2011). Appliying Analytic Network Process in Logistic Service Provider Selection. *International Journal of Electronic Business Management*.

Juliyanti, M. I. (2011). Pemilihan Guru Berprestasi Menggunakan Metode TOPSIS dan AHP. *Prosiding Semindar Penelitian, Pendidikan dan Penerapan MIPA.*

Lee, H. S. (2013). Revised DEMATEL: Resolving the Infeasibility of Dematel. *Applied Mathematical modelling*.

Özer Uygun, H. K. (2014). An integrated DEMATEL and Fuzzy ANP techniques for evaluation and selection of outsourcing provider for a telecommunication company. *Computers & Industrial Engineering.*

Tanjung, H. d. (2013). *Metodologi Penelitian Ekonomi Islam.* Bekasi: Gramatika Publising.

Tzeng, G. H. (2007). Evaluating intertwined effects in elearning programs: A novel hybrid MCDM model based on factor analysis and DEMATEL. . *Expert Systems*.

Vujanovic, D. M. (2012). Evaluation of vehicle fleet maintenance management indicators by application of DEMATEL and ANP. *Expert Syst*.

Vahit Kaplanog. (2013). Integrating fuzzy DEMATEL and fuzzy hierarchical TOPSIS methods for truck selection.

Wu, H. T. (2009). A Fuzzy MCDM Approach for Evaluating Banking Perfomance Based on Balance Scorecard.

Widiyanti, H. A. (2013). Pembangunan Sistem Pendukung Keputusan Rekrutmen Pegawai Baru di PT ABC. *Jur. Komputa. Vol. 2.*

Yang, J. L.-H. (2011). An integrated MCDM technique combined with DEMATEL for a novel. *Expert Systems with Applications*.

ANALYSIS AND IMPLEMENTATION PLAN OF TOTAL PRODUCTIVE MAINTENANCE IN THE PAPER MANUFACTURING INDUSTRY CASE STUDY : PT. XYZ

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ABSTRACT

PT. XYZ is a manufacturing company that focused on produce brown papers which has one production machine with a capacity of 150 tons/day. Currently, the condition of production machines is considered inefficient, because over the past few years the production efficiency has decreased by more than 3%. This decrease also affected the increased consumption of steam by 22% and electricity by 12%. This problem happens due to frequent decreased engine speed, unscheduled downtime, reject products, decreased engine performance, and lack of maintenance standards, as well as a lack of cleanliness of equipment and work areas. Therefore, a structured and systematic process of analysis and design of maintenance management of production machines such as TPM (Total Productive Maintenance) is needed. In this research, analysis, and planning of the implementation of TPM is carried out by the actual conditions of the company, so that problems that cause a decrease in the efficiency of production machines will be resolved. To plan the implementation of TPM, calculations, and analyzes are carried out by using the OEE(Overall Equipment Effectiveness). Based on the OEE result, an seven major loss analysis was carried out using the Pareto diagram. Then the analysis process carried out using a fishbone diagram to determine the causes of losses. From the results of the analysis, and OEE value of 82,17% was obtained, which was still below the world-class standard of 85%.And then it also obtained the TPM implementation design with 3 phases, namely the introduction phase, the implementation initiative phase, and the standardization phase. With the implementation of TPM, it is hoped that the company will be able to compete in production, especially maintenance management which will have a positive impact on company productivity.

Keywords: TPM, OEE, Seven Major Loss, Pareto Diagram, Fishbone Diagram.

1. INTRODUCTION

In this era, the technology advance is widely spread in all sector including manufacture industry. The progress is creating very competitive competitor among industry player. Those thing keep industry player have to compete with concern in potential aspect for increasing productivity. Many factors has noticed like dissipation of material and the using time inefficiency. A lot of constituent is causing waste such as incompetent operator, unskilled maintenance people, tools problem and the availability of parts get in period times. Moreover, another detriment appear involved the stoppable operation machine, inefficiency the usage of parts, losses during startup and the process of managing a litter.

PT. XYZ is a manufacture industry in brown paper production. This company machine has capacity of 150 ton/day. Because the availability of machine only one, the company have to maintain the reliability consistently. In other side, currently, the condition of the productionmachine is considered less efficient. Company data shows a decrease in production efficiency of more than 3%. This reduction in efficiency was accompanied by an increase in electricity and steam consumption by 22% and 12%.

The alleviation of efficiency ensue because there are some issue involved as decreasing machine speed, unscheduled downtime, rejecting product, reducing the machine performance, maintenance standard, safety workplace and equipment.

At this condition, the company is to be sued for returned and increased its productivity. Throughout an impact for productivity is needed as an arrangement and systematic approach. One of the method is implementing maintenance and preserve continuously. Those factor is the fundamental part for Manufacture Company. In addition, the maintenance and preserve is one of method type that required to maintain the equipment, machine or a standard system based on operation set maximum condition. TPM is maintenance methods that might utilize as a tool for increasing the machine productivity. This method assist company to reach nonstop or move gradually, zero of damage, interval time, deformed, tolerate at a litter, and an accident. It’s can be reached if the employees involved at maintenance project. The advantages of TPM will beappeared as classified in 6 categories include Productivity(P), Quantity (Q), Cost (C), Deliver (D), Safety (S), and Moral (M) (Nakajima, 1988). At figure 1 showing the structure of implementing TPM worksheet and depict what tools should be use in implementation program.

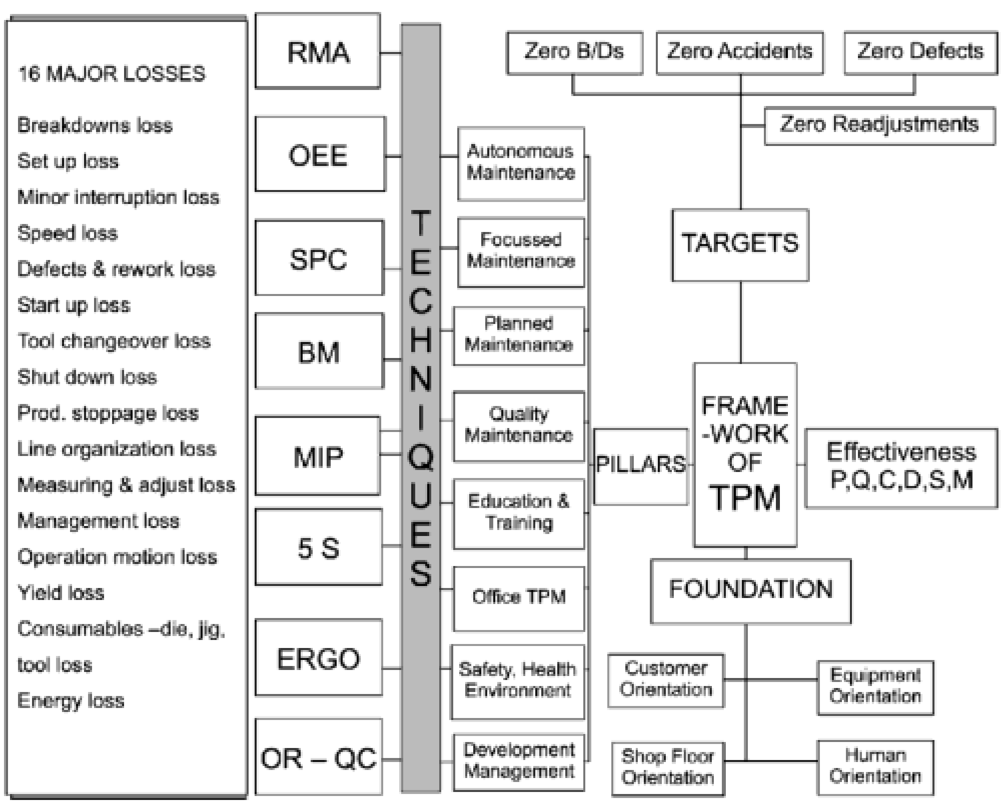

Figure 1. TPM implementation framework. Ben-Daya et al. (2009).

TPM using overall equipment effectiveness (OEE) as a parameter of the size of the plant performance. OEE is calculated by considering three things, namely availability, performance rate, and quality rate. Overall 85% of OEE is considered the benchmark standard of the world. With 90% availability, 95% performance rate and 99,9% quality rate.

There has been much research conducted to improve the productivity of the company. Some of them are research that has been done by Xiaomeng Sun in 2018. The study wasconducted by applying the method of TPM on the PTFE plant so that the resulting value of the OEE initially 64.4 percent by 77,6%. Another study in 2017 is done by Chandra Kiran K. managed to increase the OEE production line Eksamo in the U.S. by more than 4% from the beginning before the implementation of TPM.

Therefore, this study was conducted to determine the value of Overall Equipment Effectiveness (OEE) of the paper machine as the initial step of the planning application of the Total Productive Maintenance (TPM) and determine the best solution to improve productivity, to be used as input for the company to make the concept of TPM.

2. METHOD

This research was conducted at one of the industry paper manufacturing companies. The Data used as the material of the analysis of secondary data obtained from the department of production, the department of maintenance, and the department of quality control. The Data obtained is taken from the report for 2019 and 2020.

The analysis process will begin by calculating the OEE is used as the parameters of the level of effectiveness of the equipment thoroughly. OEE is divided into three terms, namely availability, performance rate, and quality rate. Of the three OEE values, further analysis of Seven Major Losses by using a Pareto diagram. The analysis of the Pareto diagram is used to sort the losses from the largest to the smallest so it will be known losses of the biggest most influential on OEE. With the unknown factor losses, the next largest analysis was performed using the diagram fishbone. Analysis diagram fishbone useful to find out the cause of the losses and the next will be given a solution. From the analysis of the problems above, further planning application program TPM is divided into three stages, namely the introduction, the initiative implementation, and standardization. Figure 2. shows the framework of the research. Having obtained a draft of the implementation of TPM on next created the formula of the master plan for the implementation of TPM.

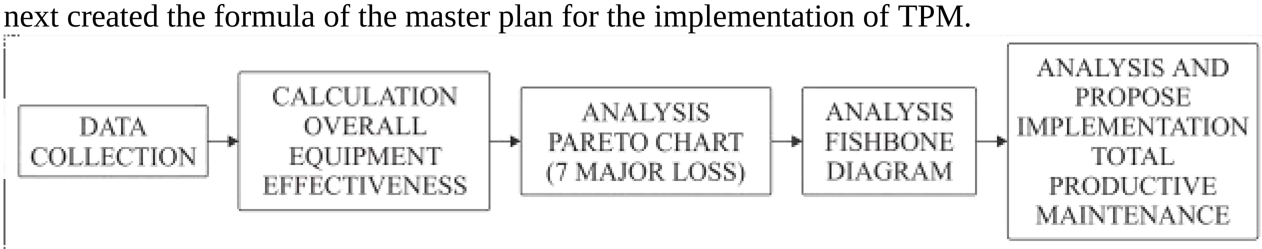

Figure 2. Research Framework

2.1 Data collection

The present study used some historical data of the company for 2019-2020. The department of production will use the data of the total production, cycle time, theoretical, time of loading, time of the beginning. Besides, some data is also obtained from the department ofmaintenance in the form of planned downtime, failed to record, repair records, and the set-up and adjustment time. And at the department of quality control will use the data in the form of notes of the defects.

2.2 Calculation OEE

At this stage it will do the calculation and analysis of the productivity of the company with a view 3 parameters, namely the availability rate, performance rate and quality rate.

Availability rate is the availability of the machine/equipment is a comparison between operating time on the preparation time of a machine/equipment. Sun (2018).

Performance rate is a measure of the efficiency of the performance of the machine running the production process. Three factors are important to calculate the performance rate is the ideal cycle time (the time of manufacture per unit of product), the output (the Number of products processed), and operation time (the time machine process). Sun (2018).

Quality rate is a comparison of the number of good products to the amount of product processed. So quality is the result of the calculation by a factor of output and defect. This Formula is very helpful to reveal the quality problem of the production process. Sun (2018).

2.3 Analysis Pareto Chart

Process analysis Pareto diagram is done as the analysis of the losses that often occur in the company. Tags losses obtained from Seven Major Loss. Seven Major Loss is Equipment Failure Loss, Set-up and Adjustment Losses, Tool Change Loss, Start-Up Loss, Minor Stoppages Loss, Reduced Speed Loss, and Defects and Reworks Loss. The seventh data will then be sorted from largest to smallest so that the known losses which the dominant happen. And losses that are dominant will be prioritized first to be repaired.

2.4 Analysis Fishbone Diagram

At this stage of the analysis will be conducted on the causes of the Seven Major Loss before. The cause of the problem will be divided into 6 categories of causes, namely Manpower, Method, Machine, Material, Mother Nature (Environment), and Measurement. Hossen et al.,(2017). The process of analysis of the causes of the problems will be done with the involvement ofseveral parties, namely the operator, production supervisor, the supervisor of maintenance, production manager, maintenance manager, manager quality control, and mill head. The engagement party was done to find the cause of and follow-up the most appropriate to solve the problems that occur and hereinafter will be given priority which will be first performed.

2.5 Analysis and propose implementation TPM

From some analysis has been done on the subsequent data analysis will be used as a basis for planning the implementation of TPM. Planning the implementation of TPM will be divided into three phases, namely: Phase 1 the Introduction, in this phase will be made an introduction of the program TPM to employees. Phase 2 of the Initiative Implementation, in this phase, will be created stages of the implementation of TPM. Phase 3 Standardization, will be made to fixed standards in the implementation of TPM.

3. RESULTS AND DISCUSSION

3.1 Availability Rate (A) Calculation

Availability calculation obtained by the following equation:

$$Avalability(A) = \frac{Loading\ Time - DownTime}{Loading\ Time}\ x\ 100\%$$

Table 1. Availability Rate Calculation Results for 2019-2020

Period	Loading Time (minutes)	Downtime (minutes)	Operating Time (minutes)	Availability (%)
2019	498125	55960	442165	88,766%
2020	520660	58460	462200	88,772%
Total	1018785	114420	904365	88,769%

From the above calculations, it is found that the availability value of 88.77% is still below the world standard of 90%.

3.2 Performance Rate (A) Calculation

Performance calculation obtained by the following equation:

$$Performance\ (P) = \frac{Output\ x\ Cycle\ Time}{Operating\ Time}\ x\ 100\%$$

Table 2. Performance Rate Calculation Results for 2019-2020

Period	Output (Kg)	Cycle Time (Kg/minutes)	Operating Time (minutes)	Performance (%)
2019	45333885	108	442165	94,93%
2020	46447833	106	462200	95,00%
Total	91781718	107	904365	94,95%

From the calculation of the performance rate in 2019-2020, it is obtained a value of 95%, which means that the company's performance has met world standards of 95%.

3.3 Quality Rate (A) Calculation

Quality calculation obtained by the following equation:

$$Quality(Q) = \frac{Output - Defect}{Output}\ x\ 100\%$$

Table 3. Quality Rate Calculation Results for 2019-2020

Period	Output (Kg)	Reject (Kg)	Quality Rate (%)
2019	45333885	1139872	97,49%
2020	45908230	1165008	97,46%
Total	91242115	2304880	97,47%

From the calculation of the quality rate in 2019-2020, it is known that it has not met the world standard of 99.9%. In this calculation, the value of the quality rate is 97.47%.

3.4 Overall Equipment Effectiveness (OEE) Calculation

OEE calculation obtained by the following equation:

$$OEE\ (\%) = Avalability(A)\ x\ Performance(P)\ x\ Quality(Q)$$

Table 4. OEE Calculation Results for 2019-2020

Period	Availability (%)	Performance (%)	Quality (%)	OEE (%)
2019	88,766%	94,93%	97,49%	82,15%
2020	88,772%	95,00%	97,46%	82,20%
Average	88,769%	94,97%	97,47%	82,17%

With an OEE value of 82.17%, the company is considered to have not met the world standard of 85%. The big thing that affects the company's OEE level is availability and qualityrate.

3.5 Pareto Chart Analysis

Table 5. The Cumulative Percentage of the Seven Big Losses factor

Seven Big Loss	2019	2020	Total Loss (Minutes)	Percentage (%)	Cumulative (%)
Reduced Speed Loss	32787	26181	58968	30,3%	30,3%
Minor Stoppage Loss	24530	29605	54135	27,8%	58,1%
Equipment Failure Loss	17870	20490	38360	19,7%	77,9%
Defect and Rework Loss	10501	10669	21169	10,9%	88,7%
Setup and Adjustment loss	8315	4160	12475	6,4%	95,1%
Tool Change Loss	4160	3070	7230	3,7%	98,9%
Startup Loss	1085	1135	2220	1,1%	100,0%

From table 5 above, it is found that reduced speed loss has the largest downtime value followed by minor stoppage loss. The two losses contributed 58.1% of downtime. Figure 3 shows the Pareto chart for the seven big losses at PT.XYZ.

Figure 3. Pareto chart of seven big loss

3.6 Fishbone Diagram Analysis

The loss analyzed on this fishbone diagram is a reduced speed loss. The analysis is discussed through the Small Group Activity (SGA) which consists of managers, supervisors, and operators. From the SGA results, the fishbone diagram is shown in Figure 4. And the improvements that can be made to each problem are shown in Table 6.

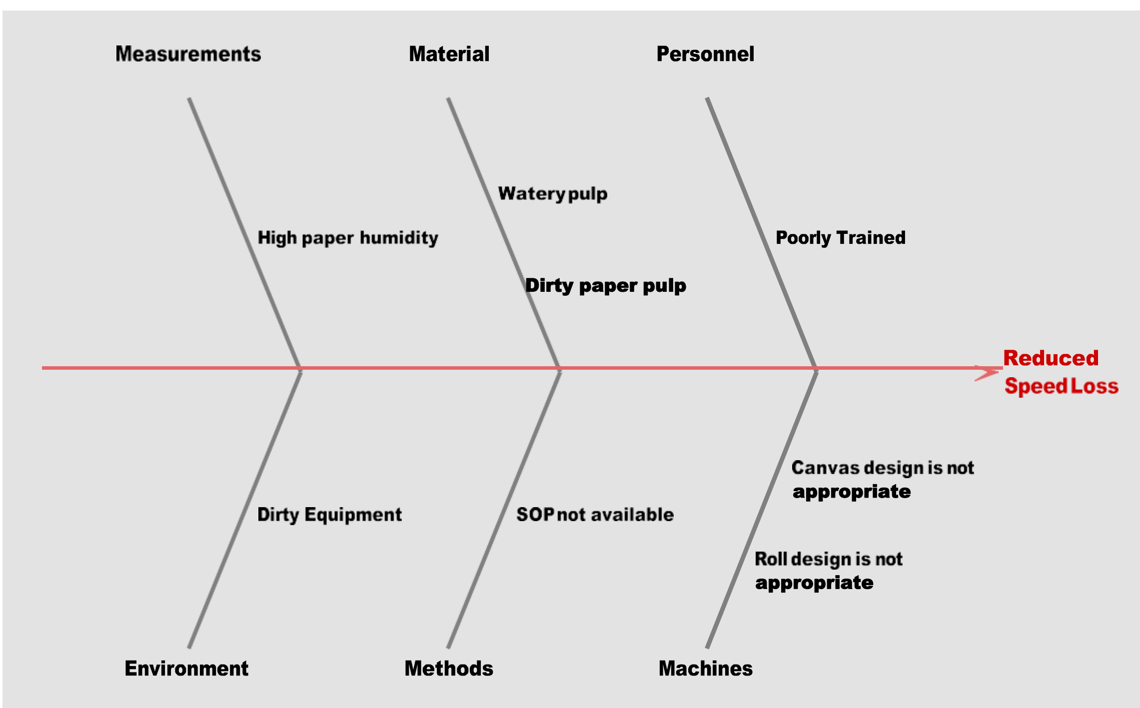

Figure 4. Fishbone diagram of reduced speed loss

Table 6. Propose improvements to reduced speed loss

Factor	Problem	Sub Problem	Improvements
Personnel	Poorly Trained	scheduled training	Carried out pillar education and training
Material	Watery Pulp	Unstable controller	Make periodic checks
	Dirty paper pulp	Filter is not working properly	Add filter path for backup
Measurements	High paper humidity	Steam quality decreases	Improve the reliability of the boiler
Machine	Canvas design is not appropriate	-	Customize the order with the part design
	ll design is not appropriate	-	
Methods	SOP not available	-	Make SOP and placed near the machine
Environment	Dirty Equipment	No scheduled cleaning	Carried out pillar Autonomous Maintenance

3.7 Proposed Implementation of TPM

To be able to overcome the above problems then be made to repair arranged in the concept of the application of TPM which is divided into three phases below

Phase 1 Introduction, beginning with the introduction of the program TPM to employees through several activities, including

a. Management Commitment
The director issued a decree on the introduction and implementation of the TPM on the company. Spending decision is accompanied by the submission of the purpose of the implementation of TPM is to increase the PQCSDM (Product, Quality, Cost, Safety, Delivery, Morale).

b. Continuous Improvement and Kaizen
A plan of Continuous Improvement and Kaizens have done holistically, to influence the improvement of the organization are significant including the reduction of inventory, reduce the time of preparation or the turn, ensure the improvement of maid and housekeeping, increase safety and hygiene in the workplace, spread the initiative of Poka-Yoke in the workplace, handle repair related equipment, perform the inspection of autonomic abnormalities in the workplace, and using visual control in the workplace.

c. Training and Multi-skilling for TPM
Employees are given the skills and competencies related to the technical work (operate, maintain and repair equipment, techniques, preventive maintenance, equipment operation, calibration, error analysis, safety training, etc.).

d. Visual Workplace
Provide a simple signal to comprehend directly about equipment condition.

Phase 2, Implementation Initiative. This step execute of implementation Pilar TPM Concept that has several part as:

a. Autonomous Maintenance
Training operator to do cleaning, lubrication, tightening, adjustment, inspection, and re-adjustment (C-L-T-A-I-R). Besides that, this step is also applied at 5s methods (seiri, seiton, seisō, seiketsu, and shitsuke).

b. Focussed Improvement

Adopt improvement initiatives focused (Kobetsu Kaizen–KK) to maximize efficiency by eliminating wastage and losses of manufacturing. The losses will be addressed through the initiative strategies KK including seven major losses that impede equipment efficiency, losses blocking the loading time of the machine, five major losses that impede the performance of human, and three major losses that impede the effective use of production resources.

c. Planned Maintenance

The stages of implementing planned maintenance are described as follows analyse difference between basic condition and current situation

1. Correct differences between basic condition/ ideal operating conditions and current situation
2. Establish standards for sustaining basic conditions
3. Extended working life of equipment and eliminate weaknesses
4. Rationalise checking and servicing
5. Perform comperhensive equipment diagnosis
6. Maximise use of equipment

d. Quality Maintenance

At this stage an analysis of the defects of the product is carried out. Data is collected and processed using seven tools (Check Sheet, Pareto Diagram, Cause and Effect Diagram, Histogram, Control Chart, Scatter Diagram and Stratification).

e. Office TPM

Things to do in this step are:

1. Efficient system to indirect /administrative department
2. Support the creation of efficient manufacturing site
3. Administrative autonomous maintenance and focused improvement

f. Safety, Health and Environment

In this section conducted with the following objectives:

1. Aiming zero accident, zero pollution and zero waste for realization of comfortable work place.
2. Build up earth friendly factory.

Phase 3 of Standardization, at this stage, made the standard application of TPM to the implementation of the TPM can still sustain.

a. Create KPI standards for company performance

KPI's needed to set the purpose, measure the performance and strengthen positive behavior to create preservation of world-class.

b. Maintain the Initiative of TPM.

3.8 Implications for the Company

Based on the calculation of time loss is known that the 4 biggest factor that affects the productivity of the machine is Reduced Speed loss, Minor Stoppage Loss, Equipment Failure loss and Defect and Rework Loss. Therefore, in this study proposed the application of TPM to be able to increase the productivity of PT.XYZ. As for the implications of this research for the company is

1. The company be able to compete in production especially maintenance management that provide positive impact for company productivity.
2. The company will continue to make improvements on the availability of the machine, the engine performance and the quality of its products.
3. The company can constantly monitor and improve the performance of employees by applying these pillars of TPM.

4. The company can make the approach OEE as one of the Key Performance Indicators (KPIS) to assess the level of productivity of the company.

4. CONCLUSION

Based on the research that has been done. So, it can be concluded as follows: (1) PT.XYZ's OEE measurement results in 2019-2020 at average level of 82.17%. This value is still below the world standard value of 85%. (2) The biggest loss factor on the seven big losses was reduced speed loss which contributed 30.3% to the loss. (3) To increase company productivity and resolve loss problems, the TPM program can be implemented which is divided into 3 stages (introduction, implementation initiative, and standardization). (4) The results of the research have implications for the company in the form of increased productivity, continuous improvements, monitoring machine performance and monitoring employees performance, and the company being able to build KPIs as measurable company targets.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Ben-Daya M., Raouf A., Knezevic K., Ait-Kadi D., (2009), Handbook of Maintenance Management and Engineering., Springer, New York.

Hossen, J., Ahmad, N., & Ali, S. M. (2017). An application of Pareto analysis and cause-and- effect diagram (CED) to examine stoppage losses: a textile case from Bangladesh. Journal ofthe Textile Institute.

Kestwal, C.K., Hudjakov R. (2017), Implementation of Total Productive Maintenance (TPM) in a Machine Shop, Department of Electrical Power Engineering and Mechatronics Chair of Mechatronics.

S. Nakajima, (1988), Introduction to TPM: Total Productive Maintenance Productivity, Portland.

Sun, X. (2018), Implementing a Total Productive Maintenance Approach into an Improvement At S Company, The Faculty of the School of Engineering and Applied Sciences Western Kentucky University Bowling Green, Kentucky

TOPIC

Simulation and Optimization

TRAVEL SIMULATION SYSTEM TO DEVELOP DOMESTIC INDONESIAN DESTINATION TOUR

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ABSTRACT

The tourism sector in Indonesia is a very important economic asset. Indonesia is a country with a variety of ethnic diversity, customs, arts, culture and tourism. The tourism industry in Indonesia develops from year to year. The development of the tourism sector is one way to boost the national economy. Not only as a source of foreign exchange income but also to increase the competitiveness of tourist areas. According to studies carried out by Global Travel Intentions Study (GITS) stated that 20% Indonesians traveler prefer overseas trip to domestic trip. This situation is caused by the lack of information about domestic travel package that were supplied by various travel agencies in Indonesia, especially in this study focused on travel agencies in East Java. Thus, this research’s aim is to create a simulation of travel package costs that can be applied by travel agents in east Java to provide domestic travel packages. In the simulation, a program has created to present several domestic tourist destinations on the islands of Java, Bali and Lombok, along with selected travel packages. After that, the user could input the number of participants who will be participated in the tour. From those inputs, the simulation program will generate the total cost and the recommended vehicle for user. As a result, the user can estimate the cost of travel in several destinations in Java, Bali or Lombok city. It also generates the type of vehicles that can be used by user according to the number of travelers that will join the tour.

Keywords: Indonesian tourist sector, tour agent simulation, price travel estimation, travel package application.

1. INTRODUCTION

A.J Burkat in Damanik (2006), tourism is the movement of people temporarily and in the short term to destinations outside the places where they usually live and work and also their activities while living in a destination. Tourism is one of the main and important factors in the development of a country, one of which is Indonesia. With a large variety of tourism destinations, domestic and foreign tourists want to know and explore these destinations directly. However, visiting a destination definitely requires preparation that is not easy. Therefore we need an agency to assist tourists in preparing for their visit. For example, with a travel agency. Using travel agency planning can be helpful because it can be used as a marketing medium and convey information about travel agents to the public or consumers. Travel agents are the driving force for planning and arranging tour trips from one place to another. Pandawa Tour and Travel is a travel agency that provides this service, namely providing tourism services to the surrounding community. The purpose of a travel agency is to develop, introduce and maintain the quality of Indonesian tourism products. Travel agents have also spread throughout Indonesia, and each travel agency provides travel services according to company standards. Therefore, the role of travel agents in the tourism industry cannot be ruled out.

2. METHOD

2.1 Observation

Looking for data by visiting articles or websites on the internet regarding travel agents.

2.2 Design

Method by designing for the purposes of delivering information relating to services provided

3. RESULTS AND DISCUSSION

The development of tourism destinations in Indonesia still plays a very important role in supporting the country's development and is also a very strategic factor to increase people's income and foreign exchange. The development of an area through tourist destinations is influenced by several important factors, such as:

- Attract tourists.
- Facilities and (cultural) attractions.
- Geographical location.
- Transport routes.
- Political stability.
- Healthy environment.
- No government restrictions.

A destination must have the various facilities needed by tourists so that a tourist's visit can be fulfilled and feel comfortable. The various needs of tourists include, among others, transportation facilities, accommodation, travel agents, attractions (culture, recreation and entertainment), food services, and souvenir items (Gde Pitana, 2005: 101).

The various facilities available will make tourists feel comfortable, so it would be more interesting interests many travelers. The amenities in as follows:

Tourism infrastructure Tourism infrastructure is an absolute and artificial natural resource required by tourists in tourist destinations, such as highways, electricity, water, telecommunications, buildings, terminals, bridges, etc. To facilitate tourists in preparing visit to tourism areas, it is necessary to build tourism infrastructure that corresponds to the location and conditions of the destination. In developing tourism infrastructure, coordination difficulties between related agencies and tourism facilities at all levels need to be addressed. Support related agencies for the formation of tourism infrastructure is very important for the development of tourism in the region.

Coordination at the planning level and then at the level of implementation is a major capital for the success of tourism development.

Infrastructure is all facilities that can encourage economic development, in this case the tourism industry can operate smoothly so that people can be easier to meet their needs. Therefore, infrastructure can be useful to complete the tour facilities to provide a decent service. Tourism infrastructure is all supporting that allows tourism to live and grow to provide service to tourists.

Some tourism industry infrastructure are:

1. Reception of various forms of commercial body or organizations whose activities are specifically addressed to travelers who are ready to reach their destination, namely:
   - The company's activity is planning and organizing traveling for people who travel. For example: travel agency and travel agency.
   - Body or organization that provides information, explanation, promotion and publicity on tourist destinations. For example, the tourist information center located at the airport, terminal, port.
2. The place of the / trout of all the facilities can accommodate travelers who are aboutto stay at a division of tourist destinations. Example: hotel, motoris hotel (motel), homestay, resort, etc.
3. Recreation Places All facilities that can be used for recreational and sports purposes. The group includes facilities to golf, swimming pool, surfing, fishing, tennis courts and other facilities.
4. Tourism facilities Tourism facilities are an integral of the destination and can meet the needs of tourists during a visit to tourist destinations. In the regional attractions, the development of tourism should meet the needs of tourists both in terms of quantity and quality.

The quantitative tourist shows the number of facilities to be provided, and demonstrates the quality of service provided, it is reflected in the satisfaction of tourists who are service. Regarding the type and quality of facilities and tourism services in destination has been established its default, both domestic and international. Therefore, the tourist provider only needs to select or determine the type and quality of the service to be provided. Tourist facilities are distinguished to three parts, namely:

1. The main tourist superstructure shows that people's lives and companies are verydependent on the entry of tourists. For example: travel and agency. Operators, travel companies, hotels, hostels, bars, restaurants, and other accommodation types. Basically the company should have minimal facilities that must be owned by a tourist destination, if not can be said the trip is not working as expected.
2. Tourism Supporting facilities is a company or place that provides entertainment facilities, its function is not only as a complement of main tourist facilities, but most importantly is possible travelers to stay longer in tourist destinations, in addition to tourism support facilities also have more important functions, so travelers spend more money on a trip to where they visit. The existence of tourism support facilities as mentioned above will support the main facility. That is, these two tourist facilities should be complementary.

- **The Positive Impact Of Tourism For The Economic**

Sector of the sector in the country shows a rapid developmental primarily for the country's economy. The impact of tourism can be measured in two stages, namely the direct impact of tourism and impact tourism indirectly to the economy. The impact of direct tourism is measured through the level of foreign exchange tourism and its impact on employment. While the impact of tourism indirectly includes measurement of effects generated against the growth and national economic revenue. In general the tourism has a positive impact on the economy, such as:

1. Income from the foreign exchange of this we can get from foreign tourists. Although in some countries revenue from the foreign exchange is not so great, but some countries such as New Zealand and Australia have considerable foreign exchange income compared to other state exchange income, as well as some countries with large currency revenues have significantly roles.
2. Push The surface of foreign trade balance from foreign exchange revenue will provide the trade balance to be healthier. This will encourage a country able to import the various items. Services and capital to improve the living and the welfare of the people.
3. Tourism can provide positive exploitation of the economic scale of national companies A large

number of tourists provide opportunities to benefit local products in the market. The tourism sector offers a wide variety of jobs, such as tourism entrepreneurs, hotel and restaurant employees, and travel agency employees, transportation services providers, tour guides, souvenirs, attractions, and so forth.

4. Government revenue
   The greatest revenue contributions from tourism emanate from tax evasion to foreign tourists. For example, the tax applications of hotels and restaurants that are part of the profits of the hotels and restaurants.
5. Absorption of labor
   Many individuals who were able to change their lives from the tourism sector. Tourism cannot be denied isa labor force that absorbs so much labor. There are many jobs to benefit from in the tourism sector.
6. Multiplier effects
   The multiplier effect is the economic effect that tourism's economic activity reposes on the economic activity of a specific region (region, country). If a visitor were to issue one dollar or maybe 1,000 dollars of money would be the income for the recipient, such as the souvenir shop owner. The owners of the shop apply either complete or partial funds to purchase items among his souvenirs for his shops, pay taxes, water, and so on.
7. A use of tourist facilities by local communities
   Tourists and local communities often various facilities. Many tourists bring high enough profits that a facility may be free of its use to local communities.

- **The Negative Effects Of Tourism On The Economy**

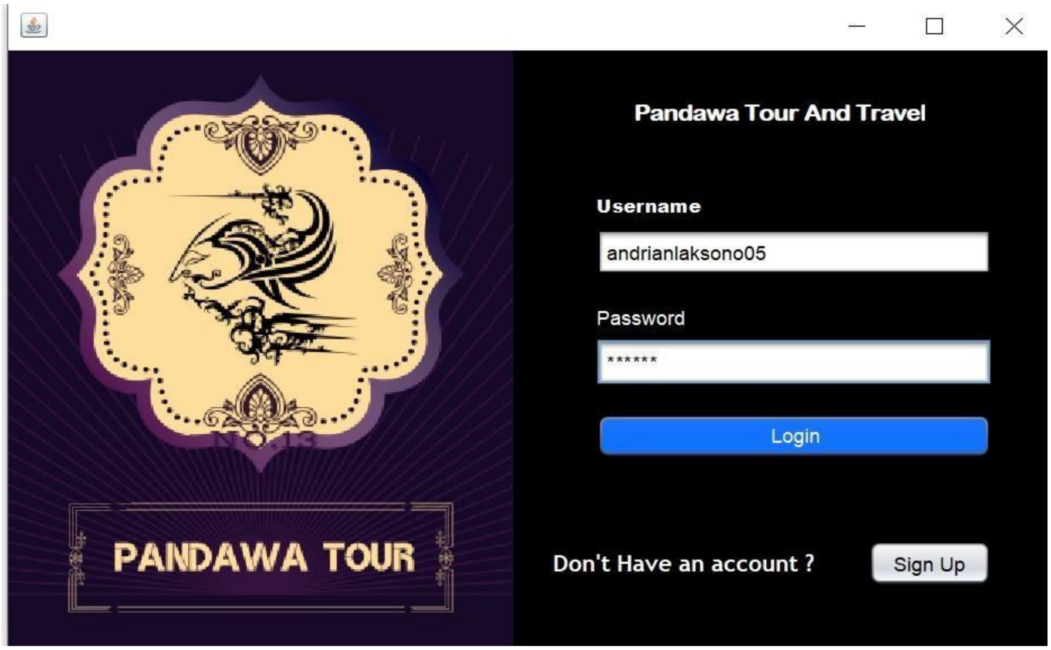
In the introductory book of tourism, pitana and diarta (2009) states that the overall negative mention of tourism is that it has a fraction of its positive effects. The current negative effects are as follows (mathieson and wall, 1982 and laiper, 1990).

1. Dependence is too great on tourism.
   Some of the tourist destinations are heavily dependent on income or economic activities in the tourism sector. As it is known, the tourism sector is vulnerable to fluctuations because of unpredictable issues of terror, disease, conflict, and so on. Once tourism drops, directly or indirectly it will lead to a decline in society's economic activities.
2. Inflating Numbers and skyrocketing land prices.
   The exchange of money in the economic activities of the tourist destination is so large that demand for foodstuff also increases, which will eventually trigger the rate of information. In other issues, the creation of tourist facilities would trigger land prices around the site to a low price, starting low after such tourism would have an increasingly unreasonable sale price.
3. Leakages occurs in import and export,
   An increasing trend to import essential goods in tourism prevents local production from being absorbed. Leakage imports include offshore spending on equipment, food and drink, and other products that the country hosts cannot meet, which conforms to foreign tourist standards. The leakage of exports is the escape money provided by foreign investors who fund resorts and hotels, since the foreign tourists choose goods from overseas. This is because tourists as consumers come from the geographic hemissions with different living patterns than what the local communities normally apply in their daily lives.
4. The seasonal nature of tourism cannot be predicted precisely, nor will it make investment returns in time. Tourism generates considerable income on certain months, such as holidays, holidays, holidays, and year changes. That will also bring the decline in the economic revenues of tourism. And as a consequence, investment returns are also inconclusive.

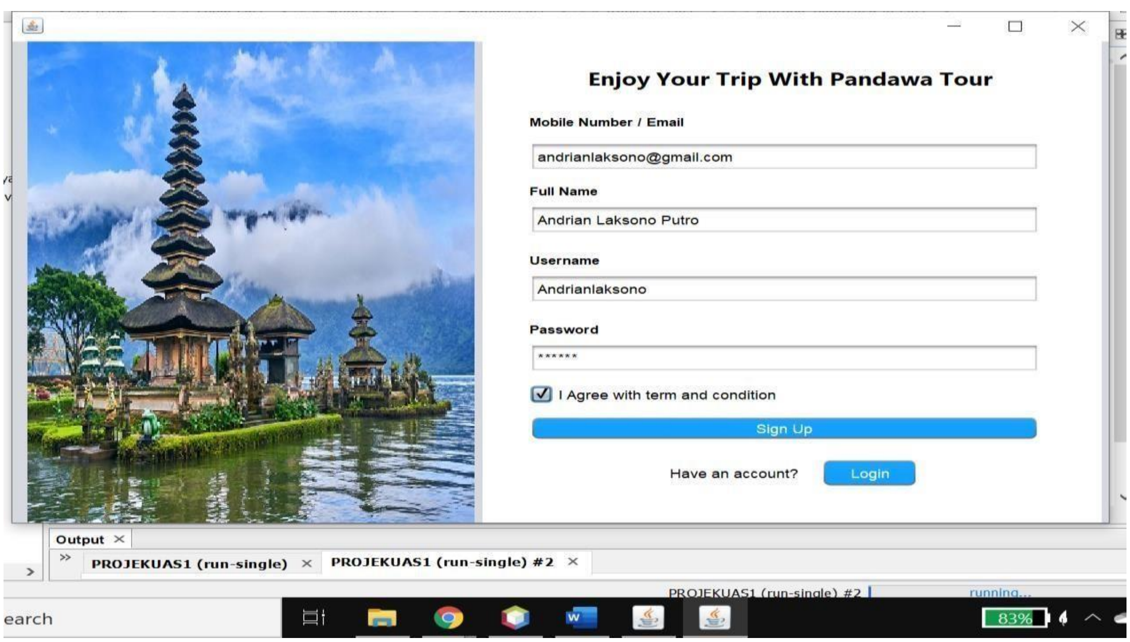
5. Another fee for the local economy was generated. It is associated with natural degradation, the emergence of large waste, pollution, transportation, and so forth that it would cost to repair.

Here is the result of the program we created:

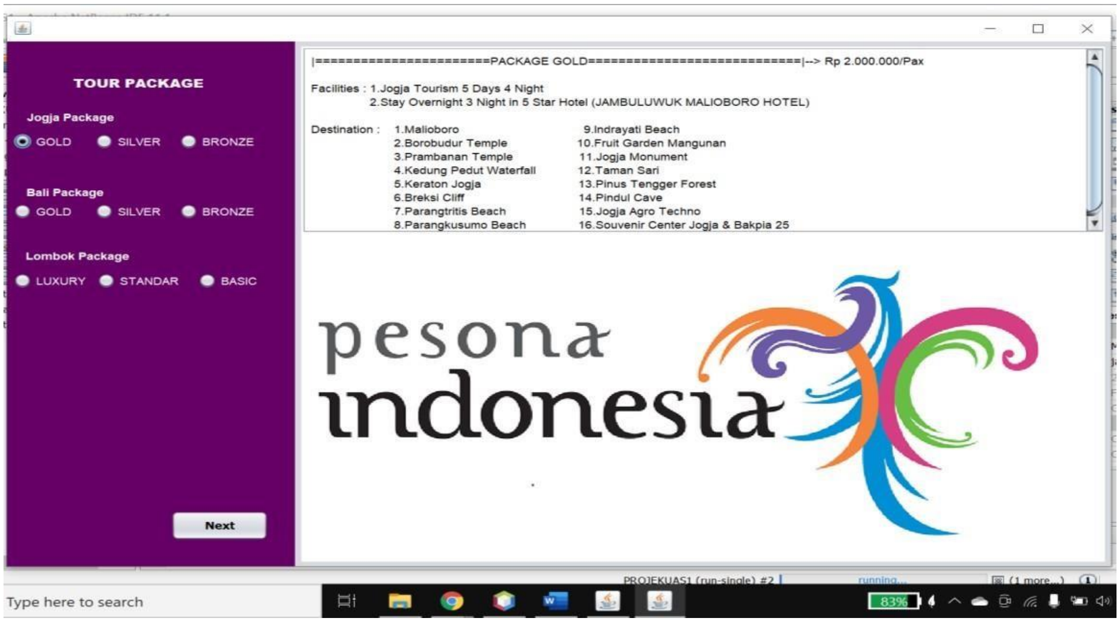
1. The user does login, when already has his username



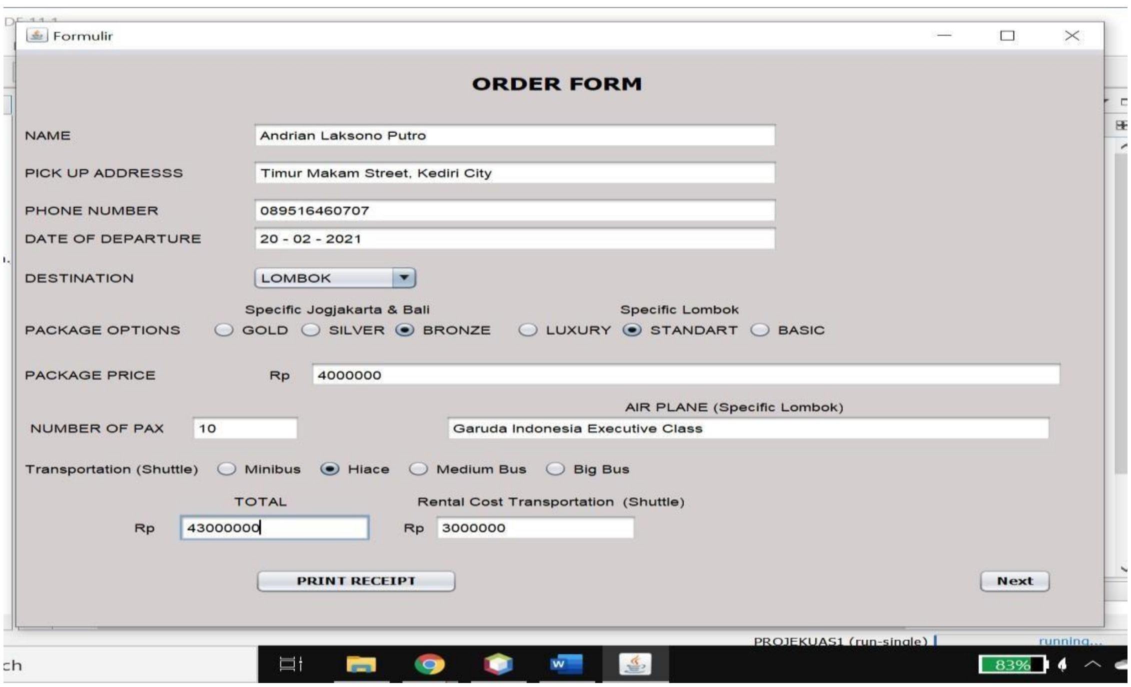
2. If the user doesn't have a username, then the user can create a username on the menu up and then login



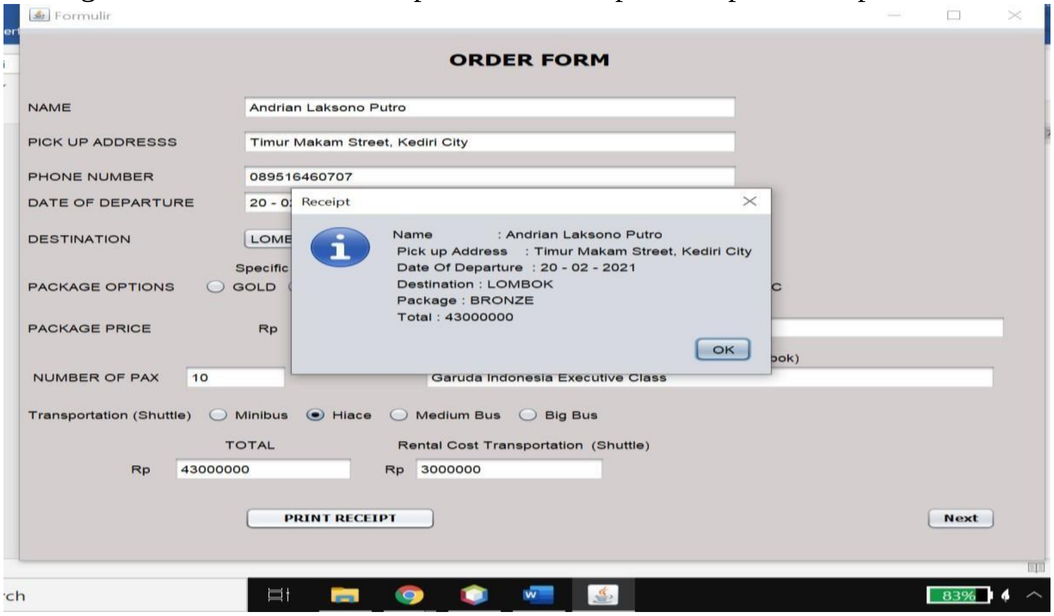
3. After user login.user will be redirected to tour package selection menu



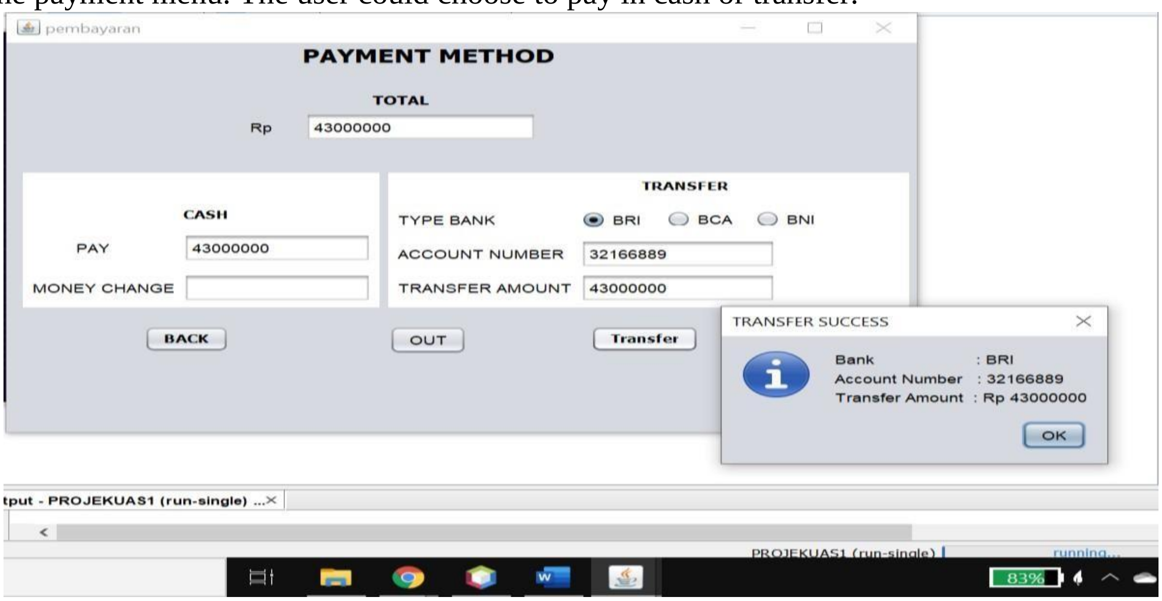
4. After selecting a tour package, the user is pointed to the form fill menu



5. After filling out a form, the user can print out a receipt in the print receipt



6. After that, the user can complete the transaction on the "next" menu. Then it gets routed to the payment menu. The user could choose to pay in cash or transfer.



4. CONCLUSION

The tour and travel agency plays a vital and enormous role in the field of tourism, one of the spearheads of developing a world of tourism as a motor in the field of tourism. So it is easier for Tours to search for information that is desired and to purchase service products sold or offered by the tour and travel bureau. The travel agency should be able to provide a variety of products of quality travel packages, as well as a good service, from tour packages to well-equipped accommodations.

5. REFERENCES

Alma, B. (2016). Manajemen Pemasaran Dan Pemasaran Jasa. Bandung: Alfabet.

Hamali, A. Y. (2016). Pemahaman Strategi Bisnis Dan Kewirausahaan. Jakarta: Kharisma Putra Utama.

Simanjuntak, B. A. (2015). SEJARAH PARIWISATA Menuju Perkembangan Pariwisata Indonesia. Jakarta: Yayasan Pustaka Obor.

Kanal.web.id.(2018, 12 Juni). Definition of Tourism Infrastructure and Facilities. 18 December 2020. https://www.kanal.web.id/pengertian-prasarana-dan-sarana- pariwisata

cvinspireconsulting.com.(2010, 4 Maret). The concept of tourism development. December 18, 2020. https://cvinspireconsulting.com/konsep-pengembangan- pariwisata/

neliti.com.(2012). Consumer Satisfaction Analysis of Quality Travel Tourism Bureau PT. Dwidaya Tour.19 December 2020. https://www.neliti.com/id/publications/218656/analisis-kepuasan-konsumen- terhadap-kualitas-pelayanan-biro-perjalanan-wisata-pt

ruslanabdullah61.wordpress.com.(2014). Tourism planning needs to be done in destinations on.february 8, 2021.https://ruslanabdullah61.wordpress.com/2014/02/24/perencanaan- pariwisata-perlu-dilakukan-di-lingkup-destinasi/

hestanto.web.id.(2009). Definisi Pariwisata (indikator, perkembangan, Objek dan daya tarik).8 Februari 2021. https://www.hestanto.web.id/definisi-pariwisata- indikator-perkembangan-objek-dan-daya-tarik/

kompasiana.com.(2019. 29 Oktober). Dampak Pariwisata terhadap Perekonomian Masyarakat.8 Februari 2021. https://www.kompasiana.com/albanyilfad/5db7fd45d541df35521b10f2/dampak-pariwisata-terhadap-perekonomian-masyarakat

fathuratunk.wordpress.com. Dampak Pariwisata.8 Februari 2021. https://fathuratunk.wordpress.com/article/dampak-pariwisata/

MULTI RESPONSE OPTIMIZATION BY USING TAGUCHI-GREY METHOD IN CALENDERING PROCESS OF PRODUCT SEMI RIGID MONO COLOR TO REDUCE QUALITY LOSS (CASE STUDY AT PT. GRAWIRA MOJOKERTO)

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ABSTRACT

The imitation leather manufacturing industry continues to grow in line with technological developments in Indonesia. One of the products currently being developed in the imitation leather industry is semi rigid. Semi rigid mono color is a product of PT. Grawira which has two critical to quality (CTQ), namely thickness and width. The specifications of the thickness and width of the semi rigid mono color are 0.23 ± 0.01 mm and 1250 ± 5 mm, respectively. Semi rigid mono color is produced by using a calendering machine which has six main rolls. The results of the semi rigid mono color production process are currently not good because there are still some products that do not meet the target specifications. Efforts to improve product quality of semi rigid mono color, it is necessary to carry out a study to determine the process parameter settings that can produce thick and wide products that meet specifications. The process parameters are the speed of calender roll 4, calender roll 5, and roll take off. The process parameters are varied with three levels. The experimental design used was the Taguchi L9 orthogonal array and the optimization method used was grey relational analysis (GRA). The Taguchi method combined with grey relational analysis (Taguchi-GRA) are applied in optimizing a process which has multiple responses (thickness and width). In addition, it also seeks to reduce the cost of loss by using a new parameter setting process. The results showed that all process parameters in calendering process of product semi rigid mono color have a significant contribution and effect in reducing the variance of the two CTQ that were observed simultaneously. Simultaneous variation of the thickness and width of the CTQ is reduced by finding the levels of optimized process parameters. There was a significant decrease in the cost of quality losses.

Keywords: Calendering Process, Grey Relational Analysis (GRA), Imitation Leather, Loss Function, Semi Rigid Mono Color, Taguchi.

1. INTRODUCTION

Quality control in the manufacturing industry has an important role in facing increasingly fierce business competition. This needs to be applied by manufacturing companies to control everything that can harm the company because the quality or quality of products in an industry is very important. One area of industry that is currently receiving a lot of special attention is the imitation leather manufacturing industry.

Semi rigid mono color is one of the products produced by PT Grawira which is located in Mojokerto. One of the processes in the formation of semi rigid mono color products is the calendering process. In this study only discusses the calendering process. This is because in the calendering process there are many product abnormalities or defects, so that the right parameter setting is needed in the calendering process in order to produce products that meet specifications.

Semi rigid mono color has two critical to quality (CTQ), namely thickness and width. The thickness specification for semi rigid mono color is 0.23 ± 0.01 mm and the specification for the width of this product is 1250 ± 5 mm. The process of making semi rigid mono color uses a calender machine consisting of 6 calender rolls. Of all the calender rolls, only the calender roll 4 speed, the calender roll 5 speed, and the roll take off speed does not have the right settings to produce products that meet specifications. An illustration of the calendering process is shown in Figure 1.

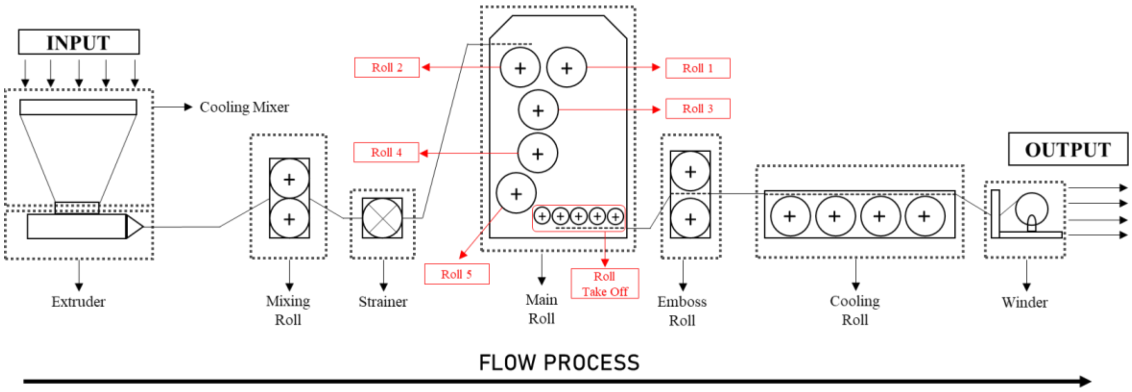

Figure 1. Calendering Process

2. TAGUCHI-GRA METHOD

Multi response optimization cannot be done using only the Taguchi method. The optimization process that results in multiple responses simultaneously can be performed by combining methods of Taguchi and Grey Relational Analysis (GRA).

2.1 Grey Relational Analysis (GRA)

Figure 2 depict the steps of optimization for the Taguchi-GRA method.

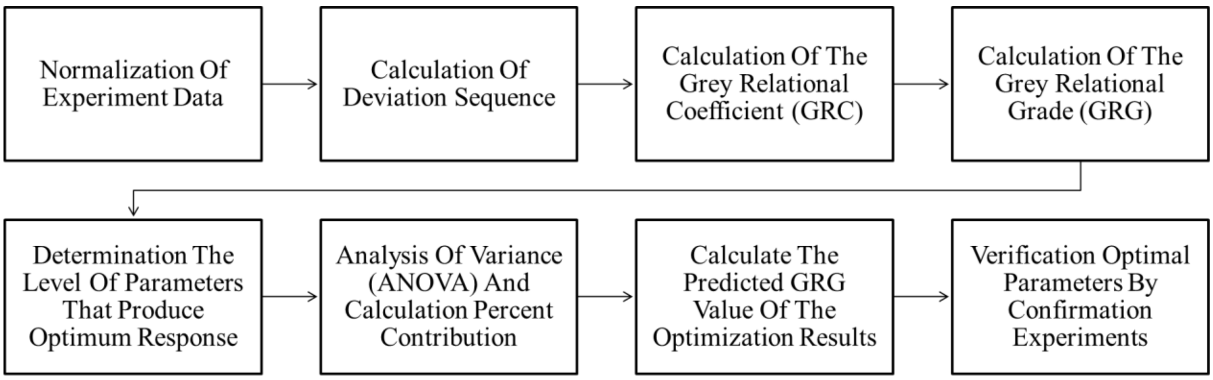

Figure 2. The steps of the optimization method in this research

Some details of these steps are as follows:

1. Normalization data
   The first calculation step use this equation, namely normalization calculations for the response variable are carried out using characteristics nominal the best (Datta and Mahapatra, 2010).

$$X_i^*(k) = 1 - \frac{|X_i(k) - X_{ob}(k)|}{\max_{\forall k} X_i(k) - X_{ob}(k)} \tag{1}$$

   Where X_i^* (k) is the normalization value, min X_i (k) is the smallest value of X_i (k) fo the k^{th} response and max X_i (k) is the largest value of X_i (k) for the k^{th} response.

2. Grey relational coefficient (GRC)
   The relationship between the actual and ideal states of the normalized responses is shown by the GRC value. Below is an equation in order to get the value of GRC (Datta and Mahapatra, 2010).

$$\xi_i(k) = \frac{\Delta_{min} + \zeta\,\Delta_{max}}{\Delta_{0,i}(k) + \zeta\,\Delta_{max}} \tag{2}$$

   Where $\Delta_{0,i}(k) = |X_0(k) - X_i^*(k)|$ is the deviation sequence of absolute value between X_0 (k) and X_i (k); ζ is the distinguishing coefficient ($\zeta = 0.5$ is generally used); Δ_{min} is the smallest value of $\Delta_{0,i}$ and Δ_{max} is the largest value of $\Delta_{0,i}$.

3. Grey relational grade (GRG)
   After averaging the grey relational coefficients, the GRC performance characteristics of each output is converted into a multi-response called γi or grey relational level (GRG). Conversion is done by using the equation (Esme, 2010).

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k) \tag{3}$$

   Where n is the number of process responses.

4. Analysis of variance and contribution
   The aim of the Analysis of Variance (ANOVA) was to find out the process parameters which significantly affect on the response and the contribution to the response characteristics. In this research, analysis of variance was carried out for GRG which represented the overall responses. The calculation of the total sum of squares (SST) from the total mean of the grey relational grade γm can be calculated using this equation (Esme, 2010).

$$SS_T = \sum_{j=1}^{p} (\gamma_j - \gamma_m)^2 \tag{4}$$

   Where p is the number of experiments in the orthogonal array and γ_j is the mean of the grey relational grade for the j^{th} experiment. Percent contribution can be calculated as:

$$\text{Percent contribution} = \frac{SS_F}{SS_T} \times 100\% \tag{5}$$

   Where SS_F is sum of squared deviations due to each factor.

5. GRG prediction
   Predicted value of GRG based on combination factor level to generate that response optimal can be calculated using this equation (Yudha et al., 2019).

$$\hat{\mu} = \gamma_m + \sum_{1}^{q} (\bar{\gamma} - \gamma_m)$$

$i=1$

(6)

Where γ_m is the total mean of the GRG, $\bar{\gamma}$ is the mean of the GRG at the optimal level, and q is the number of the parameters process that significantly affects the multiple performance characteristics.

2.2 Design Experiment

The experimental planning stage includes determination of process parameters, determination of response parameters, determination constant parameter, determine the experimental design and optimization methods.

1. Process Parameters
   There are 3 calendering process parameters which each has 3 levels. The process parameters and levels applied in this experiment are presented in Table 1.

Table 1. Parameters and levels of calendering process

No	Parameters	Unit	Level 1	Level 2	Level 3
1	Calender Roll 4 Speed (A)	m/min	10.9	11.5	12.1
2	Calender Roll 5 Speed (B)	m/min	15.1	15.9	16.7
3	Roll Take Off Speed (C)	m/min	19	19.9	20.9

2. Taguchi Orthogonal Array
   Based on the number of process parameters and levels, which is three parameters and three levels. Thus, this study uses an experimental design in accordance with the L_9 orthogonal matrix of the Taguchi design. This is because the selection of a suitable orthogonal matrix is determined by the number of degrees of freedom (DOF) of the parameter count and the number of parameter levels. Table 2 shows total combinations of the experimental design.

Table 2. Total combination of experiment

No	A	B	C
1	1	1	1
2	2	2	2
3	3	3	3
4	1	2	3
5	2	3	1
6	3	1	2
7	1	3	2
8	2	1	3
9	3	2	1

3. EXPERIMENTAL RESULT

Experimental data consist of thickness (T) and width (L) of semi rigid mono color products shown in Table 3.

Table 3. Experimental result

No. Combination	Thickness (mm)		Width (mm)	
	1	2	1	2
1	0.240	0.241	1248	1250
2	0.234	0.230	1255	1257
3	0.233	0.231	1251	1255
4	0.231	0.230	1251	1253
5	0.239	0.240	1259	1257
6	0.231	0.227	1258	1260
7	0.227	0.225	1255	1255
8	0.221	0.222	1250	1254
9	0.235	0.237	1249	1250

3.1 Taguchi-GRA optimization results

The experimental data must be normalized first. The calculation of the GRC value begins with determining the order of the deviation values or $\Delta_{0,i}$ of each response parameter. Based on the deviation sequence value of each response parameter that has been obtained, the GRC calculation can be performed. Table 4 shows the results of data normalization, the calculation of $\Delta_{0,i}$ and the GRC of each response parameter for each combination of process parameters. From the calculation of GRC calculation, the average GRC value is taken as the calue of GRG to produce an optimal responses. Table 4 shows the entire calculation, from experimental data until the GRG value is obtained.

Table 4. Taguchi-GRA calculation results from the experiment

No	Average		Normalization		$\Delta_{0,i}$		GRC		GRG
	Thickness	Width	Thickness	Width	Thickness	Width	Thickness	Width	
1	0.2405	1249	0	0.889	1	0.1111	0.3651	0.8737	0.6194
2	0.2317	1256	0.841	0.333	0.1587	0.6667	0.7908	0.4841	0.6375
3	0.2320	1253	0.810	0.667	0.1905	0.3333	0.7559	0.6556	0.7057
4	0.2303	1252	0.968	0.778	0.0317	0.2222	0.9720	0.7479	0.8600
5	0.2397	1258	0.079	0.111	0.9206	0.8889	0.3837	0.4156	0.3996
6	0.2292	1259	0.921	0	0.0794	1	0.8948	0.3889	0.6418
7	0.2260	1255	0.619	0.444	0.3810	0.5556	0.5993	0.5292	0.5643
8	0.2217	1252	0.206	0.778	0.7937	0.2222	0.4182	0.7479	0.5831
9	0.2360	1250	0.429	0.944	0.5714	0.0556	0.4984	0.9556	0.7270

The experimental design in the form of an orthogonal matrix makes it possible to classify the effect of each process parameter at different levels. Optimal conditions of level parameters can be specified explicitly using the average analysis of the response table. Response table procedure by classifying GRG based on parameter levels and calculating the average. The results of the calculation of the GRG value at each level of the process parameters are presented in the Table 5. Basically, the average value of the highest GRG, is the value that can produce some of the best responses.

Table 5. Response table for the GRG

Level	A	B	C
1	0,6812	0,6148	0,5820
2	0,5400	0,7415	0,6145
3	0,6915	0,5565	0,7162
Average	0,6376		
Rank	3	1	2

Figure 3 points out response graphs for the GRG value of each parameters levels. The biggest value of GRG at each level of parameters represent the best level setting of the process parameters which can reduce response variance simultaneously.

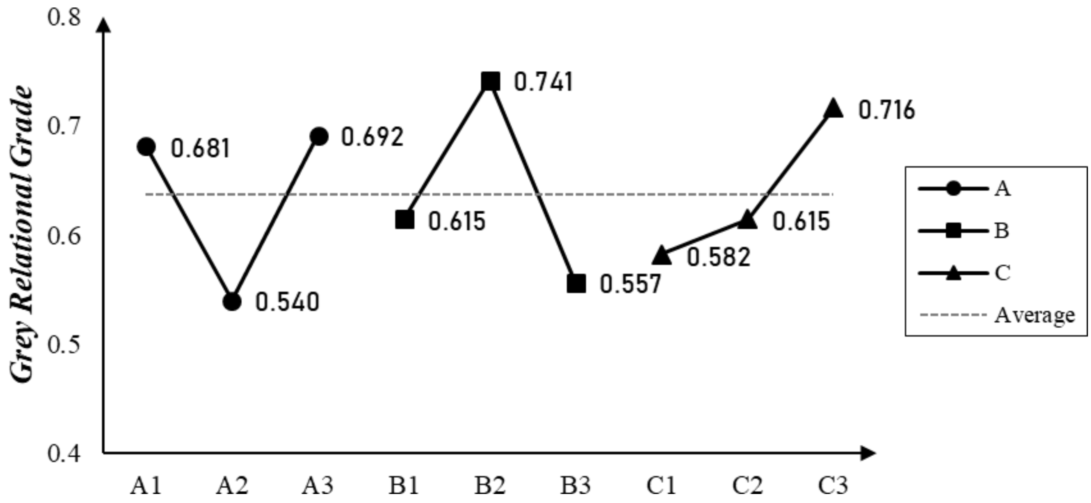

Figure 3. Grey relational grade graph

Optimal condition for the calendering process of semi rigid mono color becomes A_3 B_2 C_3 as shown in Figure 3. Specifically, calender roll 4 speed, calender roll 5 speed, and roll take off speed was set at 12.1 m/min, 15.9 m/min, and 20.9 m/min, respectively.

3.2 ANOVA and percentage contribution results

Table 6 presents the ANOVA calculation results for GRG and the percentage contribution from the responses generated by the process parameters at each level.

Table 6. ANOVA results and percent contribution

Process Parameters	df	Seq SS	Adj MS	F	P	% Contribution
Calender Roll 4 Speed	2	0.043	0.021	31.53	0.035	33.7%
Calender Roll 5 Speed	2	0.054	0.027	39.35	0.025	42.1%
Roll Take Off Speed	2	0.029	0.015	21.59	0.044	23.1%
Error	2	0.001	0.001			1.1%
Total	8	0.127				100%

The P value of each process parameter is less than the value of α (0.05). These results indicate that the process parameters have an influence on the calendering process. Process parameters that have the greatest contribution to the GRG value are the calender roll 5 speed, which is 42.1%. The contribution to the GRG value by the speed of roll calender 4 was 33.7% and the contribution by roll take off speed was 23.1%. It is all shown in table 6.

3.3 Prediction of optimal multiple respons and confirmation test

Based on the combination of factors for the optimum response as shown in Table 5, prediction of the optimal GRG value can be determined. Determination of the optimal prediction of the GRG value is carried out based on the GRG value of each factor level from a combination of factors that produces the optimum response. Thus, the predicted GRG value for the combination of factors that produced the optimum response was 0.874.
Validation of the results of experiments conducted with experimental confirmation, which results are shown in Table 7. The confirmation experiment was conducted using 4 replications and then the average was utilized to verify the predictions.

Table 7. Results of confirmation experiments.

Parameters	1	2	3	4	Average
Thickness (mm)	0.232	0.2313	0.2307	0.23	0.231
Width (mm)	1250	1251	1251	1252	1251

GRG calculated from experimental confirmation was 0.8727. The results of the comparison GRG of the confidence interval between the confirmatory experimental and the predicted at the 95% confidence level can be seen in Figure 4.

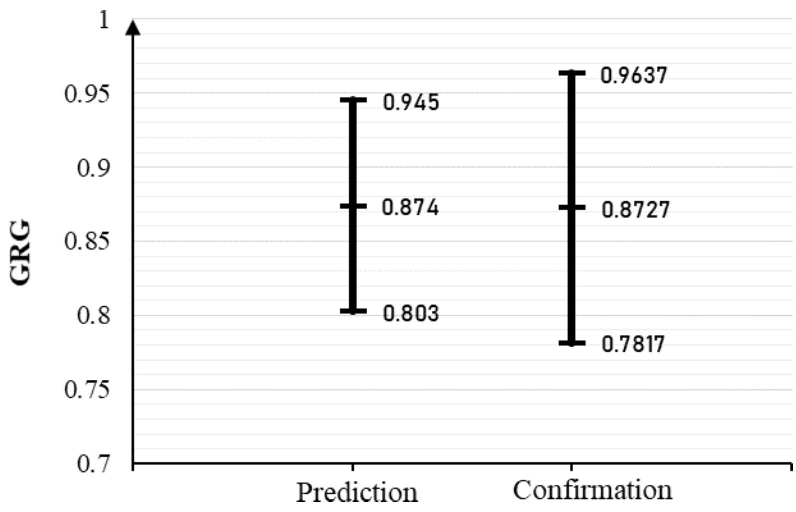

Figure 4. GRG prediction and confirmation experiments are plotted in confidence interval.

Figure 4 shows that the confidence interval for the GRG value of the confirmation experiment is within the confidence interval for the predicted GRG value, it can be concluded that the multi response optimization has been successful. Thus, the combination of process parameter settings for prediction is also a process parameter setting that produces the optimum response.

3.4 Cost of quality loss

The calculation of the reduction in the quality loss function with the characteristic "nominal is the best" is calculated using the following equation: (Ross, 1989)

$$L_{NIB} = k(s^2 + (\bar{x} - \mu_0)^2) \tag{7}$$

Where L is quality loss cost, k is quality loss coefficient, μ_0 is target specification, s is standard deviation of process, and $\bar{x}$ is average value of product. Quality loss coefficient (k) can be calculated as: (Ross, 1989)

$$k = \frac{A_0}{\Delta_0^2} \quad (8)$$

Where A_0 is replacement cost and Δ_0 is range of specification. The details of product price assumption is shown in Table 8.

Table 8. Product price assumption

No	Information	Detail	Price/meters
1	Break event point (BEP)		Rp.13.200
2	Good quality product price	= BEP + 15% BEP	Rp.15.200
3	Defect product price	= 65% Good quality product price	Rp.8.600
4	Compensation cost (A_0)	= BEP – Defect product price	
		= Rp.13.200 – Rp.8.600	Rp 4.600

The value of the standard deviation and the average product of the semi rigid mono color product obtained by the calculation of the process capability analysis is shown in Table 9.

Table 9. Average and standard deviation for initial and the optimum process

Settings	Average (x)		Std. Dev (s)	
	Thickness	Width	Thickness	Width
Initial	0.2285	1252.59	0.4622	2.8375
Optimal	0.2305	1250.87	0.1827	1.2468

By using the standard deviation value, average, and product price assumptions obtained from calculations in the previous process, the cost of quality loss is by using the old settings and the optimization result settings for each CTQ thickness and width of the semi rigid mono color product shown in Table 10.

Table 10. Cost of quality loss results

CTQ	Loss function per meters (Rupiah)			Remark
	Initial	Optimal	Difference	
Thickness	1091,65	166,02	925,63	Reduce 84,79%
Width	2532,48	425,29	2107,18	Reduce 83,21%
Total	3624,13	591,31	3032,81	Reduce 83,68%

4. CONCLUSION

Based on the results and discussions that have been carried out obtained three conclusions. First, the results showed that the roll speed of calender 5 was the process variable that had the greatest contribution in reducing the variance of the two CTQ that were observed simultaneously. Second, setting the process parameters that can reduce the amount of variance of the thickness and width of the CTQ simultaneously are the calender 4 roll speed of 12.1 m/min, the calender 5 roll speed of 15.9 m/min, and the roll take off speed of 20.9 m/min. Third,reduction in the cost of quality loss obtained in the calendering process using optimized settings was 83.68%.

5. REFERENCES

Datta, S. & Mahapatra, S. (2011). Modeling, Simulation and Parametric Optimization of Wire Edm Process using Response Surface Methodology Coupled with Grey-Taguchi Technique. International Journal of Engineering, Science and Technology. 2 (5), 162-183.

Esme, U. (2010). Use of Grey based Taguchi method in Ball Burnishing Process for the Optimization of Surface Roughness and Microhardness of AA 7075 Aluminum Alloy. Journal of Materials and Technology. 44, 129-135.

Ross, P. J. (1989). Taguchi Techniques for Quality Engineering: Loss Function, Orthogonal Experiments, Parameter and Tolerance Design, Mcgraw-Hill International Edition, New York.

Yudha, F. A, Soepangkat, B. O. P, Ratnasari, V, Suef, M, & Nurcahyo, R. (2019). Determination of Optimum Vulcanization Process Parameters using Taguchi GRA for reducing Quality loss cost, AIP conference proceeding, 1855.

OPTIMALIZATION HAZARDOUS WASTE AS ALTERNATIVE FUEL AND RAWMATERIAL IN CEMENT INDUSTRY USING MIX INTEGER LINEAR PROGRAMMING

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ABSTRACT

This study aims to make a decision-making tool in optimizing the use of alternative fuel and raw material (AFR) in one of the cement industries in Indonesia. The decision tool uses a mixed integerlinear programming mathematical model. The model developed has the objective of minimizing clinker production costs, while at the same time ensuring four constraint aspects including: product quality, smooth factory operations and capacity to handle waste, government regulations and emissions limit. Theresulting model of product quality constraint development consist of lime saturation factor, silica ratio, alumina ratio, C_3S, C_2S, C_3A, C_4AF, predicted free CaO, MgO limit, alkali equivalent. The model resultsof the development of operational plant aspects and waste management capacity consist of chlorine and SO3, alkali to SO3 ratio, coating index, hazardous waste storage capacity, AFR feeding capacity, materialavailability. Aspects of government regulations consist of limits on heavy metals and the expired date ofthe waste. The environmental aspects is VOC (Volatile Organic Compound) reported as TOC (Total Organic Carbon) emissions in CH_4. The model developed is displayed in the form of a dashboard and dialogue modeling parameters for easy interpretation and simulation of several scenarios. The model is then tested to evaluate 8 types of alternative raw materials and 10 types of alternative fuels. Based on thesimulation results, the optimal recommendation for the type of hazardous waste to be utilized is 6 types of alternative raw materials and 3 types of alternative fuels while still meeting the aspects of product quality specifications, operational smoothness, compliance and the environment, with the potential for saving on raw material and fuel costs to produce clinker is 39% per day.

Keywords: Alternative Fuel and Raw Material, Clinker, Co-processing, Hazardous Waste, MixInteger Linear Programming

1. INTRODUCTION

The cement industry in Indonesia, to maintain its competitiveness, is trying to carry out various cost reduction programs, one of which is by optimizing the use of Alternative Fuel and Raw Materials (AFR). Rahman et al. (2013) said that by utilizing AFR from waste, it is hoped that the cement industry can reduce clinker production costs. The large number of types of waste available with a wide variety of chemical content in them requires selecting the type of waste bycertain methods.

The existence of these variations and limitations as well as the demand to stabilize quality are complex challenges that must be resolved by waste users in the cement industry. Kookos et al. (2011) stated that optimizing the use of AFR is a complex problem so that a Mix Integer

Linear Programming (MILP) decision-making tool is needed in order to obtain the appropriate combination of AFR types.

AFR basically cannot completely replace raw materials and fuel directly due to unsuitability of major component, minor component, trace component composition. The variation of the chemical composition of the raw mix design must be kept stable so as not to interfere with the quality and operational processes of the kiln. Variation in raw material and fuel itsself is strongly affected by operational handling activity of AFR. Producing clinker involving chemical process reaction inside kiln. Numerous parameters should be controlled dueto highly effect to smoothness kiln operation. There are SO_3-Chlorine, Alkali to Sulphur ratio, Coating Index. Another aspect supply capacity from market, storage space limitation, feeding capacity.

Compliance aspect related heavy metal maximum limit in clinker and expired date of hazardous waste as AFR keep in inventory no more than 90 days. The environmental aspects considered in this study are only limited to the emission aspects which are only affected if the plant utilizes AFR, namely TOC emissions. This research introduces MILP that consider all of the aspects as new constraints, then developing Microsoft Excel as a tool and dashboard to assist a decision-making for AFR optimization.

2. METHOD

The transformation process from raw material to clinker in this mathematicalmodeling is to follow the diagram as follows (Figure 1).

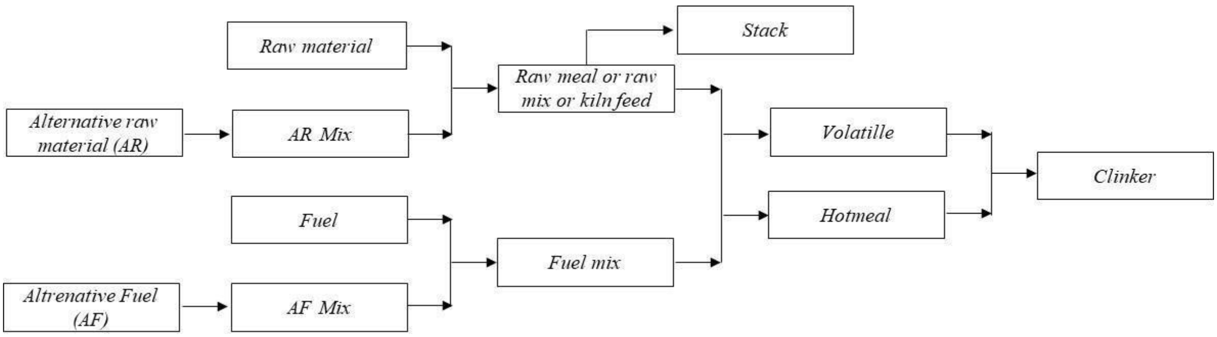

Figure 1. The raw material and fuel phase until it becomes a clinker

- Indeks superscript

  R = raw material phase
  AR = alternative raw material phase
  F = fuel phase
  AF = alternative fuel phase
  AR Mix = AR Mix phase
  AF Mix = AF Mix phase
  HM = hot meal phase
  C = clinker phase
  Stack = stack phase
  Kiln feed = kiln feed (raw meal)
  phaseFuel mix = fuel mix phase
  U = upper limit

- Indeks subscript

  j = traditional raw material , j = {limestone,clay,silica sand}
  a = alternative raw material, a ={AR1,AR2…..,AR8}
  l = traditional fuel, l ={coal}

b = alternative fuel, b ={AF1,AF…..,AF10}
AR handling = internal handling activity of alternative raw material inside cement plantAF handling = internal handling activity of alternative fuel inside cement plant
i = oxide ={CaO, SiO_2,Al_2O_3, Fe_2O_3}
L = lower limit
p = clinker phase predicted by bogue equation, p ={C_3S, C_2S, C_3A, C_4AF}
MgO = MgO content
k = Alkali, k ={K_2O, Na_2O}
SO_3 = SO_3 content
n = heavy metal = {As, Pb, Cd, Cr, Co, Cu, Ni, Hg, Se, Zn}
Cl = chlorine content
T = lead time delivery

- Parameter

UC_j^R = unit variable cost raw material – j (IDR/ton)
m_j^R = raw material – j consumed (ton/day)
UC_a^{AR} = unit variable cost AR – a (IDR/ton)
m_a^{AR} = AR – a consumed (ton/day)
UC_l^F = unit variable cost fuel – l (IDR/ton)
m_l^F = fuel –l consumed (ton/day)
UC_b^{AF} = unit variable cost AF – b (IDR/ton)
m_b^{AF} = AF – b consumed (ton/day)
AC_a^{AR} = acquisition cost AR -a (IDR/a)
X_a^{AR} = decision variable 1 if AR-a selected as AR, 0 otherwise
AC_b^{AF} = Acquisition cost AF-b (IDR/b)
X_b^{AF} = decision variable 1 if AF-b selected as AF, 0 otherwise
$FC_{AR\ Handling}^{AR\ Mix}$ = fix charge cost for package job internal handling by 3rd party AR (IDR/day)
$VC_{AR\ Handling}^{AR\ Mix}$ = variable cost for internal handling AR (Rp./ton)
$m_a^{AR\ Mix}$ = tonnage of AR Mix consumed (ton/day)
$FC_{AF\ Handling}^{AF\ Mix}$ = fix charge cost for package job internal handling by 3rd party AF (IDR/day)
$VC_{AF\ Handling}^{AF\ Mix}$ = variable cost for internal handling AF (Rp./ton)
$m_b^{AF\ Mix}$ = tonnage of AF Mix consumed (ton/day)
m = mass (ton/day)
ω = fraction (%)
C_3S = alite formation predicted by bogue equation (%)
C_2S = belite formation predicted by bogue equation (%)
C_3A = aluminate formation predicted by bogue equation (%)
C_4AF = ferrite formation predicted by bogue equation (%)
NCV = net calorific value (Mj)
M = pick up limit material AFR in market (ton)
$Barge$ = material AR-a delivered using barge
μ = mean of lead time delivery AFR
σ = standard deviation of lead time delivery AFR

2.1 Objective function Minimize

$$Fuel\ and\ Material\ Cost\ of\ Clinker\ per\ day = \Big(\big(\textstyle\sum_{j \in Rawmaterials} UC_j^R m_j^R + \sum_{a \in AR} UC_a^{AR} m_a^{AR} \big) + \big(\sum_{l \in Fuels} UC_l^F m_l^F + \sum_{b \in AF} UC_b^{AF} m_b^{AF} \big) \Big) + \big(\sum_{a \in AR} AC_a^{AR} X_a^{AR} \big) + \big(\sum_{b \in AF} AC_b^{AF} X_b^{AF} \big) + FC_{AR\ Handling}^{AR\ Mix} + VC_{AR\ Handling}^{AR\ Mix}\ m_a^{AR\ Mix} + FC_{AF\ Handling}^{AF\ Mix} + VC_{AF\ Handling}^{AF\ Mix}\ m_b^{AF\ Mix} \quad (1)$$

2.2 Quality Constraint

$$m_i^C = \textstyle\sum_{j \in RawMaterials} \omega_{i,j}^R\, m_j^R + \sum_{a \in AR} \omega_{i,a}^{AR}\, m_a^{AR} + \sum_{l \in Fuels} \omega_{i,l}^F m_l^F + \sum_{b \in AF} \omega_{i,b}^{AF}\, m_b^{AF}, \quad \forall i \in \text{Oxides} \quad (2)$$

- Alumina Ratio (AR) atau alumina modulus (AM)

$$AR_L^C \le \frac{m_{\mathrm{Al2O3}}^C}{m_{\mathrm{Fe2O3}}^C} \le AR^{C,U} \quad (3)$$

- Silica Ratio (SR) atau silica modulus (SM)

$$SR_L^C \le \frac{m_{\mathrm{SiO2}}^C}{m_{\mathrm{Al2O3}}^C + m_{\mathrm{Fe2O3}}^C} \le SR^{C,U} \quad (4)$$

- Lime saturation factor (LSF)

$$LSF_L^C \le \frac{100\, m_{CaO}^C}{2.8\, m_{\mathrm{SiO2}}^C + 1.2\, m_{\mathrm{Al2O3}}^C + 0.65\, m_{\mathrm{Fe2O3}}^C} \le LSF^{C,U} \quad (5)$$

- Clinker phase based on bogue equation

$$C_3S^C = 4{,}07 m_{CaO}^C - 7{,}6 m_{\mathrm{SiO2}}^C - 6{,}72 m_{\mathrm{Al2O3}}^C - 1{,}43 m_{\mathrm{Fe2O3}}^C \quad (6)$$

$$C_2S^C = -3{,}07 m_{CaO}^C + 8{,}6 m_{\mathrm{SiO2}}^C + 5{,}07 m_{\mathrm{Al2O3}}^C + 1{,}08 m_{\mathrm{Fe2O3}}^C \quad (7)$$

$$C_3A^C = 2{,}65 m_{\mathrm{Al2O3}}^C - 1{,}69 m_{\mathrm{Fe2O3}}^C \quad (8)$$

$$C_4AF^C = 3{,}04 m_{\mathrm{Fe2O3}}^C \quad (9)$$

$$m_{L,p}^C \le m_p^C \le m_p^{C,U}, \quad \forall p \in ClinkerPhases \quad (10)$$

- MgO limit

$$m_{MgO}^C \le m_{MgO}^{C,U} \quad (11)$$

- Alkali limit

$$m_k^C = Na_2O^C + 0.658 K_2O^C \quad (12)$$

- Predicted free CaO (PFC)

$$PFC^C = LSF^C + 6(SR^C - 2) - (MgO^C + K_2O^C + Na_2O^C) \quad (13)$$

2.3 Plant Operational and Capacity Handling Hazardous Waste

- Thermal energy demand

$$\big(\textstyle\sum_{l \in Fuels} m_l^F\, NCV_l^F + \sum_{b \in AF} m_b^{AF}\, NCV_b^{AF} \big) \ge TED^C \quad (14)$$

- Market capacity alternative raw material

Minimum pick up if selected : $X_a^{AR} M_L^{AR} - m_a^{AR} \le 0$ (15)

Maximum pick up if selected : $m_a^{AR} - X_a^{AR} M^{AR,U} \le 0$ (16)

Recommended maximum feeding if selected $m_a^{AR} - X_a^{AR} * \left(\frac{Barge_a}{2*\mu_T + 1.645*\sigma_{T,a}^{AR}} \right) \le 0$ (17)

- Market capacity alternative fuel

Minimum pick up if selected : $X_b^{AF} M_L^{AF} - m_b^{AF} \leq 0$ (18)
Maximum pick up if selected : $m_b^{AF} - X_b^{AF} M^{AF,U} \leq 0$ (19)

- SO_3 and Chlorine

This formula inside curly bracket only apply for typical plant, different plant need torebuild new formula using linear regression approach.

$$1{,}2\{0{,}97(SO_3^{Kiln\,feed} + SO_3^{Fuel\,mix}) + 0{,}39\} + 3{,}5\{1{,}97(Chlorine^{Kiln\,feed} + Chlorine^{Fuel\,mix}) + 0{,}53\} \leq 4{,}2 \quad (20)$$

- Alkali to Sulphur ratio (A/S)

$$A/S_L^C \leq \frac{\frac{\%K_2O^C}{94} + \frac{\%Na_2O^C}{62} - \frac{\%Cl^C}{71}}{\frac{\%SO_3^C}{80}} \leq A/S^{C,U} \quad (21)$$

- SO3 limit

$$m_{SO_3}^C \leq m_{SO_3}^{C,U} \quad (22)$$

- Mass of clinker produced per day

$$\sum_{i \in Oxides} m_i^C + \sum_{k \in Alkalis} m_k^C + m_{SO_3}^C + \sum_{n \in HeavyMetals} m_n^C + m_{MgO}^C + m_{Cl}^C = 8000\ ton \quad (23)$$

Coating Index (CI)

$$CI^C = C_3A^C + C_4AF^C + 0{,}2C_2S^C + 2Fe_2O_3^C \quad (24)$$

- Feeding capacity alternative raw material

$$(\textstyle\sum_{a \in AR} m_a^{AR}) \leq 1000 \quad (25)$$

- Feeding capacity alternative fuel

$$(\textstyle\sum_{b \in AF} m_b^{AF}) \leq 600 \quad (26)$$

- Max capacity alternative raw material storage

$$2\left(\textstyle\sum_{a \epsilon AR}\left(m_a^{AR}\, \mu_{T,a}^{AR}\right)\right) + 1{,}645\left(\textstyle\sum_{a \epsilon AR}\left(m_a^{AR} \sigma_{T,a}^{AR}\right)\right) \leq 16000 \quad (27)$$

- Max capacity alternative fuel storage

$$2\left(\textstyle\sum_{a \epsilon AR}\left(m_a^{AR}\, \mu_{T,a}^{AR}\right)\right) + 1{,}645\left(\textstyle\sum_{a \epsilon AR}\left(m_a^{AR}\, \sigma_{T,a}^{AR}\right)\right) \leq 12000 \quad (28)$$

2.4.Compliance Constraint

- Heavy metal limit

$$m_n^C \leq m_n^{C,U} \quad (29)$$

- Expired date

$$(X_a^{AR} * \frac{Barge_a}{90}) - (m_a^{AR}) \le 0 \tag{30}$$

2.5 Environmental Constraint

- VOC reported as TOC in CH_4

$$(\sum_{a\in AR} \omega_{voc,a}^{AR}\, m_a^{AR})47{,}12 + 9{,}24 \le TOC^{Stack,U} \tag{31}$$

The objective function is to minimize the cost of producing clinker raw materials and fuel (1). Constraint an oxide in the clinker (2), the minimum and maximum limits of AR, SR andLSF (3,4,5), the clinker phase according to the type of clinker produced (6,7,8,9,10), the MgO limit in the clinker (11), alkalis limit in clinker (12), free lime in clinker value (13), thermal energy required to produce clinker per day (14), market capacity related minimum and maximumpick up (15,16,17,18 , 19), SO3 and Chlorine in hot meal limitation (20), alkali to sulfur ratio is maintained within a certain range (21), SO_3 limit on clinker (22), mass of clinker produced per day considering major component, minor component, trace component (23), coating index in kiln (24), feeding capacity of AFR (25,26), hazardous waste storage capacity (27,28), heavy metal limit in clinker (29), expired date limit if alternative raw material selected (30), TOC limitin stack (31).

2.6 Model development in Microsoft Excel

To facilitate the decision-making process and evaluate several scenarios and their impacts, a dialogue modeling parameter is created. The results of running the model simulation are then displayed in the form of a dashboard in order to facilitate illustration and as a medium for communicating the simulation results. The simulation model will be updated every time a new AFR material candidate introduced or clinker type production change is planned.

PARAMETER DIALOGUE MODELLING

Category	Parameter	Phase	Unit	Min	Value	Max
QUALITY	AM	Clinker	-	1.40	1.70	1.70
	SM	Clinker	-	2.30	2.46	2.70
	LSF	Clinker	-	94	95	97
	C3S	Clinker	-	54%	56%	67%
	C2S	Clinker	-	11%	15%	19%
	C3A	Clinker	-	8%	9%	15%
	C4AF	Clinker	-	8%	10%	15%
	MgO	Clinker	-	-	1.9%	2.0%
	Na2O	Clinker	%	-	0.37	-
	K2O	Clinker	%	-	0.53	-
	Alk.eqv	Clinker	%	-	0.74	1
	PFCaO	Clinker	%	0.5	0.5	3

Figure 2. Dialogue modeling parameter for quality aspect

The following is a parameter dialogue model for aspects of ensuring the smooth operation of the plant and the ability to manage waste.

PARAMETER DIALOGUE MODELLING						
Category	**Parameter**	**Phase**	**Unit**	**Min**	**Value**	**Max**
PLANT OPERATIONAL & HANDLING CAPACITY	Plant Cap	-	tpd	8,000	-	-
	STEC clinker	-	Mj/t-	3,400	-	-
	Est.SO3	Hotmeal	%	0	1.0	3
	Est.Chlorine	Hotmeal	%	0	0.6	1
	Alk/SO3.Ratio	Hotmeal	-	0.8	1.0	1.5
	Coating Index (AW	Hotmeal	-	27	28	30
	Feed.AF Cap.	-	tpd	-	503	1,000
	Feed.AR Cap.	-	tpd	-	600	600
	TPS1 Cap.	-	ton	-	14,337	16,000
	TPS2 Cap.	-	ton	-	3,787	12,000
	TR1	Material	tpd	0	8,991	12,000
	TR2	Material	tpd	0	2,627	4,000
	TR3	Material	tpd	25	25	500
	AR1	Material	tpd	25	52	300
	AR2	Material	tpd	25	91	100
	AR3	Material	tpd	25	0	100
	AR4	Material	tpd	25	0	100
	AR5	Material	tpd	25	100	100
	AR6	Material	tpd	25	100	100
	AR7 (Barge)	Material	tpd	56	66	66
	AR8 (Barge)	Material	tpd	78	95	95
	TF1	Fuel	tpd	800	807	2,000
	AF1	Fuel	tpd	25	0	100
	AF2	Fuel	tpd	25	0	100
	AF3	Fuel	tpd	25	0	200
	AF4	Fuel	tpd	25	0	200
	AF5	Fuel	tpd	25	200	200
	AF6	Fuel	tpd	25	0	200
	AF7	Fuel	tpd	25	200	200
	AF8	Fuel	tpd	25	200	200
	AF9	Fuel	tpd	25	0	200
	AF10	Fuel	tpd	25	0	200

Figure 3. Dialogue modeling parameter for plant operational and handling capacity aspect

The following is a parameter dialogue model for compliance and environmental aspects,namely TOC (Total Organic Carbon).

PARAMETER DIALOGUE MODELLING						
Category	**Parameter**	**Phase**	**Unit**	**Min**	**Value**	**Max**
COMPLIANCE	Arsen (As)	Clinker	tpd	-	0	2
	Lead (Pb)	Clinker	tpd	-	0	8
	Kadmium (Cd)	Clinker	tpd	-	0	1
	Krom (Cr)	Clinker	tpd	-	0	12
	Kobal (Co)	Clinker	tpd	-	0	2
	Tembaga (Cu)	Clinker	tpd	-	0	8
	Nikel (Ni)	Clinker	tpd	-	0	8
	Merkuri (Hg)	Clinker	tpd	-	0	0
	Selenium (Se)	Clinker	tpd	-	0	0
	Seng (Zn)	Clinker	tpd	-	0	40
ENVIRO	TOC as CH4	Stack	mg/Nm3	-	70	70

Figure 4. Dialogue modeling parameter for compliance and environmental aspect

The following is a dashboard display of the results of running a mathematicalsimulation model.

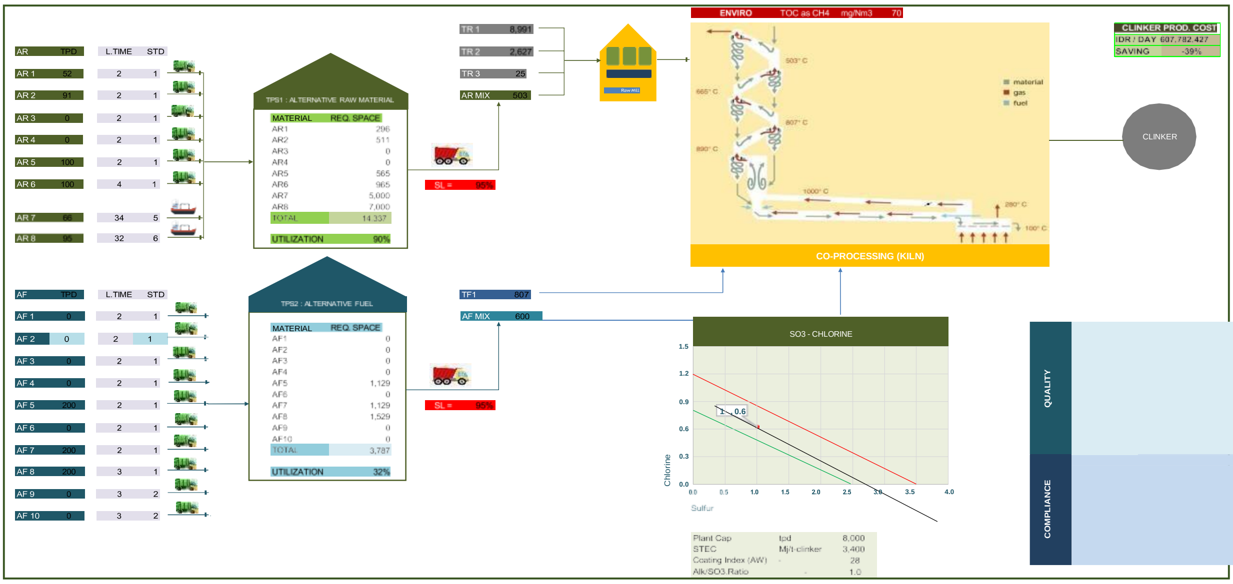

Figure 5. Dashboard result of simulation

3. RESULTS AND DISCUSSION

With the option of selecting alternative raw materials according to the optimal model output, the utilization of TPS 1 (external hazardous waste storage 1) will reach 90% with service levels for all types of materials at 95%. The storage condition will be divided into 8 section. Asalternative fuels, according to the output of the optimization model, the utilization of TPS 2 (external hazardous waste storage 2) will only reach 32% with service levels for all types of materials at 95%. The storage condition will be divided into 3 section.

Coatings in the kiln are in the ideal range, with the coating index value of 28. This coating index shows the thickness of the coating inside the kiln. Sufficient coating on the inside of the kiln reduces thermal loss due to radiation coming out of the kiln shell. A coating index that is too thick also poses a risk to the smooth operation of the kiln.

C3S (alite) is the main constituent component of clinker. The results of running simulation obtained the value of C3S = 56%. C3S affects the initial compressive strength of cement, namely in the first 14 days. C2S (belite) whose potential is formed through the optimal solution of a mathematical model is 15%. C2S affects the final compressive strength of cement at 14 to 28 days. Although C2S and C3S both contribute to the compressive strength of cement, when producing cement clinker type I tends to prefer low levels of C2S compared to C3S. Another factor is the ease of doing the grinding in the cement milling process, namely C3S is easier to grind than C2S because C3S tends to be more brittle.

Based on Indonesia government regulations, the TOC emission in the cement industry stack is 100 mg / Nm3. With the composition of the optimization results of the MILP model, theestimated value of TOC emissions due to the use of alternative raw materials is around 70 mg /Nm^3.

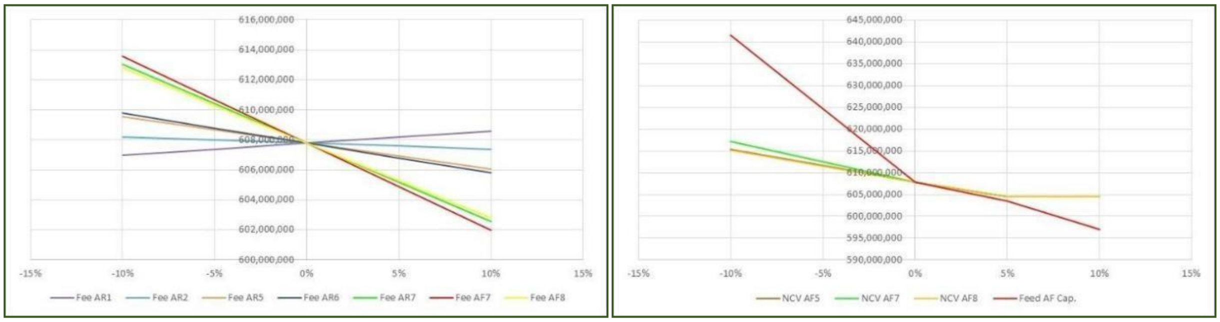

Figure 6. Sensitivity analysis of gate fee dan NCV (net calorific value)

The simulation results then performed a sensitivity analysis. Based on the results of thegate fee sensitivity analysis for alternative raw materials type 7 (AR 7), alternative fuel type 7 (AF 7), and alternative fuel type 8 (AF 8) the highest sensitivity values. The NCV of each alternative fuel type is known that even if the NCV value of alternative fuels increases by 5% and 10% it does not significantly reduce clinker production costs. However, the opposite condition is the NCV sensitivity graph of all alternative fuels, if it goes down, it changes to be very sensitive, which means that the clinker production costs immediately increase significantly. This is due to the limitation in the minimum coal model that is used per day, which is 800 tons per day.

4. CONCLUSION

Mathematical models by considering the development of new constraints on the aspectsof Quality, Plant operations and Capacity handling, Compliance, and Environmental are declaredvalid and can be used further. The MILP model can then be used for decision making purposes regarding AFR optimization. Alternative raw material consists of AR 1 = 52 tpd; AR 2 = 91 tpd;AR 5 = 100 tpd; AR 6 = 100 tpd; AR 7 = 66 tpd; AR 8 = 95 tpd. Alternative fuel consists of AF 5 = 200 tpd; AF 7 = 200 tpd; and AF 8 = 200 tpd. Potential to save 39% of the variable raw material and fuel production cost from the clinker.

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6. REFERENCES

Alsop,P.A., (2019). *Cement Plant Operations Handbook for Dry-process Plant*, 7th Edition, Tradeship publication, Dorking.

Basel Convention, (2011). Technical guidelines on the environmentally sound *Co-processing* of hazardous wastes in cement kilns.

Chatterjee, A. K., (2018). *Cement Production Technology: Principles and Practice*, 1st Edition, CRC Press, New York.

Carpio, R.C., Sousa Júnior, F.D., Coelho, L.D.S. and Silva, R.J.D., 2008. Alternative fuels mixture in cement industry kilns employing particle swarm optimization algorithm. *Journal of the Brazilian Society of Mechanical Sciences and Engineering* 30 (4), 335-340.

Deolalkar, S.P., (2009). *Handbook Designing Cement Plants*, 1st Edition, BS Publications, Hyderabad.

Elfaham, M.M. and Eldemerdash, U., 2019. Advanced analyses of solid waste raw materials from cement plant using dual spectroscopy techniques towards co-processing. *Optics & Laser Technology* 111, 338-346.

Fellaou, S., Harnoune, A., Seghra, M.A. and Bounahmidi, T., 2018. Statistical modeling and optimizationof the combustion efficiency in cement kiln precalciner. *Energy* 155, 351-359.

Ghalandari, V., Majd, M.M. and Golestanian, A., 2019. Energy audit for pyro-processing unit of a new generation cement plant and feasibility study for recovering waste heat: A case study. *Energy* 173, 833-843.

Global Cement and Concrete Association (GCCA), 2019. Retrieved Mei 13, 2020, from https://gccassociation.org/sustainability-innovation/sustainability-charter-and-guidelines/

Imron, A.,2019. Residents Insist on Rejecting the Establishment of a Waste Factory. Retrieved Mei 13, 2020, from https://radarmojokerto.jawapos.com/read/2019/11/20/166570/warga-ngotot-tolak-pendirian-pabrik-limbah

Republik Indonesia, 2014. *Peraturan Pemerintah Nomor 101 Tahun 2014 tentang Pengelolaan Limbah Bahan Berbahaya dan Beracun*, Jakarta.

Republik Indonesia, 2014. *Peraturan Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia No.95 tentang Perizinan Pengelolaan Limbah Bahan Berbahaya dan Beracun Terintegrasi Dengan Izin Lingkungan Melalui Pelayanan Perizinan Berusaha Terintegrasi Secara Elektronik*, Jakarta.

Kaddatz, K.T., Rasul, M.G. and Rahman, A., 2013. Alternative fuels for use in cement kilns: process impact modelling. *Procedia Engineering* 56, 413-420.

Kookos, I.K., Pontikes, Y., Angelopoulos, G.N. and Lyberatos, G., 2011. Classical and alternative fuel mix optimization in cement production using mathematical programming. *Fuel* 90 (3), 1277- 1284.

Ngadi, Z. and Lahlaouti, M.L., 2017. Impact of using alternative fuels on cement rotary kilns: Experimental study and modeling. *Procedia Engineering* 181, 777-784.

Parlikar, U., Bundela, P.S., Baidya, R., Ghosh, S.K. and Ghosh, S.K., 2016. Effect of Variation in the Chemical Constituents of Wastes on the *Co-processing* Performance of the Cement Kilns. *Procedia Environmental Sciences* 35, 506-512.

PT Semen Indonesia Tbk., 2020. *Presentasi Korporasi PT Semen Indonesia Tbk.* PT Semen Indonesia Tbk, Jakarta.

Rahman, A., Rasul, M.G., Khan, M.M.K. and Sharma, S., 2013. Impact of alternative fuels on the cement manufacturing plant performance: an overview. *Procedia Engineering* 56, 393-400.

Sengupta, P., 2020. *Refractories for the Cement Industry*. Springer, Cham.

Waltisberg, J. and Weber, R., 2020. Disposal of waste-based fuels and raw materials in cement plants in Germany and Switzerland–What can be learned for global co-incineration practice and policy?. *Emerging Contaminants* 6, 93-102.

Zhang, W., Maleki, A., Khajeh, M.G., Zhang, Y., Mortazavi, S.M. and Vasel-Be-Hagh, A., 2019. A novel framework for integrated energy optimization of a cement plant: An industrial case study. *Sustainable Energy Technologies and Assessments* 35, 245-256.

FACTORS THAT AFFECT THE BURSTING STRENGTH OF KRAFT LINER PAPER USING STATISTICAL PROCESS COONTROL (SPC) AND TAGUCHI METHODS

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ABSTRACT

PT. X is a manufacturing company that produces corrugated cardboard boxes, kraft liner paper, and strapping bands. Even though it is equipped with high technology, in fact there are still defective products produced. The problem that often arises is that the compressive strength of kraft liner paper is not up to standard. This causes the company to suffer sufficient losses. The purpose of this study is to determine the process capability of the current production system and to determine the factors that affect the quality of kraft liner paper. This research was conducted using the SPC (Statistical Process Control) method and the Taguchi method. The Statistical Process Control (SPC) method is used to identify the root of the problem that occurs in the kraft liner paper making process. Then the Statistical Process Control data is integrated with the Taguchi method as an Offline Quality Control todetermine the factors that influence the optimization of the compressive strength of kraft liner paper. The results of the study indicate that the influencing factors are the origin of the old corrugated cardboard (OCC), the amount of freeness, the type of dry strength, and the dry strength dosage. Of the four factors, the optimal setting factors are OCC Australia, freeness OCC 400 ml, DS 980, and dry strength 15 kg/tp. With the confirmation experiment, the optimal burst index was 2.35 kgf/cm^2.

Keywords: Product Defect, Product Quality, SPC, Taguchi

1. INTRODUCTION

In industry, one way to survive and continue a business is to produce quality products. Quality is important because it can meet the needs and desires of consumers. However, often the product quality does not meet specifications. PT X is a manufacturing company that produces corrugated cardboard boxes, kraft liner paper, and strapping bands. The company produces kraft liner paper with a substance of 112 to 200 grams. The problem that is often encountered is that the quality of kraft liner paper is not up to standard. Liner kraft paper is required to meet the bursting index standard of more than 1.8 kgf / cm2 (Liner, 2019).

Table 1. Data Percentage of Failed Products at PT. X February 2020

Production date	Production Amount (roll)	Number of Failed Products (roll)	Failure Percentage (%)
21 February 2020	532	3	0,56
22 February 2020	496	3	0,61
23 February 2020	528	3	0,57
24 February 2020	356	3	0,84
25 February 2020	392	2	0,51
26 February 2020	512	3	0,59
27 February 2020	496	1	0,20
TOTAL	3.312	18	

Table 1 shows the total production on February 21 2020 - February 27 2020 amounting to 3,312 rolls with a total product failure of 18 rolls. The average percentage of defective product produced is 0.55. In order to reach the six six sigma level, the production department must reduce the defective product to 0.0000034 (Ardita, 2012). This study aims to determine the factors that influence the quality of kraft liner paper and to determine the optimal performance design of these factors in order to produce quality in accordance with the standards. The method used is Taguchi to produce a better product. To improve the quality of a product, Taguchi is integrated with Statistical Process Control.

2. METHOD

2.1 Average and range control chart (X bar-R)

Average control chart to see whether the process is within control limits or not. Range control map to determine the accuracy of the process by finding the range of the sample under observation.

2.2 Process Capability Analysis

Process capability analysis to measure process capability. Then the process capability ratio can be calculated using equations (1) and (2).

$$\sigma = \frac{\bar{R}}{d_2} \qquad (1)$$

$$Cp = \frac{UCL - LCL}{6\sigma} \qquad (2)$$

Cp is the ratio of process capability and σ is the standard deviation of the process. The value of Cp>1 means the process is still good, Cp<1 means the process is not good, and Cp=1 means the process is the same as the specifications. Process capability index value represents the real capability of a process. The value of Cpk is calculated by equations (3),(4), and (5) (Ariani, 2004).

$$CPU = \frac{UCL - \bar{\bar{X}}}{3\sigma} \qquad (3)$$

$$CPL = \frac{\bar{\bar{X}} - LCL}{3\sigma} \qquad (4)$$

$$Cpk = \min\{Cpu, Cpl\} \qquad (5)$$

2.3 Independent Variable

The change in the independent variable does not depend on other variables. At this stage, the factors that influence the dependent variable are selected. The method used to identify these factors is the cause effect diagram.

2.4 Orthogonal Array

The selection of an orthogonal array is done by calculating: db level $= l - 1$ (6)

l is the number of levels and db(level) is the degree of freedom of the level. Then determine the db orthogonal array with the equation:

$$\text{db (OA)} = f \times \text{db (level)} \tag{7}$$

db (OA) is the degree of freedom of the orthogonal array and f is the number of factors. Determination of the number of rows in the experiment with the equation:

$$n = \text{db (OA)} + \tag{8}$$

n is the number of rows in the experiment. From the above calculations, the orthogonal array matrix is obtained, $L_n(l^f)$.

3. RESULT AND DISCUSSION

The bursting strength index measurement was carried out on products from February 21, 2020 to March 21, 2020 by taking 1 sample on 1 roll 5 times. This measurement was carried out on 150 samples. The measurement results can be seen in Table 2.

Table 2. Bursting Strength Index Measurement Data

Sample	1	2	3	4	5	Sample	1	2	3	4	5
21-Feb-20	1,88	1,87	1,82	1,88	1,90	07-Mar-20	1,87	1,88	1,85	1,84	1,85
22-Feb-20	1,90	1,87	1,90	1,92	1,86	08-Mar-20	1,86	1,85	1,86	1,87	1,85
23-Feb-20	1,82	1,84	1,83	1,85	1,86	09-Mar-20	1,87	1,86	1,87	1,88	1,86
24-Feb-20	1,84	1,86	1,85	1,86	1,87	10-Mar-20	1,98	1,97	1,95	1,96	1,97
25-Feb-20	1,87	1,89	1,87	1,85	1,87	11-Mar-20	1,87	1,85	1,88	1,88	1,86
26-Feb-20	1,85	1,89	1,86	1,84	1,88	12-Mar-20	2,05	2,07	2,05	2,06	2,06
27-Feb-20	1,80	1,81	1,81	1,79	1,78	13-Mar-20	1,76	1,77	1,76	1,76	1,77
28-Feb-20	1,88	1,91	1,84	1,95	1,74	14-Mar-20	1,88	1,91	1,88	1,90	1,90
29-Feb-20	1,95	1,91	1,94	1,98	1,90	15-Mar-20	1,83	1,87	1,85	1,84	1,86
01-Mar-20	1,75	1,77	1,74	1,76	1,78	16-Mar-20	1,86	1,87	1,85	1,86	1,85
02-Mar-20	1,85	1,84	1,87	1,84	1,86	17-Mar-20	1,86	1,87	1,84	1,87	1,86
03-Mar-20	1,86	1,84	1,85	1,84	1,84	18-Mar-20	1,85	1,86	1,85	1,83	1,82
04-Mar-20	1,83	1,84	1,83	1,84	1,86	19-Mar-20	1,85	1,84	1,83	1,84	1,83
05-Mar-20	1,87	1,88	1,83	1,85	1,86	20-Mar-20	1,86	1,84	1,85	1,87	1,84
06-Mar-20	1,83	1,84	1,85	1,84	1,85	21-Mar-20	1,97	1,94	1,96	1,93	1,95

3.1 Xbar-R Control Chart

Based on data from the bursting strength index of kraft liner paper production, February 21, 2020 - March 21, 2020, the values were determined $\bar{\bar{X}}$, $\bar{R}$ UCL $\bar{X}$, LCL $\bar{X}$, UCL R, and LCL R. In the first calculation, there are 7 samples that are still outside the average control limit and 1 sample outside the range control limit, so that it is necessary to improve the average and range control chart by removing out of control data. The second calculation, there are 2 samples that are still outside the average control limit and 1 sample outside the range control limit so that out of control data is removed. After the second repair, all data were within the control limits, there were no outliers. Obtained the value of the $\overline{\overline{X}}$, UCL , and LCL of the control chart an average of 1.8537; 18717; and 1,8356. On the control chart, the range is 0.0312; 0.0660; 0 can be seen in Figure 1.

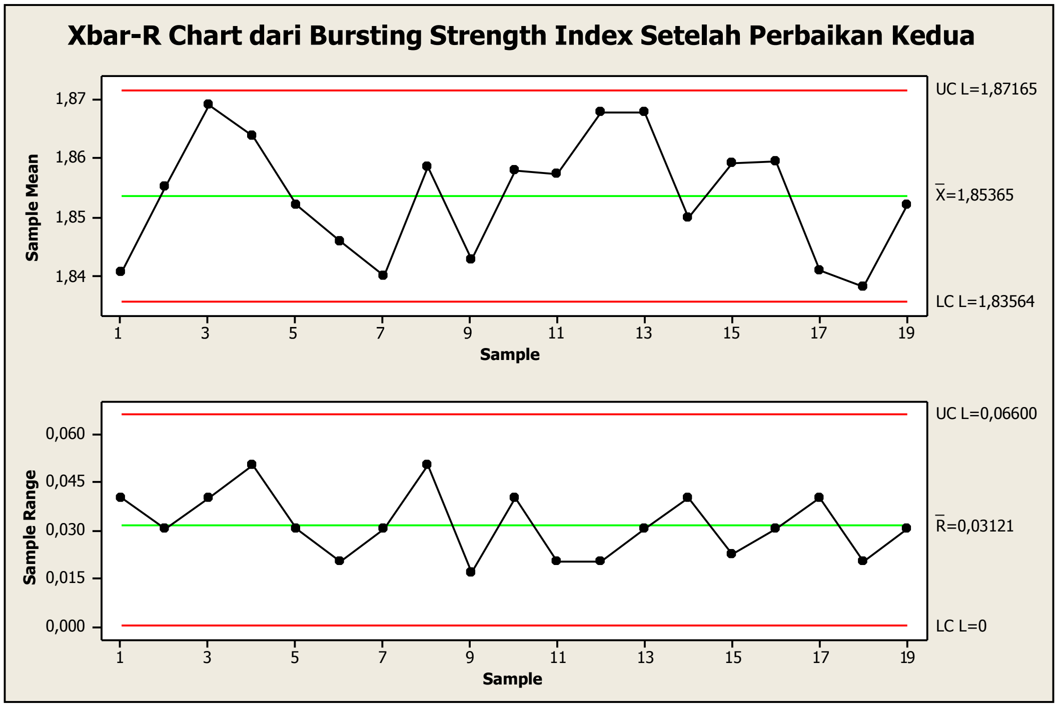

Figure 1. Xbar-R Bursting Strength Index Control Chart After Second Repair

3.2 Process Capability Analysis

Analysis of process capability is calculated using equations (9), (10), (11), (12), and (13). Obtained a Cp value of 0.7061, it is concluded that the kraft liner paper production process in this company has a low capability. Process capability index (Cpk) of 0.7059 indicates low capability.

3.3 Independent Variable

The making of this fishbone diagram is the result of interviews with quality control supervisors. From the results of interviews and literature, it is known that the burst index is influenced by fiber bond and fiber length, but is more influenced by fiber bonding.

Figure 2. Fishbone Diagram

The following is an explanation for each of these factors:

1. Material factor, old corrugated cardboard has low bond between fibers due to the hornification process due to reduced hemicellulose content due to washing. However, the dry strength agent increases the interaction between fibers so that the fiber bonds are stronger.
2. Environmental factors, paper is sensitive to water so it is easily influenced by environmental humidity. High moisture results in a low burst index.
3. Machine factor, the drying process gives rise to hydrogen bonds which increase the strength of the fiber network. If the temperature of the dryer is too high, the fibers dry out and stick to the dryer so that the resulting paper is damaged. The machine is down due to lack of maintenance and periodic checks on the machine.

3.4 Orthogonal Array

This study uses 4 influencing factors and 3 different levels to see which factors and levels have the most influence on the burst index paper.

Table 3. Determination of Factors and Level of Factors

Factor	Factor Level		
	1	2	3
The area of origin of the OCC	Belanda	Singapura	Australia
Total Freeness	500 ml	450 ml	400 ml
Dry Strength Type	Hopelon	DS 980	ETDS
Dry Strength Dosage	15 kg/tp	10 kg/tp	5 kg/tp

To determine the orthogonal array matrix, calculations are performed using equations (14), (15), and (16). The orthogonal array matrix for the Taguchi experimental design is obtained, namely $L_9(3^4)$, which can be seen in Table 4.

Table 4. *Orthogonal Array* $L_9(3^4)$

No	Factor				Replication		
	The area of origin of the OCC	**Total Freeness (mL)**	**DS Type**	**DS Dosage (kg/tp)**	**R1**	**R2**	**R3**
1	Belanda	500	Hopelon	15	1,85	1,79	1,78
2	Belanda	450	DS 980	10	2,10	1,90	1,87
3	Belanda	400	ETDS	5	1,85	1,80	1,83
4	Singapura	500	ETDS	5	1,75	1,73	1,78
5	Singapura	450	DS 980	15	1,90	1,98	2,00
6	Singapura	400	Hopelon	10	2,00	1,91	1,93
7	Australia	500	ETDS	10	1,80	1,78	1,72
8	Australia	450	Hopelon	5	1,80	1,75	1,79
9	Australia	400	DS 980	15	2,20	2,11	2,09

3.5 ANOVA Average Value

The calculation of the experimental average value 1 to 9 is shown in Table 5, with the formula $\frac{1}{n}\sum_{i=1}^{n} y_i$

Table 5. Calculation of Average Value

Experiment	Controlled Factors				Value	Average
	A	**B**	**C**	**D**		
1	1	1	1	1	5,42	1,8067
2	1	2	2	2	5,87	1,9567
3	1	3	3	3	5,48	1,8267
4	2	1	2	3	5,26	1,7533
5	2	2	3	1	5,88	1,9600
6	2	3	1	2	5,84	1,9467
7	3	1	3	2	5,30	1,7667
8	3	2	1	3	5,34	1,7800
9	3	3	2	1	6,40	2,1333
Total					50,79	16,93

To calculate the ANOVA average value, the following steps are needed:

1. Average value of all experiments

$$\bar{y}_{total} = \frac{\sum y}{n}$$

2. Average value of each factor level

$$\bar{\bar{y}}_{jk} = \frac{\sum \bar{y}_{ijk}}{n_{ijk}}$$

3. Total sum of square value

$$SS_{total} = \sum y^2$$

4. Sum of squares due to mean

$S_m = \bar{y}n^{2}$

5. Sum of squares due to factors

$SS_A = ((n_{A1} \times \overline{A_1}^2) + (n_{A2} \times \overline{A_2}^2) + (n_{A3} \times \overline{A_3}^2)) - S_m$

6. Sum of squares due to error

$SS_e = SS_{total} - S_m - (SS_A + SS_B + SS_C + SS_D)$

7. Degrees of freedom DF_A = jumlah level – 1
8. Mean of squares $MS_A = \frac{SS_A}{DF_A}$
9. F ratio

   $F_A = \frac{MS_A}{MS_e}$
10. Pure sum of squares $SS_A' = SS_A - (DF_A \times MS_e)$
11. Percent contribution $\rho_A = \frac{SS_A'}{SS_t} \times 100\%$

The results of the ANOVA calculation of the average value that have been carried out, however, the Fratio factor A value is smaller than the F table value so it is necessary to do pooling up.

12. Pooling up

Pooling up is applied to a factor that has no effect, factor A, here is the calculation: SS (pooled e) = $SSe + SS_A$

DF (pooled e) = $DF_e + DF_A$ MS (pooled e) = $\frac{S\ (pooled\ e)}{DF\ (pooled\ e)}$

Table 6. ANOVA After Pooling Up

Source	pool	SS	DF	MS	F_{ratio}	SS’	Ratio (%)	F table
A	Y	0,0045	-	-	-	-	-	-
B		0,1725	2	0,0862	39,7367	0,1681	37,9975	3,35
C		0,0602	2	0,0301	13,8702	0,0559	12,6246	3,35
D		0,1469	2	0,0734	33,8385	0,1425	32,2118	3,35
Error		0,0585	-	-	-	-	-	
Pooled		0,0629	29	0,0022	1	0,0760	17,1660	
SS_t		0,4425	35	0,0126		0,4425	100	
Mean		95,5416	1					
SS_{total}		95,9841	36					

From the table, it is known that factors B, C, and D have a significant effect on the burst index, while factor A has a small effect in the experiment. The percentage of contribution error is 17,166%, which means that all the factors that have a significant effect are in the experiment. In the Taguchi method, the percent contribution error must be ≤ 50% (Sousa, 2020).

3.6 ANOVA Signal to Noise Ratio

1. Signal to noise ratio value in each experiment

The value of the signal to noise ratio is calculated by using the larger is better method. Experiments 1 to 9 in Table 7 use the formula:

$\eta = -10 \log_{10}(\frac{1}{n} \times \sum \frac{1}{y^2})$

Table 7. Calculation of Signal to Noise Ratio Value

Experiment	Controlled Factors				SNR
	A	B	C	D	
1	1	1	1	1	5,1338
2	1	2	2	2	5,7964
3	1	3	3	3	5,2315
4	2	1	2	3	4,8755
5	2	2	3	1	5,8387
6	2	3	1	2	5,7808
7	3	1	3	2	4,9382
8	3	2	1	3	5,0065
9	3	3	2	1	6,5747

2. Average signal to noise ratio value across experiments
$\bar{\eta} = \frac{\sum \eta}{9}$
3. Average value of signal to noise ratio at each factor level
$\bar{\bar{\eta}} = \frac{\sum \eta_{ijk}}{n_{ijk}}$
4. Total sum of squares $SS_{total} = \sum \eta^2$
5. Sum of squares due to mean $S_m = n \times \overline{\eta^2}$
6. Sum of squares due to factors
$SS_B = ((n_{B1} \times \eta\overline{B_1}^2) + (n_{B2} \times \eta\overline{B_2}^2) + (n_{B3} \times \eta\overline{B_3}^2)) - S_m$
S (pooled e) = SS_A
7. Degree of freedom DF_B = jumlah level – 1
8. Mean sum of squares $MS_B = \frac{SS_B}{DF_B}$
9. F_{ratio}
$F_B = \frac{MS_B}{M_E}$
10. Pure sum of squares $SS_B' = SS_B - (DF_B \times M_E)$
11. Percent contribution $\rho_B = \frac{SS_B'}{SS_t} \times 100\%$

The results of the ANOVA calculation of the signal to noise ratio value are shown in Table 8.

Table 8. ANOVA Value of Signal to Noise Ratio

Source	Pool	SS	DF	MS	F_{ratio}	SS'	Ratio (%)	F tabel
A	Y	0,0266	-	-	-	-	-	-
B		1,1923	2	0,5962	44,7944	1,1657	45,1796	19,00
C		0,3665	2	0,1832	13,7673	0,3398	13,1711	19,00
D		0,9948	2	0,4974	37,3724	0,9682	37,5228	19,00
E		0,0266	2	0,0133	1	0,1065	4,1265	
SS_t		2,5802	8			2,5802	100	
Mean		268,6989	1					
Sstotal		271,2791	9					

From the table, shows that factors B and D have a significant effect on the burst index, while factor C has a small effect in the experiment. The percentage of contribution error is 4.1265%, which means that all factors that have a significant effect are in the experiment.

3.7 Setting Level

Tabel 9. Setting Level

Factor	Effect	Setting Level
A	Less significant	A3
B	Significant	B3
C	Significant	C2
D	Significant	D1

3.8 Determining the Optimal Condition Confidence Interval

If the results of the confidence interval for the optimal conditions are almost the same as the confirmation experiment, then the experimental design that has been made meets the Taguchi requirements. Determination of the confidence interval for optimal conditions is divided into two, the average value and the value of the signal to noise ratio.

1. The confidence interval for optimal conditions is the average value

a. Estimated optimal conditions

$\mu_{predictions} = \bar{y} + (\bar{B}3 - \bar{y}) + (\bar{C}2 - \bar{y}) + (\bar{D}1 - \bar{y})$

b. Confidence interval

calculation neff = $\frac{\text{jumlah eksperimen}}{DF_{mean} + DF_B + DF_C + DF_D}$

$CI_{mean} = \pm \sqrt{F_{0{,}05;1;20} \times MS_e \times \left|\frac{1}{neff}\right|}$

So that the optimal condition confidence interval for the average value is obtained: $\mu_{predictions} - CI_{mean} \leq \mu_{predictions} \leq \mu_{predictions} + CI_{mean}$

$2{,}0616 \leq \mu_{predictions} \leq 2{,}1808$

2. Confidence interval is the optimal condition of the signal to noise ratio value

a. Estimated optimal conditions

$\mu_{predictions} = \bar{y} + (\bar{B}3 - \bar{y}) + (\bar{C}2 - \bar{y}) + (\bar{D}1 - \bar{y})$

b. Confidence interval

calculation neff = $\frac{\text{jumlah eksperimen}}{DF_{mean} + DF_B + DF_C + DF_D}$

$CI_{SNR} = \pm \sqrt{F_{0{,}05;1;2} \times MS_e \times \left|\frac{1}{neff}\right|}$

So that the optimal condition confidence interval for the signal to noise ratio is obtained: $\mu_{predictions} - CI_{SNR} \leq \mu_{predictions} \leq \mu_{predictions} + CI_{SNR}$

$6{,}0946 \leq \mu_{predictions} \leq 6{,}9700$

3.9 Confirmation Experiments

Table 10. Results of Confirmation Experiment Burst Index

Sample	Factor	Burst Index
1	A3 + B3 + C2 + D1	1,92
2	A3 + B3 + C2 + D1	2,08
3	A3 + B3 + C2 + D1	2,35
4	A3 + B3 + C2 + D1	2,02
5	A3 + B3 + C2 + D1	1,84
6	A3 + B3 + C2 + D1	1,97
7	A3 + B3 + C2 + D1	2,19
8	A3 + B3 + C2 + D1	2,13
9	A3 + B3 + C2 + D1	2,30
10	A3 + B3 + C2 + D1	2,09

Calculation of the average value and calculation of the signal to noise ratio as follows:

1. Average value $\mu = \frac{1}{n} \times \sum_{i=1}^{n} y_i$
2. Signal to noise ratio value $\eta = -10 \log_{10}\left(\frac{1}{n} \times \sum_{i=n}^{n} \frac{1}{y_i^2}\right)$

Confirmation experiment confidence interval calculation:

1. Average value confidence interval

$CI_{mean} = \pm\sqrt{F_{0,05;1;20} \times MS_e \times \left|\frac{1}{neff} + \frac{1}{r}\right|}$

So that the average value confidence interval is obtained:

$\mu_{confirmation} - CI_{mean} \leq \mu_{confirmation} \leq \mu_{confirmation} + CI_{mean}$

$2,0187 \leq \mu_{confirmation} \leq 2,1589$

2. Confidence interval signal to noise ratio

value $CI_{SNR} = \pm\sqrt{F_{0,05;1;2} \times MS_e \times \left|\frac{1}{neff} + \frac{1}{r}\right|}$

So that the confidence interval of the signal to noise ratio value is obtained:

$\mu_{confirmation} - CI_{SNR} \leq \mu_{confirmation} \leq \mu_{confirmation} + CI_{SNR}$

$5,8634 \leq \mu_{confirmation} \leq 6,7935$

It is known that the confidence interval of the confirmation experiment is within the confidence interval for the optimal conditions, so that the experiment confirms the average value and the signal to noise ratio can be accepted.

4. CONCLUSION

Based on the results and research, the following conclusions were drawn:

1. Factors that are thought to affect the burst index are the origin of the old corrugated cardboard, the amount of freeness, the type of dry strength and the dosage of dry strength.
2. Of the 4 factors, the factors that have a significant effect on the burst index value are the number of freeness (B) factors of 400 ml, the type of dry strength (C) is DS 980, and the dosage of dry strength (D) is 15 kg/tp. Meanwhile, the origin factor of old corrugated cardboard has less significant effect on the burst index value.
3. The optimum compressive strength of the confirmation experiment is 2.35 kgf / cm2.

5. REFERENCES

Ardita, F. A. (2012). Analysis of Reducing the Number of Defective Products in the Paper Industry Using Lean Six Sigma Approach. Thesis, Institut Pertanian Bogor, Bogor.

Ariani, D. W. (2004). Statistical Quality Control. Yogyakarta: Penerbit

Andi. Liner, P. K. K. (2019), Master Code Defect. PT. X

Sousa, Mayko Rannany S. (2020), Operating Conditions Optimization via the Taguchi Method to Remove Colloidal Substances from Recycled Paper and Cardboard Production Wastewater. US National Library of Medicine National Institutes of Health, Vol. 10(8), p. 170.

ANALYSIS OF MOBILE TELECOM COMPANY'S MARKET COMPETITION TERRITORY MAPPING

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ABSTRACT

Currently, the telecommunications services industry, in particular the cellular services sector, which is run by cellular operators, is an industry with a high market value, a good growth rate and a high level of competition between operators. In each operational area which consists of several cities, each city has a different level of competition which requires a specific strategy in winning the competition in each city. This issue definitely requires an appropriate business analysis to help management make strategic choices related to the competitive strategy of the company. The competition strategy must start from properly mapping the competitive area. In this case, the mapping is based on the conditions of each cellular operator's market share in each city. As technology progresses rapidly, business intelligence can be used to accurately map competitive areas. In this research, business intelligence is used as a supporting tool to monitor the movement of competition from time to time between cellular operators. In addition, it helps to analyze competitive conditions that occur between cellular operators through the use of business intelligence. The business intelligence used is created as a solution to generate problem solving recommendations through a combination of the use of big data, cluster analysis, and analysis dashboards. From this research, it was found that the 119 cities that were the subject of the study were grouped into 3 (three) clusters of market areas, namely clusters of low, medium and high levels of competition, with 6 (six) different levels of urgency for each cluster. In addition, itis found that there has been a rapid shift in the status of market competition in many cities over the weekly period. The final output of this research is the city mapping matrix, which is a positive recommendation for management in selecting priority list of cities requiring a quick win response to market action, particularly for 18 cities with a high level of urgency in the mid-level competition cluster.

Keywords:Business Intelligence, Cluster Analysis, Market Competition, Territory Mapping

1. INTRODUCTION

As part of the information and telecommunications business sector, the cellular service industry is one of the manufacturing sectors with a high market value and a strong growth rate. BPS (2020) recorded that business growth in the information and telecommunications sector in thethird quarter of 2020, even in the midst of the Covid-19 pandemic, appears to continue to increasefor each quarter, even recording double-digit growth. Puslitbang (2018) noted that the essence of the cellular market is not monopolistic, but that there is tight open market competition among cellular operator companies. There are still 5 (five) big companies that are still in the cellular market, at least so far in Indonesia. Porter (1998) claimed that, in order to retain the company's competitive advantage, competitive conditions must be adequately addressed through the preparation of competitive strategy plans. Of course, for the sustainability of the company's profits, this is an important and essential thing.

Operator A with 4 (four) competitors is one of the firms operating the mobile operator business. This competition takes place both in terms of product aspects, marketing aspects, price aspects of product and service, quality of product and service, and others. The highest level of all of these ways, as the height of different forms of competition, is the level of competition known as market share. Operator A divides its operating areas into many area groups to facilitate the monitoring and control process of its target market. The current situation currently consists of four areas, which are referred to as Area 1, Area 2, Area 3 and Area 4, where geographical factors are responsible for this division. Each of these areas consists of hundreds of cities. For each city, the facts on the field have a very varied level of competition for market share and differ with competitors for each city. For each city, the requirements for various levels of market competition require different market strategies for each city when dealing with the market.

Area 3 is one area considered to be strategic for the role of the organization in the cellular industry. Area 3 is made up of 119 cities as operational areas. There are various levels of market competition in each city out of 119 cities that appear to be fierce, and there are also some cities that have a market share value below their competitors so that they require an adequate and successful strategic strategy to deal with it, given that each city must be able to handle it. According to each market's needs. Therefore, the effective market competition area mapping strategy for Area 3 should be analyzed and mapped on the basis of the market share position of each City with intense monitoring, in order to build efficiency in carrying out operational activitiesin order to achieve the target although with a restricted budget and operating time.

Deming (2015) said that "If you can't measure it, you can't manage it". Operator A's current condition officially monitors the movement of the level of competition to control its market share by cooperating with an external party which is a surveyor company which, through amarket survey mechanism, has a reputation and credibility and relies on secondary data. But it takes a long time. As the survey process often takes a long time to complete, the findings of the market share rivalry movement will obtain the new data after a period of 1.5 - 2 months after the current measurement period. Operator A, as a company engaged in the cellular sector and currentlyusing more modern and all-digital technology in the midst of a mobile industry that is so competitive, shifts its market growth from time to time very rapidly, this situation is considered ineffective.

From the literature review of previous studies, further analysis is being carried out on bottom-up variables on competition. For example, Naeruz (2018) focused on competition in terms of price or tariff factors, promotion factors, number of subscribers, number of employees and number of owned tower networks. In telecommunications research, several kinds of competitive strategy analysis are often used, including the method of SERVO (Strategy, Atmosphere, Capital, Values, and Organization) that is researched by Rizal (2015) and also the method of SCP (Structure, Behavior, Performance) by Nugroho (2020) to map out its competition.

In the midst of the demands to retain the competitive advantage of the business through the correct competition strategy to achieve the aim of the company, both sales targets and in particular the target market share in an environment of the cellular industry that has a rapid level of competition, due to the various conditions described above. An overview of the mapping of market rivalry areas for cellular operators, which is much more efficient compared to the current conditions, is required to predict this and to be able to adapt to any changes that arise very quickly.

2. METHOD

2.1 Framework

This research was conducted on the basis of the following framework as the foundation for each step that was used.

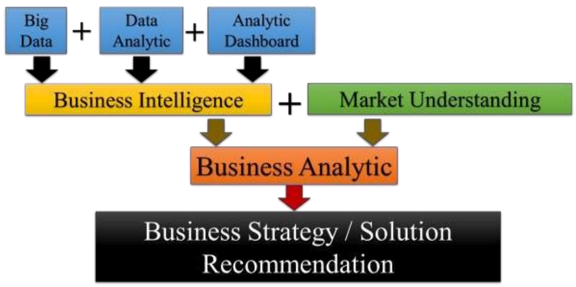

Figure 1. Research Rationale Framework

2.2 Data Collection

This research uses a new approach to the use of big data to gather market competition data through a method of scraping and crawling from different legitimate and reliable data sources while adhering to the rules of the ITE Law and still complying with customer data security rules. The new methodology is to quantify market share based on the amount of specific consumer IDs that are widely used by the broader population today, such as FB, IG, and others, based on network providers, with a minimum period of 20 percent of total usage. So in this case, if there areclients that have the features of using dual sim cards in one mobile phone with 2 (two) different types of operators, they will still be accommodated and can be counted since each operator will still be counted separately as 1 (one) unique ID. Big data will be derived from the results of this primary data collection, which is then processed to generate secondary data that is organized and ready to be used for data processing and further analysis for decision-making purposes. The data collection process therefore uses primary data and secondary data from internal firms in this scenario. The data collected is data for 119 cities observed in Area 3.

2.3 Cluster Analysis

In this study, cluster analysis is used to identify cities that have competitive conditions with similar characteristics. The software used at this stage uses the R Studio. Since the number of groups to be created was not determined from the outset, the cluster analysis used is the hierarchical approach. The number of groups or clusters created will adapt to the performance of the process of cluster analysis being conducted. The model used is to use the agglomerative approach where the grouping of the city or district is based on the value of market share in each city. In several stages, the steps in the cluster analysis process are carried out as follows:

Step 1: Determine the data period for cluster analysis
Step 2: Collecting appropriate data
Step 3: Calculating the market share correlation value between operators
Step 4: Calculating the data distance
Step 5: Calculating the correlation value of data distance between cities
Step 6: Comparing the correlation value of each method (single linkage method, complete linkage method, average linkage method, ward linkage method, and centroid method)
Step 7: Grouping of city clusters
Step 8: Documentation of clustering results

2.4 Analytic Dashboard

The design of an analytical dashboard is intended to enable related parties in this study, especially company management, to more quickly and effectively track and monitor changes in market competition more easily because this dashboard will provide a visual display which is simple and easy to understand. The dashboard consists of 16 (sixteen) parts that can be grouped into 4 main sections in general, namely:

a. Group 1: Main Report

This group consists of 3 (three) primary outputs, i.e.

1. Main Page
2. Detailed Per-City Data Last Update
3. Cluster Analysis

Result b. Group 2:

Tracking Report

This group consists of 4 (four) primary outputs, i.e.

1. Market Share Data Tracking
2. WIN/LOSE Status Data Tracking
3. ALERT Status Data Tracking
4. CLUSTER Status Data

Tracking c. Group 3: GIS Mapping

This group consists of 8 (eight) primary outputs, i.e.

1. Map of Cluster Analysis Result
2. Map of City Status WIN / LOSE
3. Map of Market Winner Operator
4. Map of City ALERT Status
5. Map of Cluster Analysis Result Vs Existing Cities Mapping
6. Map of ALERT Status Vs WIN/LOSE Status
7. Map of Cluster Analysis Result Vs Status ALERT
8. Map of Market Potency Vs Gap to Closest

Competitor d. Group 4: City Matrix of Recommendation

Market Mapping

This section is the final part of the market competition intelligence analysis dashboard output, where there is only one part, namely the City Matrix Mapping Recommendation

3. DATA ANALYSIS AND RESULTS

3.1 Data Analysis

The analysis of data starts with descriptive statistical analysis using the software R Studio with the following results.

```
> #Statistika Deskriptif
> summary(Data_Market_Share[,2:6])
     Opr. A          Opr. B           Opr. C          Opr. D           Opr. E      
 Min.   :20.39   Min.   : 0.000   Min.   : 2.43   Min.   : 0.000   Min.   : 0.000  
 1st Qu.:31.59   1st Qu.: 4.975   1st Qu.:12.72   1st Qu.: 1.895   1st Qu.: 2.390  
 Median :37.61   Median :22.850   Median :17.08   Median : 7.960   Median : 8.910  
 Mean   :48.20   Mean   :21.926   Mean   :20.77   Mean   : 7.677   Mean   : 9.338  
 3rd Qu.:50.83   3rd Qu.:32.925   3rd Qu.:26.41   3rd Qu.:11.305   3rd Qu.:14.475  
 Max.   :97.44   Max.   :54.290   Max.   :60.81   Max.   :22.810   Max.   :28.820  

> var(Data_Market_Share[,2:6])
           Opr. A     Opr. B      Opr. C      Opr. D      Opr. E
Opr. A  613.5660 -290.24757 -160.238904 -106.281209 -129.276959
Opr. B -290.2476  237.68586  -17.6337[illegible]   50.086325   53.030818
Opr. C -160.2389  -17.63375  186.815031    2.840536    7.559976
Opr. D -106.2812   50.08633    2.840536   34.238374   33.170409
Opr. E -129.2770   53.03082    7.559976   33.170409   52.599362
```

Figure 2. Output Descriptive Statistical Analysis

As a result of descriptive statistical analysis, looking at the mean and variance values of each operator, there are signs that there are cities with very large market share values and, at the same time, there are cities with very low or maybe even smaller market share values for Operator A compared with the market share of its rivals. This needs to be further confirmed through cluster analysis.

Usman (2013) wrote that there are 5 methods for agglomerative method on hierarchical approach. Using the five existing methods, both the single linkage method, the average linkage method, the complete linkage method, the ward linkage method, and even the centroid method, the cluster analysis process using the agglomerative hierarchy method provides the highest correlation value for the average method, such that the average method is selected for the process of city clustering.

```
> corave
  [1] 0.9162826
> corcomp
  [1] 0.8797837
> corsing
  [1] 0.8968243
> corward
  [1] 0.9081513
> corcent
  [1] 0.9062804
```

Figure 3. Correlation Value

From the results of the simulation calculation of the optimal number of clusters using the elbow method, it is found that the line curvature begins to slope and forms an angled angle and has a total value that is not much different within the amount of square, that is when the line crosses the point, the number of clusters is 3 (three). From this, we can conclude that 3 (three) clusters are the optimal number of clusters in the city level competition category. The grouping of cities into each cluster can be seen from the results of the dendogram.

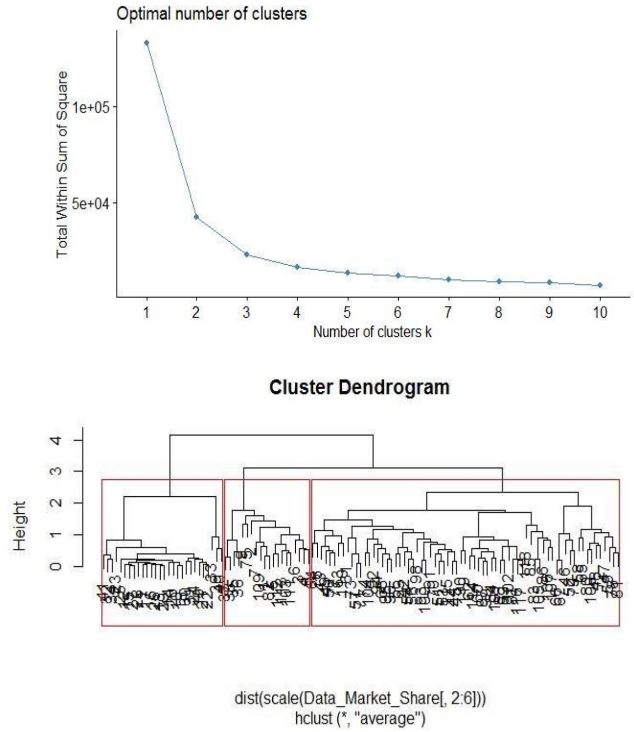

Figure 4. Elbow Method and Cluster Dendogram Result

3.2 Results

From the results of the dendogram shown in Figure 4 above, the cluster members' documentation process from 119 cities can then be conducted in accordance with the group formed.

Table 1. City Cluster Result

Cluster	Cluster Member
Cluster 1 - Low Competition Cluster (28 cities)	*City-1, City-114, City-113, City-108, City-107, City-106, City-105, City-104, City-103, City-10, City-11, City-98, City-94, City-93, City-79, City-78, City-76, City-75, City-74, City-72, City-21, City-22, City-23, City-67, City-63, City-61, City-44, City-40*
Cluster 2 - High Competition Cluster (20 cities)	*City-110, City-2, City-3, City-4, City-109, City-95, City-83, City-8, City-82, City-66, City-65, City-64, City-48, City-42, City-38, City-33, City-17, City-18, City-29, City-24*
Cluster 3 - Mid Competition Cluster (71 cities)	*City-20, City-100, City-99, City-97, City-96, City-25, City-26, City-27, City-28, City-92, City-30, City-31, City-32, City-91, City-34, City-35, City-36, City-37, City-90, City-39, City-89, City-41, City-88, City-43, City-87, City-45, City-46, City-47, City-86, City-49, City-50, City-51, City-52, City-53, City-54, City-55, City-56, City-57, City-58, City-59, City-60, City-85, City-62, City-84, City-81, City-80, City-77, City-73, City-68, City-69, City-70, City-71*

The average market share value of each operator was determined from the clustering results above, with the results as shown in Table 2 below. From the result, it can be identified and interpreted the tendency of the characteristics of each cluster formed along with the characteristics of the cities that are members of each cluster formed.

Table 2. City Cluster Result

Cluster	Count of Member	Average *Market Share* (%)				
		Opr.A	Opr.B	Opr.C	Opr.D	Opr.E
1	28	90.67	1.87	8.98	0.51	0.71
2	20	37.94	13.79	45.54	4.50	6.65
3	71	34.33	32.13	18.44	11.40	13.50

Dashboard analysis of market competition intelligence created on the Microsoft Power BI platform that can be accessed using personal computers, tablets, as well as Android and iOS based smartphone users. The development of this business intelligence dashboard is part of the process of solving issues that are not only a discourse or suggestion but a concrete solution that can be used in the future by company management.

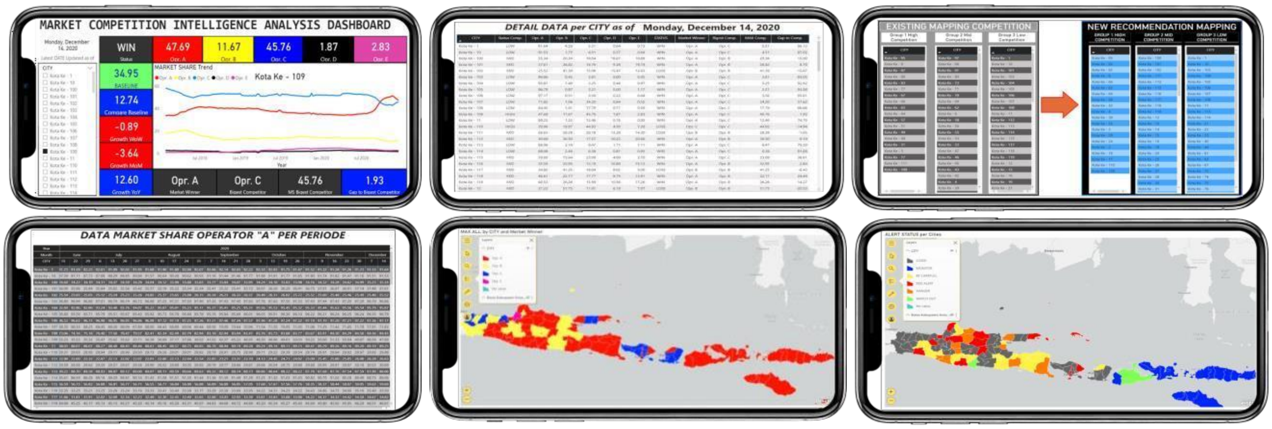

Figure 4. Preview Dashboard

4. DISCUSSION

Porter (1998) said that the essence of the formulation of a strategy is how to overcome the competition itself. The City Matrix Mapping Recommendation is a translation of the merger of 2 (two) criteria which must be considered by management in relation to the competition strategy which must be adopted by the company on the basis of territory mapping results. These two conditions are the market competition status based on the results of the analysis of the cluster and the position of Operator A in relation to competitors in regard to the urgency of action based on its alert status. Or, in other words, this section is the translation into quantitative data of the GIS mapping output and a list of cities for priority management response actions.

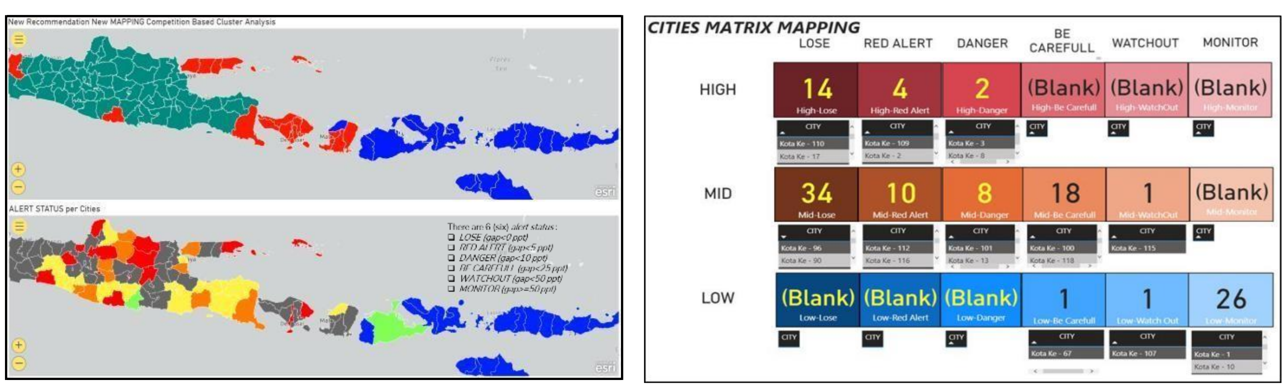

Figure 5. City Matrix Mapping

Porter (2020) stated that finding and finding the best position for the company is the secret to growth and even survival where that position is not too vulnerable to direct attacks from current or new competitors or rivals. From the results shown in the matrix in Figure 5 above, it can be shown that 34 cities with the MID level of competition are in LOSE status and 10 cities and 8 cities are already in RED ALERT and DANGER conditions, respectively. This city needs more emphasis on business management. The current conditions in company are very focused on areas in the HIGH competition cluster and a lot of resources are used to win competition, while competition is rarely concentrated and paid enough attention to that in cities in the LOW and MID areas. This can also be seen in the leadership's primary desire that it is not acceptable for a single city to have a losing position relative to the competitor, so the competition is regardless of the city or district's business potential. The business potential factor is still considered, even though, after the combination of the two previous key points, it is the third priority. This was taken out by the management because the management considered that if there were one city that was lost, the city that was lost would be the hub of movement for rivals who relocated and extended their space to neighboring cities in the vicinity so that it would eventually slowly but steadily weaken the market share position of Operator A as a whole.

As a result, the performance generated in the above Citi Matrix Mapping can be used as a further management guide to decide a strategy based on the results of the mapping of suitable and up-to-date cities, which updates the data every week. In terms of competition strategy, the recommendations provided to management are that management needs to take multiple policies as follows (in order of priority) :

1. Offer the cities that are in the new MID competition cluster the first priority focus, then the second priority in the HIGH competition cluster.
2. Prioritize areas in the warning status, namely RED ALERT and DANGER for the response to the quick win action, then pursue cities with LOSE status. However, if you get the same prioritization for all three forms of status alerts, it will be easier, of course, by djusting all the resources you have.
3. Prioritizing cities with significant market potential, especially those with LOSE status.
4. Any market shift from Operator B to cities in the mid-competence cluster and from Operator C to cities in the high-competence cluster is targeted at competitive operators that demand more focus.

All these recommendations need to be further addressed with management so that the implementation process will run smoothly.

5. CONCLUSION

This study shows that there is very tight competition between cellular operators. As a result of this rivalry, this is evident from shifts in market share fluctuations in each city that occur so rapidly. And it is also clear from the findings of the cluster analysis that at the level of competition, there are low, mid and high clusters. Through this report, it can be shown that, while still being focused on a good market understanding, the use of business intelligence through the use of big data accompanied by analytical data presented in an analytical dashboard can provide an accurate and rapid business analysis and will be very helpful for company management in formulating relevant and appropriate business strategy policies. This study is not without limitations. This analysis is restricted to only 119 cities observed, so that the findings for all cities in Indonesia cannot be generalized. However, it is possible to reproduce the approach used in this study to analyze conditions in other cities. Furthermore, for the next analysis, the degree of brand switching between cellular operators can also be calculated. Hence, this research offers a valuable reference for future business intelligence and strategy management studies.

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REFERENCES

Badan Pusat Statistik, (2020), *Berita Resmi Statistik 5 November 2020 [Official Press Release BPS Nov 5th 2020]*, No.85/11/Th. XXIII, BPS, Jakarta

Deming, M.E (2015), *Myth: If You Can't Measure It, You Can't Manage It*, Retrieved from The Deming Institute : https://deming.org/myth-if-you-cant-measure-it-you-cant-manage-it/

Naeruz, M. (2018), Analisis Determinan Persaingan Industri Telekomunikasi (PT.Indosat Ooredoo, PT. Telkomsel, PT. XL Axiata) di Indonesia Dalam Pasar Oligopoli [Analysis of the Telecommunications Industry Competition Determinants (PT. Indosat Ooredoo, PT. Telkomsel, PT. XL Axiata) in Indonesia in the Oligopoly Market], *Quantitative Economics Journal*, Vol. 7, No. 1,1-21.

Nugroho, G. dan Darwanto. (2020), Analisis Struktur Pasar, Perilaku Perusahaan, dan Kinerja Perusahaan dalam Industri Telekomunikasi Indonesia [Analysis of the Indonesian Telecommunication Industry's Market Structure, Company Actions, and Company Efficiency], *Media Trend*, Vol. 15, No. 1, 97-110.

Porter, M.E, (1998), *Competitive Advantage - Creating and Sustaining Superior Performance with a New Ontroduction.* The Free Press, New York

Porter, M.E, (1998), *Competitive Strategy – Techniques for Analyzing Industries and Competitors.* TheFree Press, New York

Porter, M.E (2020), *How Competitive Forces Shape Strategy*, Retrieved from Harvard Businees Review: https://hbr.org/1979/03/how-competitive-forces-shape-strategy

Rizal, Y. (2015), Evaluasi Strategi Pengembangan Jaringan Telekomunikasi dengan Blue Ocean Strategy [Evaluation of the Development Strategy for Telecommunication Networks with the Blue Ocean Strategy], *Jurnal Telekomunikasi dan Komputer*, Vol. 6, No. 1, 45-68.

Tim Peneliti Puslitbang SDPPI, (2018), *Analisis Industri Telekomunikasi Indonesia Untuk Mendukung Efisiensi [Analysis of the Indonesian Telecommunications Industry to Support Efficiency]*, KEMKOMINFO, Jakarta

Usman, H. dan Sobari, N., (2013), *Aplikasi Teknik Multivariate Untuk Riset Pemasaran [Applications of Multivariate Engineering for Marketing Research]*, PT Grafindo Persada, Jakarta

SALES PLAN OPTIMIZATION OF TELECOMMUNICATION PRODUCTS

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ABSTRACT

Telecommunication products have become one of the most important human needs in the current era. SA (smart acquisition) products, which are products to acquire new customers, are the most important products sold by distributors, but often provide losses. As a distributor of a large telecommunications company in Indonesia, called as PT X, must make an SA product sales plan to maximize sales. In fact, the results of SA sales from distributor data and systems are not the same. The existence of this gap can then be seen that more optimal SA production is able to maximize SA sales. To carry out the plan, PT X needs to estimate the new sales revenue target which is the revenue from the SA product using the forecasting method. Forecasting methods are used by paying attention to data trends, then the forecasting results are used as a reference for Goal Programming modelling. The modelling process is carried out to find the best solution in terms of production planning by considering the SA sales results from PT X's data and SO (sales out) results from other telecommunication companies' data. In accordance with the formulation of the problem, the results of the research of forecasting and optimization methods can be applied to this case study for 5 months, namely April-August 2020, showing valid results with the LINGO application. Where the result of the calculation is greater than the actual value and less than or equal to the predetermined upper limit value. So that the research objectives that want to maximize the value of revenue and minimize the production of pieces are obtained.

Keywords: Sales Plan, Forecasting, Optimization, Goal Programming.

1. INTRODUCTION

Telecommunication technology is currently not using voice and SMS much, this is because people are getting used to data. The large number of cellular data packages is proof that data is one of the biggest revenues for operators. In Indonesia alone, cellular operators, namely PT Telekomunikasi Selular (Telkomsel), PT Indosat (Indosat Ooredoo), PT XL Axiata (XL), PT Hutchison 3 Indonesia (Tri), PT Smartfren Telecom (Smartfren), and PT Sampoerna Telekomunikasi Indonesia (Net1) (Research Team of the Center for Research and Development of SDPPI, 2018).

PT A is one of 3 companies which is included in 90% of the total operator market share in Indonesia. This research discusses a case study that occurred in PT A, precisely in the Sidoarjo branch, East Java. The Sidoarjo branch is included in the East Java region and is located in Area 3 which covers the areas of East Java, Central Java, Bali, Nusa Tenggara. East Java Region has six branches under it; Surabaya, Sidoarjo, Jember, Lamongan, Madiun, and Malang. PT A does not run its own business but with a distributor company that has been determined by management. PT X as a distributor company of PT A in Sidoarjo, East Java. This means that PT X is responsible for all 18 sub-districts in Sidoarjo regency including Balong Bendo, Buduran, Candi, Gedangan, Jabon, Krembung, Krian, Porong, Prambon, Sedati, Sidoarjo, Sukodono, Taman, Tanggulangin, Tarik, Tulangan, Waru, Wonoayu. PT X then acts as a distributor in the region and is responsible for all resellers or what is commonly referred to as outlets or counters.

The problem that then arises is that distributors are too focused on selling SA products at any outlet. Meanwhile, PT X is responsible for Sidoarjo regency and has obligations for 18 sub-districts to hundreds of outlets under it. Each distributor in their respective regions has SA targets that must be met. This has led to competition among distributors by selling outside the region (outer). It often happens that SA products in region A are sold to large outlets in region B. Due to the need to sell SA products and the need for a fast turnover of money, distributors do not heed theirobligations to fill outlets in their region and sell outside the region even at prices below the selling price.

The sales plan is an important reference for the sales division in marketing its products and ensuring all products are sold. Often planning without considering the future, so that the forecasting method is expected to be able to make good estimates as the goal of forecasting (Heizer and Render, 2016). The first process, namely revenue new sales, is made forecasting modeling. This is necessary considering that revenue is a very sensitive matter for a company, so a prediction is needed to determine the number of products to be produced to generate the expected revenue. In addition, companies must pay more attention to the number of products to be produced considering that there are several products.

After forecasting, then the SA product data is optimized to find the best solution in order to get the appropriate production & sales figures. There are two things that underlie this, namely the company's losses due to SA sales that are not on target or outside the region as well as sales data from distributor data and those captured on different systems, so it should be maximized. There are two goals to be achieved, namely maximizing district revenue and minimizing the number of sub-district SA (pieces) and there are limitations to this problem that must be met. The method used is goal programming as a method to assist planning and decision making needed to get the best solution.

Fulfilling the needs of SA in the Sidoarjo region is carried out by producing SA products starting with a planning process. SA production planning with three different variations is optimized to meet revenue targets with the amount of production in accordance with SO (sales out) and SA (distributor) data. SA data itself indicates products sold, while SO data are products that customers have been actively using. The optimization includes two objective functions. This study aims to determine the production capacity that can be produced to meet the district revenue target and the sales target of each product in each district. The revenue target as shown in Figure 1.4 is the district target in one month which is then divided into pieces for each district. Meanwhile, the sales target in each district is based on last month's SO (sales out) and SA (distributor) as the minimum target for the following month. In doing this final research, revenue is forecast for the next five months for short-term forecasting. The results of the forecast are used as the limitation of the objective function in the mathematical model. The model that is formed will be finished using a computer program. From the results of research and calculations, it is expected to achieve the goal of maximizing sales by referring to the distributor's ability to sell products and customer demand.

2. LITERATURE REVIEW

2.1 Distribution Channel

Distribution strategy is an important part of a company's marketing strategy because it relates to prices, products and promotions. The distribution model varies by consumer and industrial market. This choice will have a big impact on the company's strategy. Kotler (2003) notes that there are strategic alternatives available in terms of distribution or placement, namely Intensive Distribution, Selective Distribution, and Exclusive Distribution.

Exclusive distribution includes the granting of exclusive rights for one distributor with a certain territory or area to sell the company's products. The company will also supply all the necessary tools, including the need for promotion to distributors. The company on the other hand, is free from the burden of having to fully handle the marketing of its products. Examples for exclusive distribution include products such as computers, air conditioners, oil products, car products, elevators (Ilesanm, 2011).

2.2 Agregat Planning

Planning in a company with many different fields has limitations and constraints, as well as difficult coordination. This coordinated planning effort has developed into a process known as sales and operations planning (S & OP). The output of this S&OP is called an aggregate plan. Aggregate planning is concerned with determining the quantity and timing of production in the medium term in the future, usually between the next 3 to 18 months. The aggregate plan uses information about groups or product lines instead of individual products. This plan relates to the total or the aggregate (Heizer and Render, 2016). Aggregate planning is able to provide optimal production plans, decision support tools with sequential, stochastic, and linear optimization models (Filho, Cezarino, and Ratto, 2010).

2.3 Forecasting

According to Heizer and Render (2016: 113), forecasting is an art and science in predicting events in the future. Forecasting involves taking historical data (such as last year's sales) and projecting into the future with a mathematical model. According to Nasution and Prasetyawan (2008: 29) forecasting is a process to estimate how much future needs include needs in terms of quantity, quality, time and location required in order to meet demand for goods or services. Forecasting is an estimate of future demand based on several forecasting variables, often based on historical time series data (Gaspersz, 2005: 72).

2.4 Goal Programming

Goal Programming or GP was originally developed by Charnes and Cooper (1961). "This technique allows to take into account many objectives simultaneously while the decision maker looks for the best solution from several viable solutions. The popularity of GP is increasing due to the easy understanding of GP and the fact that it is easy to apply because it is an extension of the mathematical technique of linear programming which is a very effective algorithm" (Aouni and Kettani, 2001).

GP is an extension of the linear programming model originally developed by A. Charles and W. M. Cooper so that all assumptions, notations, mathematical formulations, model formulation procedures and solutions are not much different. The difference lies in the presence of a pair of deviational variables that will appear in the objective function and the constraint function. Linear programming itself is a mathematical model that is used to find an optimal solution by maximizing or minimizing the objective function against an arrangement constraint. Goal Programming has three main elements, namely decision variables, objective functions and constraint functions (Harjiyanto, 2014).

3. METHODOLOGY

Research is a series of steps that are carried out in a planned and systematic manner to be able to solve a problem or get an answer to a particular problem. This chapter discusses the research step by step and the research flow diagram which is presented in Figure 1. The research will consist of several stages, namely the stage of problem identification and data collection, forecasting, modeling, data processing, analysis and conclusions.

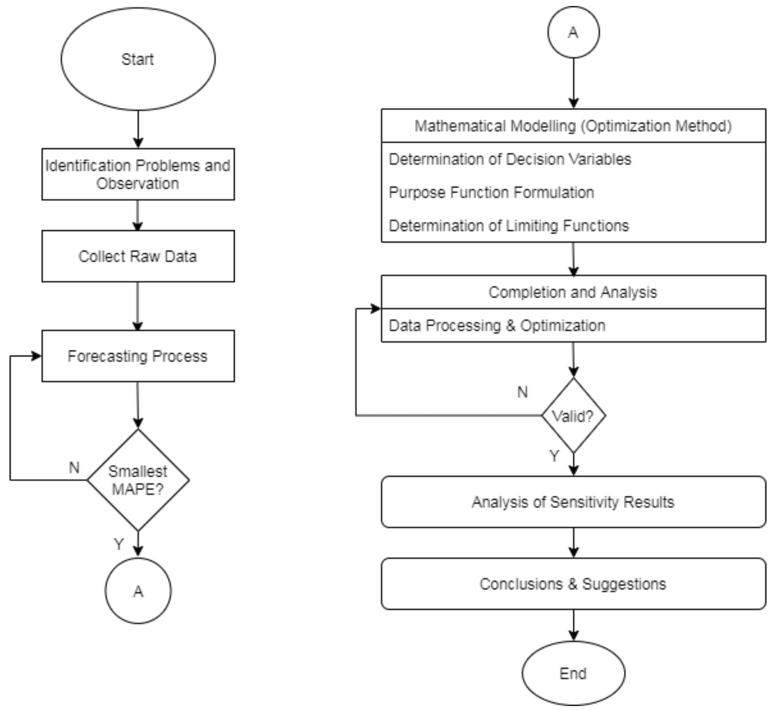

Figure 1. Research Methodology Flowchart

4. RESULT AND DISCUSSION

4.1 Product Forecasting

By using revenue data from January 2018-March 2020, demand forecasting is carried out using the method in Minitab. To find out the suitability of the methods used, in this research, all existing methods were tested including:

- Method 1: Linear Trend Analysis
- Method 2: Quadratic Trend Analysis
- Method 3: Exponential Trend Analysis
- Method 4: S-Curve Trend Analysis
- Method 5: Decomposition Additive Seasonal Only
- Method 6: Decomposisiton Multiplicatives
- Method 7: Single Exponential Smoothing
- Method 8: Double Exponential Smoothing
- Method 9: Winter Method Triple Multiplicative
- Method 10: Winter Method Triple Additive

To determine the most suitable method among the calculated methods, the MAPE method is used, which uses the absolute error in each period divided by the actual observed value for that period. Then, average those absolute percentage errors. From the results of the MAPE calculation, the method with the smallest MAPE value was chosen. The complete calculation results can be seen in Table 1. Meanwhile, Table 2 shows the results of forecasting using method 9 with the smallest MAPE value. So that this value will be used in the optimization process.

Table 1. MAPE Calculation Value

Type of Method	MAPE (%)
Method 1	42
Method 2	33
Method 3	35
Method 4	33
Method 5	48
Method 6	49
Method 7	50
Method 8	102
Method 9	24
Method 10	40

Table 2. New Sales Revenue Forecasting Results

Month	Forecasting Results (Rupiah)
Apr-20	1,014,810,383
Mei-20	1,861,229,373
Jun-20	1,593,053,369
Jul-20	1,337,670,064
Agust-20	1,042,978,524

4.2 Optimization Model Formulation

The next process is optimization with Goal Programming. Writing a mathematical model first uses a linear programming model and after that the linear form is converted into a goal programming form. The first thing that needs to be done is to identify the problem in a mathematical form. The problem of goal programming is a problem of conditional optimization, which is the search for the maximum or minimum value of an objective function with respect to limitations or conditions that must be met. The main components in developing the goal programming model are as follows:

A. Index
Index is the definition of the naming that will be used on the decision variable, the indexes to be used are as follows:

i = district
j = type of product

B. Research Parameters
The parameters used in the mathematical model of this study are as follows:
An = The minimum total product produced for Sidoarjo district based on the forecasted value
Bn = The maximum total product that can be produced per product based on the MAX SA SO value last month
Cn = The maximum total product that can be produced per product per district based on the MAX SA SO value last month
Dn = Minimum total product that can be produced per product per district based on last month's SO value

4.2.1 Determination of Decision Variables

The decision variable is a variable that describes it completely decisions to be made. The decision variables used in this study are:

x_{i_j} = The number of SA products sold in the i-district for product j, so the notation is X_{1_1} through X_{18_3} .

Where :
i = kecamatan –i which will be sold
j = type of product –j to be produced

The decision variable to be used is the number of SA product sales in each sub-district. There are 3 SA products and 18 districts in Sidoarjo, so there are 54 decision variables. 3 SA products refer to only 3 types of SA products and 18 sub-districts in Sidoarjo district. The variable d_i^- is the negative deviation indicating the lack of a value from the target that has been set, d_i^+ is the positive deviation which indicates the value is more than the target that has been set.

Meanwhile, the goals are as follows:
Goal 1: Achieve the revenue target (district) by determining the number of pcs to sell (Rupiah). Get a minimum income target according to the specified number.
Goal 2: Achieve the sales target of each product in each district (pcs). Get the maximum sales target figure according to the specified number.

4.2.2 Formulation of Objective Functions

Function The purpose of this study is to find the production value in accordance with the situation and the limits set, namely maximizing revenue (Minimizing DB1) in all districts and minimizing sales targets (pcs) (Minimizing DA1) in each district. So that the objective function:

Minimize $DB_1 + DA_1$
From the above equation, it is known that the defined limit will be reached if the deviation variables DB1 and DA1 are zero. Therefore, the value of both must be minimized in the objective function. The formulation of the objective function is:
$Z = d_1^- + d_2^+ + d_3^+ + d_4^+$

4.2.3 Formulation of Limiting Functions

Limits or constraints that must be considered in this study, meaning that to achieve the goal there are several limitations that cannot be violated. The limitations used in this study are:

1. Limitation on the total sales target for Sidoarjo district
$$\sum_{i=1}^{n} x_{i\_j} + d_1^- - d_1^+ = An$$
2. Limitation of sales targets per product for all district
$$\sum_{i=1}^{n} x_{i\_j} + d_j^- - d_j^+ = Bn_j \ ,\forall j$$
3. Limitation of sales targets per product per district
$$x_{i\_j} \leq Cn_{i\_j} \ ,\forall i \ \forall j$$
4. Limitation of sales targets per product per district
$$x_{i\_j} \geq Dn_{i\_j} \ ,\forall i \ \forall j$$

The objective function and mathematical model are as follows:
$Z = d_1^- + d_2^+ + d_3^+ + d_4^+$ with delimiter:

$$25000x_{1\_1} + 35000x_{1\_2} + \cdots + 55000x_{18\_3} + d_1^- - d_1^+ = 1014810383$$
$$25000x_{1\_1} + 35000x_{2\_1} + \cdots + 55000x_{18\_1} + d_2^- - d_2^+ = 2213443195$$
$$25000x_{1\_2} + 35000x_{2\_2} + \cdots + 55000x_{18\_2} + d_3^- - d_3^+ = 122411611$$
$$25000x_{1\_2} + 35000x_{2\_2} + \cdots + 55000x_{18\_3} + d_4^- - d_4^+ = 134067933$$
$$25000x_{1\_1} \leq 14924250$$
$$25000x_{1\_1} \geq 12753265$$
$$x_{1\_1,\dots,}x_{18\_3} \geq 0$$
$$d_i^- \geq 0, i = 1,2,3,4$$
$$d_j^- \geq 0, j = 1,2,3,4$$

4.3 Optimization Method Results

The completion of the optimization model is done using LINGO 18 software. The results of the optimization of the number of products produced in each product can be seen in Table 3

Table 3 SA Product Optimization Results (pcs)

Produk	Apr-20	Mei-20	Jun-20	Jul-20	Agust-20
X1_1	597	558	432	393	415
X2_1	49,885	35,159	82,146	64,523	46,437
X3_1	3,064	2,994	982	881	1,115
X4_1	2,850	1,767	1,207	1,023	1,202
X5_1	292	255	301	304	182
X6_1	463	269	370	324	312
X7_1	1,525	1,429	1,087	771	880
X8_1	584	905	378	382	392
X9_1	426	994	358	358	365
X10_1	1,312	1,229	893	899	1,363
X11_1	3,771	2,715	2,128	1,791	2,193
X12_1	3,946	1,784	827	754	1,006
X13_1	1,732	1,955	1,556	1,512	1,736
X14_1	386	309	359	360	376
X15_1	471	1,636	295	282	292
X16_1	2,078	4,016	632	507	570
X17_1	10,547	4,991	2,380	1,910	2,180
X18_1	444	526	432	394	473
X1_2	35	37	42	31	21
X2_2	1,850	1,876	7,261	4,227	2,983
X3_2	174	162	54	40	45
X4_2	100	117	88	55	60
X5_2	6	16	25	37	13
X6_2	15	12	32	20	19
X7_2	72	108	82	40	31
X8_2	25	75	35	19	23
X9_2	13	67	31	20	18
X10_2	54	92	55	44	76
X11_2	377	618	166	98	93
X12_2	165	115	59	41	41
X13_2	60	138	99	80	75
X14_2	11	23	28	21	18
X15_2	17	99	31	16	13
X16_2	87	186	47	21	21
X17_2	415	282	150	99	92

Produk	Apr-20	Mei-20	Jun-20	Jul-20	Agust-20
X18_2	20	24	32	18	19
X1_3	17	24	8	38	19
X2_3	1,285	1,544	3,490	498	387
X3_3	128	63	15	127	70
X4_3	52	42	26	142	106
X5_3	4	4	9	14	3
X6_3	10	5	7	11	9
X7_3	44	35	24	48	39
X8_3	10	25	11	32	56
X9_3	3	26	6	40	17
X10_3	21	38	16	159	147
X11_3	353	294	59	454	193
X12_3	76	38	13	91	53
X13_3	27	54	28	162	84
X14_3	5	7	5	81	30
X15_3	12	37	8	14	22
X16_3	82	82	12	122	67
X17_3	294	80	43	297	183
X18_3	16	10	7	33	17
	90,308	**69,946**	**108,867**	**84,656**	**66,652**

5. CONCLUSION

Results of the research that has been done, the following conclusions can be divided to two conclusion, from the forecasting results for the April-August 2020 period, the revenue new sales fluctuates. This is consistent with the fluctuating data pattern. The greatest value of forecasting results is in May 2020, which is the month of fasting and Eid al-Fitr. Also in May 2020, the majority of people were at home because of the pandemic and Large-Scale Social Restrictions (PSBB) so that revenue increased.Also the optimization results for all months are valid, except for May 2020 with the optimization result of 1,861,229,375 while the actual value is 2,918,455,000. This large gap is due to the value of Rev MAX SA SO using the Naive method which is generally used by companies. Due to the lack of supporting data when using this method, this method should no longer be used because it cannot get a suitable value for certain times with large demands.

6. REFERENCES

Aliev, R. A., Fazlollahi, B., Guirimov B. G., dan Aliev, R. R. 2007. Fuzzy-genetic approach to aggregate production–distribution planning in supply chain management, *The Int. J. Information Science*, 177, 4241-4255.

Aouni, B. dan Kettani, O. 2001. Goal programming model: A glorious history and a promising future, *European Journal of Operational Research*, 133, 225-231.

Colapinto, C., Jayaraman, R. dan Marsiglio, S. 2017. Multi-criteria decision analysis with goal programming in engineering, management and social sciences: a state-of-the art review. *Annals of Operations Research*, 251(1–2), 7-40.

Djie, I. S. J. 2013. Analisis Peramalan Penjualan dan Penggunaan Metode Linear Programming dan Decision Tree Guna Mengoptimalkan Keuntungan pada PT Primajaya Pantes Garment (Analysis of Sales Forecasting and Use of Linear Programming and Decision Tree Methods to Optimize Profits at PT Primajaya Pantes Garment) , *Journal The WINNERS*, 14(2), 113-119.

Fayaz, R., dan Azizinia, M. 2016. Current challenges in distribution channels of cultural goods and services. *Marketing and Branding Research*, 3(1), 75-85.

THE DEVELOPMENT OF AIRBUS A330-SERIES AIRCRAFT HEALTH INDEX

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ABSTRACT

As a parameter that appeared in corporate annual reports on commercial aircraft, on-time performance (OTP) maintained to achieve certain targets. This study establishes an aircraft health index on the basis of operational parameter and historical technical delay data on aircraft type Airbus A330-series that operated by Garuda Indonesia. Aircraft Health Index isa ranking based on the Dispatch Reliability achievement of each aircraft registration that will be used as a guideline for the aircraft being operated. This study uses Data Envelopment Analysis to rank aircraft performance, which is an efficient performance assessment tool based on previous studies. By calculating the Aircraft Health Index using DEA method, it can be concluded that there are 18 aircrafts declared efficient with score = 1while the other 6 registrations had efficiency less than 1. These six registrations can be increased as follows: REG-24 has efficiency score 0.9870439, REG-21 score 0.9774638, REG-18 score 0.9724941, REG-19 score 0.9527347 and REG-16 score 0.9471994. However, by reducing the slack values of the variables three DMUs have become efficient and the other three DMUs: REG-16, REG-20 and REG-21 have increased their efficiency values, although not yet reached score 1.

Keywords: delay rate, dispatch reliability, data envelopment analysis, aircraft health index.

1. INTRODUCTION

As an Indonesian' flag carrier, Garuda Indonesia prioritized on-time performance (OTP) as its highest selling attribute. In general, the standard of airline service is measured on the basis of the OTP that is stated in the corporate annual report for this achievement. This is important to know because flight delays or delays are regulated by the aviation authority in PM 89/2015 which is divided into 3 types, namely:

1. Flight delayed
2. Denied boarding passenger
3. Cancelation of flight

Handling flight delays is also regulated in PM 89/2015 which is classified into 6, namely:

1. Category 1, 30 to 60 minutes delay
2. Category 2, delay of 61 to 120 minutes
3. Category 3, 121 to 180 minutes delay
4. Category 4, 181 to 240 minutes delay
5. Category 5, a delay of more than 240 minutes
6. Category 6, flight cancellations

Based on that category, in the event of delays according to their category, airlines are expected to offer reimbursement to passengers. So that OTP becomes an important KPI for each airline, not only contributes to passenger comfort, but also needs to comply with aviation regulations, which have implications as stated above.

To support the targeted OTP, Garuda Indonesia using Dispatch Reliability as a KPI (key point indicator). Dispatch Reliability is the level of availability of aircraft to be operated or identified as on-time flights (without delays and cancellations of flights) for all flights in total. Aircraft flight delay is defined as the difference between the schedule and the actual departure and arrival time of the flight (Wieland, 1997). The higher the Dispatch Reliability value means that the more aircraft flying on time and have an impact on the increasing customer satisfaction.

Analysis to Aircraft Health Index that shows the rank value of Dispatch Reliability will be carried out with DEA (data envelopment analysis), which is a method for evaluating the performance of activities in an entity (Charnes, 1978). DEA was introduced by Farrell andCharnes (Charnes, 1978) as a method for measuring the efficiency of the performance of an entity called a Decision-Making Unit (DMU) or a work unit that is responsible for using inputs to produce output. The DEA method is also known as the efficient frontier because in its evaluationit uses a unit that has optimal efficiency as a benchmark for calculating the efficiency of other DMUs. A DMU is considered to have the best efficiency if there are no other DMUs that can produce the same output with less resources than used. As the effective frontier, the unit with the optimal efficiency value is placed and other DMUs will be evaluated relative to that unit. The efficient units will be connected to the frontier line, so that it can be stated that the DMU which is located farthest from the frontier line is inefficient. The DEA will be used in this study to measure the most effective variable (efficient frontier) in an aircraft registration and make it a reference for the effectiveness of peer-variables in other aircraft. So that the total performance value of an aircraft registration can be obtained as a reference for the health ranking of the aircraft for all typesof aircraft.

Research that develop a system for controlling performance was carried out by Rouse et al (2002). This research uses the DEA method to form monthly performance reporting system of the division. The results of the research can be the basis for making decisions related to work performance, for example employee incentives and to determine which divisions need improvement. However, this study does not explicitly indicate the ranking of each division. Meanwhile, Rocha & Netto (2002) conducted a study to select the best supplier who would receive awards in 3 categories. Using several DEA methods with multiple inputs and multiple outputs, Rocha & Netto (2002) found that the DEA/ CCR model and DEA super efficiency can avoid the same value between 2 efficient candidates. In their research, Rocha & Netto determined the ranking of all candidates. The research that will be carried out also aims to get a ranking of all Airbus A330 series aircraft registrations based on the health level represented by the value of dispatch reliability.

This study aims to analyze a flight readiness per aircraft by its operational parameter in order to obtain an Aircraft Health Index for Airbus A330-series operated by Garuda Indonesia that can display the health rating of each aircraft registration, which is intended to be a reference for determining the planner to compile the scheduling of the aircraft.

2. METHODS

2.1 Dispatch Reliability

Dispatch reliability which shows the level of aircraft on time performance can be defined as:

1. Percentage of scheduled flights that fly without mechanical delay or delay (FAA, 2010)
2. The percentage of scheduled flights on time which is the complement of the delay rate and is calculated by dividing the delay rate from 100 flights (Bineid, 2005)

The formula used in Dispatch Reliability calculation is as follows (Management, 2009):

$$\text{Dispatch Reliability} = \frac{\text{Total Take-Off Revenue} - (\text{Technical Delay} + \text{Technical Cancellation})}{\text{Total Take-Off Revenue}} \times 100\% \quad (2.1)$$

Based on formula (2.1), it can be defined that Dispatch Reliability is the percentage ofscheduled flights on time without any delay or flight delay.

2.2 Data Envelopment Analysis

The development of aircraft health rankings or that will be referred to as the Aircraft Health Index (AHI) will be carried out using the Data Envelopment Analysis (DEA)method using Lingo software. In this method, 24 registrations of Airbus A330 aircraft will be analyzed as a Decision Making Unit (DMU) whose performance will be measured basedon the specified input and outputs variables.

The mathematical equation used in calculating the efficiency ratio at x input and y output for the *i*-th data is written as follows (Rizwanullah, 2016)

$$Efficiency_i = \frac{\text{weighted sum of } outputs}{\text{weighted sum of } inputs}$$

$$\frac{u_1 y_{1,i} + u_2 y_{2,i} + \ldots + u_s y_{s,i}}{v_1 x_{1,i} + v_2 x_{2,i} + \ldots + v_m x_{m,i}} = \frac{\sum_r^s u_r y_{r,i}}{\sum_p^m v_p x_{p,i}}$$

Where u and v are the weights of each output and input, s is the number of outputs, and mis the number of inputs. So to get the best weights for -i it is formulated using linear programming as follows :

$$\max imized \;\; h = \sum_r^s u_r y_{r,i}$$

$$subject \;\; to \sum_r^s u_r y_{r,\mathrm{j}} - \sum_p^m v_p x_{\mathrm{p,j}} \leq 0$$

$$every \; j \; record$$

$$\sum_p^m v_p x_{\mathrm{p,i}} = 1$$

$$u_r, v_p \geq 0$$

So if the number of data as -n, the calculation is carried out as many as -n. The following is a linear programming model in DMU REG-1 :

$$Max \;\; Z = u_1 y_{11}$$

Limitation function :

Total input DMU REG-1

$$v_1x_{1,1} + v_2x_{2,1} + v_3x_{3,1} + v_4x_{4,1} + v_5x_{5,1} + v_6x_{6,1} + v_7x_{7,1} + v_8x_{8,1} = 1$$

Efficiency constraint of DMU REG-1

$$-v_1x_{1,1} - v_2x_{2,1} - v_3x_{3,1} - v_4x_{4,1} - v_5x_{5,1} - v_6x_{6,1} - v_7x_{7,1} - v_8x_{8,1} + u_1y_{1,1} \leq 0$$

Efficiency constraint of DMU REG-2

$$-v_1x_{1,2} - v_2x_{2,2} - v_3x_{3,2} - v_4x_{4,2} - v_5x_{5,2} - v_6x_{6,2} - v_7x_{7,2} - v_8x_{8,2} + u_1y_{1,2} \leq 0$$

Efficiency constraint of DMU REG-n

$$-v_1x_{1,n} - v_2x_{2,n} - v_3x_{3,n} - v_4x_{4,n} - v_5x_{5,n} - v_6x_{6,n} - v_7x_{7,n} - v_8x_{8,n} + u_1y_{1,n} \leq 0$$

Constrain input and output weights

$$u_1 \geq 0$$

$$v_1, v_2, v_3, v_4, v_5, v_6, v_7, v_8 \geq 0$$

The steps taken for this DEA method are as follow :

1. Input and outputs variables

   Input to be use is the aircraft operational parameters, namely :

   1. Aircraft utilization : average aircraft flight hours per day
   2. Number of passengers : average number of passengers on each flight
   3. Age of aircraft : The number of flight hours conducted by the aircraft
   4. Pilot reports (PIREP) : number of pilot reports per 1000 FH
   5. Maintenance reports (MAREP) : number of maintenance reports per 1000 FH
   6. Post Flight Report (PFR) : reports of fault messages and warnings during flight
   7. Technical Incident-Accident (TIA) : the number of incidents and accidents
   8. Time Since Last Maintenance : the flying hours since last aircraft maintenance This parameter will be paired with the output in the form of Dispatch Reliability,which is complementary to the delay rate. While the output is a variable that isconsidered efficient if equal amountof the input value produce higher value, so Dispatch Reliability as the value on-time performance of an aircraft is selected.

2. DEAMOD modeling using Lingo 18

   DEAMOD will determine the efficient frontier for each parameter. The parameter with the optimum value will be a reference for calculating the efficiency of thesame parameters in other DMUs. The parameter with the best efficiency value has slack = 0. In this modeling, the reference value weights for each DMU variable is also obtained. Reference weights are used to identify the position of a DMU if its value is efficient on the efficient frontier line. The calculationis carried out by referring to the effective DMU in such a way that, if added up, the proportion obtained is the efficiency point of the less efficient DMU.

3. A330 Aircraft Health Ranking

   The results of the DEA efficiency calculation will be set to a value in the aircraft health ranking. The highest efficiency value, namely 1, will be used as the aircraft registration in the best order to fly.

4. Proposed Improvements for Inefficient DMUs

   An effective parameter value for each DMU is determined on the basis of the Slack variable to obtain a recommendation for the parameter value that should be used.For example, the suggested amount efficient utilization for REG-1.

5. Super Efficiency for Ranking Aircraft with Efficiency Value = 1
   Aircraft registration that has an efficiency value = 1, it will be processed using the DEA Model superefficiency method which will compare the efficient DMU to the overall linear combination of other DMUs in the observation, overriding theobserved DMUs so that an efficiency value is more than 1.

3. RESULTS AND DISCUSSION

3.1 Aircraft Health Index

The efficiency value of each aircraft registration is generated based on linear programming Data Envelopment Analysis and the results can be seen in Table 1. Aircraft Health Index below:

Table 1. Aircraft Health Index

Aircraft Registration	Efficiency	Remark	Ranking
REG-1	1	efficient	1
REG-2	1	efficient	1
REG-3	1	efficient	1
REG-4	1	efficient	1
REG-5	1	efficient	1
REG-6	1	efficient	1
REG-7	1	efficient	1
REG-8	1	efficient	1
REG-9	1	efficient	1
REG-10	1	efficient	1
REG-11	1	efficient	1
REG-12	1	efficient	1
REG-13	1	efficient	1
REG-14	1	efficient	1
REG-15	1	efficient	1
REG-16	0.9471994	inefficient	6
REG-17	1	efficient	1
REG-18	0.9724941	inefficient	4
REG-19	0.9527347	inefficient	5
REG-20	0.9180517	inefficient	7
REG-21	0.9774638	inefficient	3
REG-22	1	efficient	1
REG-23	1	efficient	1
REG-24	0.9870439	inefficient	2

Based on the modeling on Lingo 18, there are 6 registrations of aircraft with efficiency of less than 1 in a row, namely REG-24 with an efficiency of 0.9870439, REG-21 of 0.9774638, REG-18 of 0.9724941, REG-19 of 0.9527347 and REG-16 of 0.9471994. The efficiency value of the DMU <1 indicates that the linear combination of other DMUs is able to produce the same output value with a smaller input value. This efficiency value describes the radial distance from the estimated frontier line production to the observed DMU (Andersen, 1993). This makes all aircraft registrations with an efficiency of 1 are those that are declared efficient during operation and are given rank 1 in the Aircraft Health Index.

3.2 Slack Variable

To get the slacks value so that we can find out which variables need to be fixed, R Studio is used with the function: slacks(). The following Table 2. Slack Variable shows the slacks value of each variable in each aircraft registration. The value of slacks = 0 then the variable is efficient.

Table 2. Slack Variable

Aircraft Registration	PFR	TIA	PIREP	MAREP	Util	PAX	TSN	TSLM	DR
REG-1	0	0	0	0	0	0	0	0	0
REG-2	0	0	0	0	0	0	0	0	0
REG-3	0	0	0	0	0	0	0	0	0
REG-4	0	0	0	0	0	0	0	0	0
REG-5	0	0	0	0	0	0	0	0	0
REG-6	0	0	0	0	0	0	0	0	0
REG-7	0	0	0	0	0	0	0	0	0
REG-8	0	0	0	0	0	0	0	0	0
REG-9	0	0	0	0	0	0	0	0	0
REG-10	0	0	0	0	0	0	0	0	0
REG-11	0	0	0	0	0	0	0	0	0
REG-12	0	0	0	0	0	0	0	0	0
REG-13	0	0	0	0	0	0	0	0	0
REG-14	0	0	0	0	0	0	0	0	0
REG-15	0	0	0	0	0	0	0	0	0
REG-16	0	0	0.80	2.52	2.26	11.37	1150.10	411.29	0
REG-17	0	0	0	0	0	0	0	0	0
REG-18	18.19	0	2.72	1.84	0	73.81	3178.52	131.70	0
REG-19	20.23	0	5.88	4.80	0	68.56	1690.18	961.11	0
REG-20	6.53	0.02	5.60	1.57	0	0	3225.56	1918.09	0
REG-21	0	0	2.53	0	0.56	29.77	528.76	1804.38	0
REG-22	0	0	0	0	0	0	0	0	0
REG-23	0	0	0	0	0	0	0	0	0
REG-24	28.99	0.03	0.85	0.18	0	89.46	0	1666.84	0

3.3 Proposed Improvement of Variable Value and Efficiency of DMU

To improve the efficiency of the presence of slack shall be calculated by reducing the value ofthe variable by the amount of slack in that variable. From the previous calculation stated that there were 6 registrations that inefficient, it is recommended to increase the efficiency as follows:

- REG-24
  Slack at PFR = 28.99, TIA = 0.03, PIREP = 0.85, MAREP = 0.18, PAX = 89.46, TSLM = 1666.84. It is recommended that REG-24 has PFR = 227.33, TIA = 0.00, PIREP = 20.86,MAREP = 28.16, PAX = 113.75, TSLM = 2493.94

Using the same method for other aircraft registrations, the recommended value is obtained as shown in Table 3. Recommended Improvements of Variable:

Table 3. Recommended Improvements of Variable

Aircraft Registration	PFR	TIA	PIREP	MAREP	Util	PAX	TSN	TSLM
REG-16			20.59	27.04	8.93	177.62	22969.19	810.00
REG-18	210.86		23.28	31.78		115.81	14280.60	4200.42
REG-19	231.88		11.80	24.89		122.98	18894.35	4625.42
REG-20	240.99	0.00	15.78	30.85			16793.28	4009.75
REG-21			22.74		11.36	160.88	18305.73	2500.12
REG-24	227.33	0.00	20.86	28.16		113.75		2493.94

After calculating the proposed variables to improve the efficiency of the six registrations, DEA modeling is carried out using the proposed variable values to determine the resulting efficiency values. Performed using Lingo, the following efficiency values were obtained:

Table 4. New Efficiency Value

Aircraft Registration	Initial Efficiency	New Efficiency
REG-1	1	1
REG-2	1	1
REG-3	1	1
REG-4	1	1
REG-5	1	1
REG-6	1	1
REG-7	1	1
REG-8	1	1
REG-9	1	1
REG-10	1	1
REG-11	1	1
REG-12	1	1
REG-13	1	1
REG-14	1	1
REG-15	1	1
REG-16	0.9471994	0.9998048
REG-17	1	1
REG-18	0.9724941	1
REG-19	0.9527347	1
REG-20	0.9180517	0.9999444
REG-21	0.9774638	1
REG-22	1	1
REG-23	1	1
REG-24	0.9870439	0.9987696

Based on Table 4. New Efficiency Values, with changes in the value of the variable that has slack, a new efficiency value is generated in the six registrations which have an efficiency value <1. The six inefficient DMUs have experienced an increase in efficiency, even three DMUs have become efficient with an efficiency value of = 1. The improvements are as follows: REG- 16 efficiency increased from 0.9471994 to 0.9998048, REG-18 from efficiency 0.9724941 to 1, REG-19 from efficiency 0.9527347 to 1, REG-20 from 0.9180517 to 0.9999444, REG-21 from 0.9774638 to 0.9777905 and REG-24 from an efficiency value of 0.9870439 to increase to 1.

4. CONCLUSION

The Aircraft Health Index that is an aircraft registration ranking as a performance-based reference for aircraft readiness to fly, is performed using the Data Envelopment Analysis method on 24 A330-series aircraft registrations as DMUs, resulting in 18 aircraft registrations declared efficient with an efficiency value = 1 while 6 other aircraft registrations are stated inefficient with efficiency values <1 consecutively namely REG-24 with efficiency 0.9870439, REG-21 of 0.9774638, REG-18 of 0.9724941, REG-19 of 0.9527347 and REG-16 of 0.9471994. These six inefficient DMUs can be improved their efficiency by reducing the values of the variables by the amount of slack in that variable: three DMUs have become efficient and the other three improve as follows: REG-16 efficiency increased from 0.9471994 to 0.9998048, REG-20 from 0.9180517 to 0.9999444, and REG-21 from 0.9774638 to 0.9777905.

5. REFERENCES

Andersen, P. and Petersen, N.C., 1993. A procedure for ranking efficient units in data envelopment analysis. *Management science*, 39(10), pp.1261-1264.

Bineid, M. &. Fielding, J. P., 2003. Development of a civil aircraft dispatch reliabilityprediction methodology. *Aircraft Engineering and Aerospace Technology Vol. 75 Iss 6*, pp. 588 - 594.

Charnes A., Cooper, W. W. & Rhodes, E., 1978. Measuring the efficiency of decision making units. *European Journal of Operational Research*, pp. 429- 444.

FAA, 2010. 14 CFR Ch. II. In: *Code of Federal Regulations.* s.l.:The Office of The Federal Register Natinal Archives and Records Administration, p. 94.

Management, A., 2009. *Reliability Control Program Manual*, Jakarta: Garuda Indonesia.

Rizwanullah, M., 2016. Data Envelopment Analysis with LINGO Modeling for Technical Educational Group of an Organization. *Int. J. Data Envelopment Analysis, Vol. 4, No. 1*, p. 917-927.

Rocha, R.B. and Cavalcanti Netto, M.A., 2002. A data envelopment analysis model for rank ordering suppliers in the oil industry. Pesquisa Operacional, 22(2), pp.123-131.

Rouse, P., Putterill, M. and Ryan, D., 2002. Integrated performance measurement design: insights from an application in aircraft maintenance. Management Accounting Research, 13(2), pp.229-248.

Tone, K., 2017. Super-efficiency DEA Models. Advances in DEA Theory and Applications: With Extensions to Forecasting Models, p.28.

Wieland, F., 1997. Limits to Growth: Results from the Detailed Policy Assessment Tool [Air Traffic Congestion]. *16th DASC. AIAA/IEEE Digital Avionics Systems Conference. Reflections to the Future. Proceedings.*

ADVANCING HUMANITY

TOPIC

Quality Management

PROCESS CAPABILITY ANALYSIS FOR QUALITY CONTROL OF PHARMACEUTICAL SALT IN PT XYZ

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ABSTRACT

PT XYZ is a company engaged in the pharmaceutical industry. One of the production units of PT XYZ makes one of the raw materials for medicine, namely pharmaceutical salt. Production data for the period February to December 2018 are known to have mismatches in the expected results. The mismatch is related to the number of products that do not meet the requirements (TMS). The purpose of this research is to analyze the process capability of pharmaceutical salt products by designing a control chart to control quality, analyzing the factors causing the products that do not meet the requirements and providing suggestions for improvements to control pharmaceutical salt products. Quality control can use process capability analysis to determine how much the multivariate process capability is. The multivariate control chart can use the T2 Hotteling control chart to determine whether the process has been controlled or not. Pareto diagram analysis is used to determine the priority characteristics that must be taken first, while the fishbone diagram is used to find the root causes of parametersthat are out of control. Analysis using Minitab 18 software shows that the process in February - June 2018 and July - December 2018 has no shift The mean process is significant, this can be seen with the T2Hotelling control chart which has been controlled statistically. The process capability index of each characteristic shows thatin February - June 2018 there was an incapable process, namely the characteristics of NaCl. The characteristic of NaCl has a Cp of 1.03 and a Cpk of 0.99 where a Cpkvalue of less than 1 means that the process of this characteristic is not capable. In July -December 2018 it was also known that there was no significant shift in the mean process, this can be seen with the T2 Hotelling control chart which has been controlled statistically. The process capability index of each characteristic, it can be concluded that there are characteristics that are not capable, namely the characteristics of theNaCl content (Cp of 0.53 and Cpk of 0.59) and the water content which has a Cpk of
0.78. Analysis using the Pareto diagram shows the characteristics of the most dominant NaCl levels to the characteristic mismatch.

Keywords: Process capability, Quality, Pharmaceutical Salt, T2 Hotteling Fishbone Diagram, Pareto Diagram.

1. INTRODUCTION

Quality is the most important thing in the production process in a pharmaceutical industry. With good quality, more and more products are produced for sale. PT XYZ is a pharmaceutical industry that produces various kinds of generic and non generic drugs. One of the products produced by PT XYZ is pharmaceutical salt. Pharmaceutical salt is a medicinal raw material commonly used as raw material for cosmetics, electrolyte drinks and infusions. Based on data obtained in 2018, it shows that there are many characteristic discrepancies in the form of products that do not meet the standards or parameters set by the company. One of the efforts that can be made in improving and controlling the quality of pharmaceutical salts is by using the process capability analysis evaluation.

A process can be said to be capable if it is statistically controlled, meets specification limits, and has a high degree of precision and accuracy. Thus, to perform a process capability analysis, it is necessary to make a multivariate control chart, namely the T2 Hotelling control chart. The variables used in this study consisted of four quantitative variables and two qualitative variables. For quantitative variables using process capability, Pareto diagram and Ishikawa diagram to determine suggestions and improvements. Meanwhile, the qualitative variables onlyuse the Pareto diagram and Ishikawa diagram in determining future improvements.

2. METHOD

2.1 Research variables

The characteristics of the quality of the pharmaceutical salt products used consisted of four quantitative variables, namely levels of NaCl, moisture content, fungi, and bacteria. While the qualitative characteristics consist of levels of sulfate and barium. The characteristics set by the company can be seen in Table 1.

Table 1. Variable Characteristics

No	**Component**	**Spesification**	**Unit**
1	NaCl content	99,0 – 100,5	%
2	Moisture content	0 – 0,5	%
3	Fungi	0 - 5	Cfu/10gram
4	Bacteria	0 - 100	Cfu/10gram
5	Barium	Passed	-
6	Sulfate	Passed	-

2.2 Data Sources

This study uses secondary data and primary data as research support, where the data taken is the quality characteristics of pharmaceutical salt products from February 2018 to December 2018. Test result data consists of six samples per batch and tested in the PT XYZ laboratory six times each characteristics.

2.3 Step analysis

The first step used in this study was to make a descriptive summary to make it easier to present the data, then to test the correlation between variables followed by testing the multivariate normal distribution. If the variables are correlated with each other and have a multivariate normal distribution, then proceed with making the T2 Hotelling control chart. If the independent variables are not normally distributed, then continue using the I-MR control chart. The calculation of process capability can be done if the data is statistically controlled. The final step is making Pareto diagrams and Ishikawa diagrams to determine priority improvements and suggestions for improvements.

3. RESULTS AND DISCUSSION

This study focuses on six predetermined characteristics, consisting of four quantitative characteristics (NaCl content, moisture content, fungi and bacteria) and two qualitative characteristics (barium and sulfate). The analysis is carried out separately which is divided into two phases. The two-phase division aims to determine whether the process mean is shifting or not.

3.1 Descriptive Statistics

Characteristic analysis in general can be carried out with the aim of summarizing the data reading shown in table 2 and table 3.

Table 2. Descriptive Statistic Phase 1

No	February – June 2018						
	Characteristic	Mean	Varians	Min	Max	UCL	LCL
1	NaCl Content	99,724	0,234	98,411	101,109	100,5	99,00
2	Moisture Conrtent	0,2977	0,0089	0,0963	0,6225	0,5	0
3	Bacteria	36,241	8,008	23,110	45,120	100	0
4	Fungi	2,5319	0,9731	0,0843	4,9830	5	0

Table 3. Descriptive Statistic Phase 2

No	July – December 2018						
	Characteristic	Mean	Varians	Min	Max	UCL	LCL
1	NaCl Content	99,782	0,855	96.649	102,383	100,5	99,00
2	Moisture Content	0,373	0,0115	0,1134	0,6342	0,5	0
3	Bacteria	36,241	31,718	21,598	53,730	100	0
4	Fungi	3,3077	0,2748	1,7847	4,6579	5	0

Phase 1 in the period February - June 2018, obtained an average quality characteristic of NaCl content of 99.724; water content of 0.2977; bacteria of 36,241; and fungi of 2.5319 where the largest variance was in the characteristics of the quality of the bacteria, which means that the test results for the characteristics of the quality of bacteria in phase 1 had a high diversity compared to the diversity of other quality characteristics. It is also known that the upper control limit (UCL) and the lower control limit (LCL) have been determined by the company, so the NaCl content is a quality characteristic that has test results outside the specifications where there are 98.411 test results that are less than the specified lower specification limit. It is also known that there is a value that exceeds the upper limit determined by the company, namely the NaCl content of 101.109 and the moisture content of 0.6225.

Phase 2 in the period July - December 2018, the average quality characteristics of NaCl levels were 99.821; water content of 0.373; 36,764 bacteria; and fungi of 3.3077 where the largest variance was in the characteristics of the quality of the bacteria, which means that the test results for the characteristics of the quality of bacteria in phase 2 had high diversity compared to the diversity of other quality characteristics. It is also known that the upper control limit (UCL) and the lower control limit (LCL) have been determined by the company, so the NaCl content is a quality characteristic that has test results outside the specifications where there are 96.649 test results that are less than the specified lower specification limit. It is also known that there is avalue that exceeds the upper limit determined by the company, namely the NaCl content of 102.383 and the moisture content of 0.6342.

3.2 Dependency Test

To find out whether the research variables are interrelated or not, the following hypothesis is used:
H0: $\rho = I$ (quality characteristics of phase 1 or 2 pharmaceutical salts are uncorrelated)
H1: $\rho \neq I$ (quality characteristics of phase 1 or 2 correlated pharmaceutical salts).

In the data correlation test for quality characteristics of phases 1 and 2, a significance level ($\alpha = 0.01$) was used with a significance level of 1% based on pharmaceutical salt products intended for health (raw materials for drugs and cosmetics). The results of the analysis of the correlation testing of quality characteristics in phases 1 and 2 using bartlett's test in Minitab 18 software that the p-value in phases I and 2 is 0.00. Based on this value, H0 is rejected, because the p-value (0.00) $< \alpha$ (0.01), meaning that the quality characteristics of phase I pharmaceutical salts are mutually correlated.

3.3 Normality Test

The second assumption that must be fulfilled in order to continue the analysis is the multivariate distribution of data with variable levels of NaCL, moisture, bacteria and fungi. In phases 1 and 2 using the minitab macro, the di^2 proportion values were 53.9% and 50.8% (see figure 1 and 2). In Figures 1 and 2 it is also known that the sample distribution has approached the diagonal line . If the di^2 value is less than χ^2 where the value is greater than 50%, it can be concluded that the results of observations in phases 1 and 2 have a multivariate normal distribution. After the assumptions have been fulfilled, it will be followed by a multivariate control chart. Multivariate control charts are used to determine whether the process has been controlled statistically or not, where the quality characteristics of a product are more than 1.

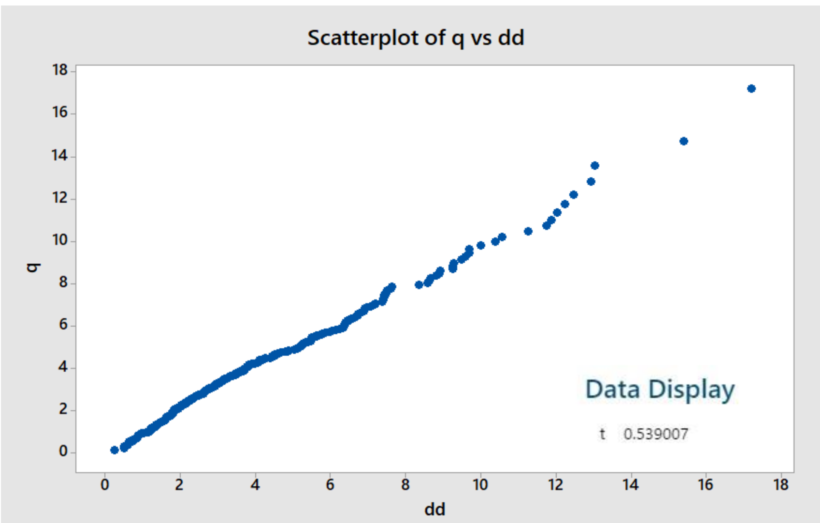

Figure 1. Normality test result for phase 1

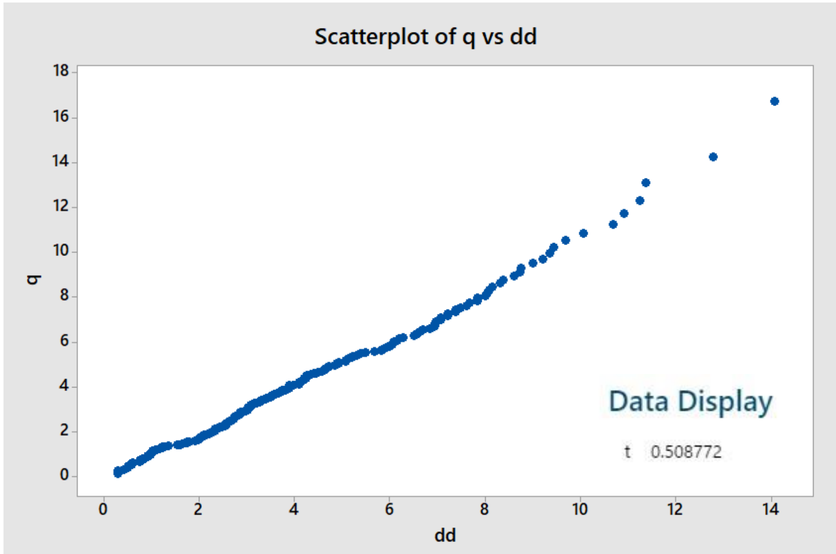

Figure 2. Normality test result for phase 2

3.4 T^2 Hotelling chart

The T^2Hotelling control chart is used to monitor the process mean for multivariate data with multivariate observations with 38 subgroups and each subgroup consisting of 6 observation samples. By using Minitab 18 software on the quality characteristics of pharmaceutical salts, a control chart is obtained as shown in Figures 3 and 4.

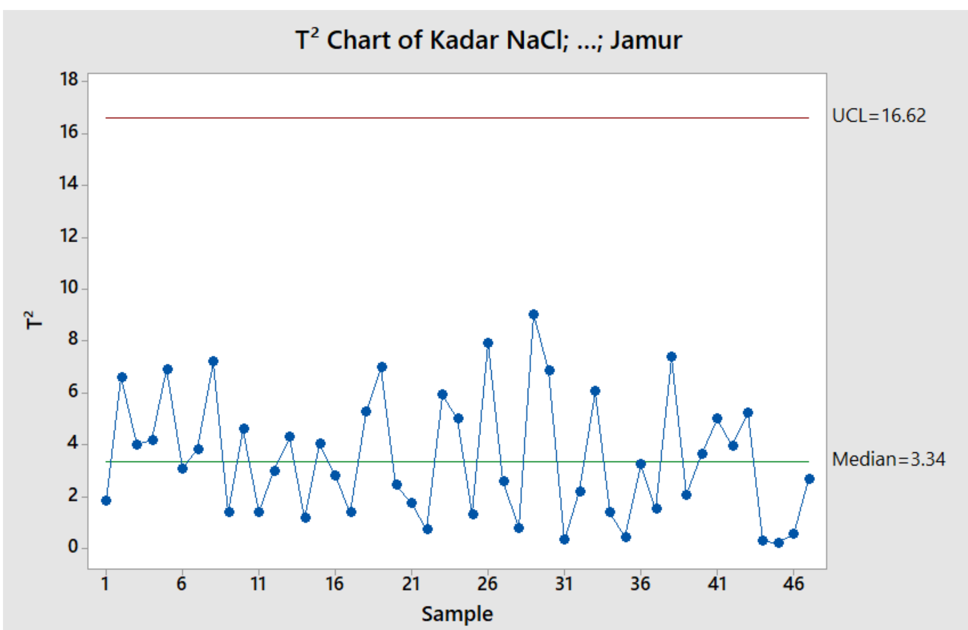

Figure 3. T^2Hotelling chart for phase 1

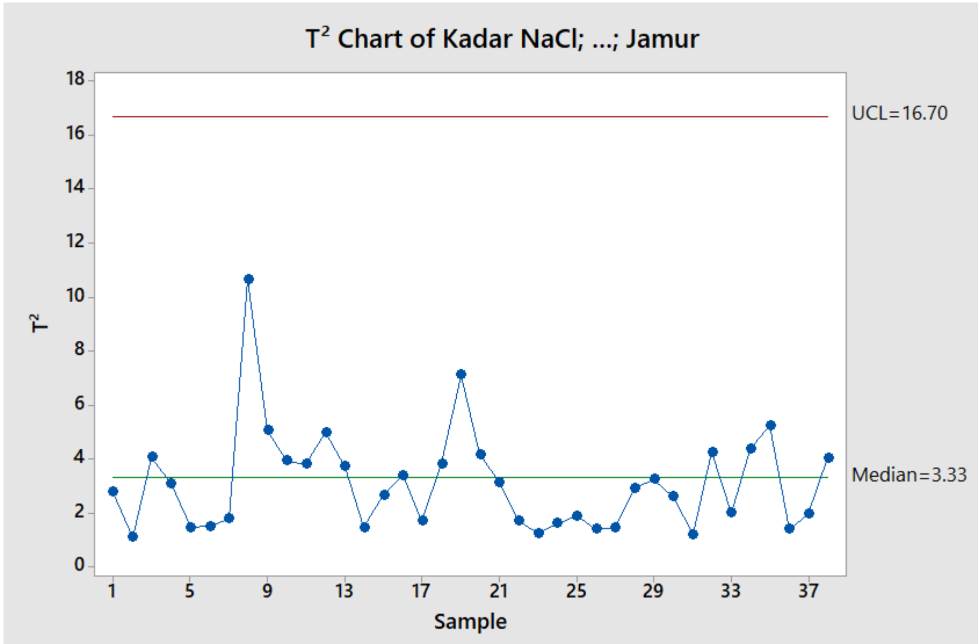

Figure 4. T^2Hotelling chart for phase 2

Figures 3 and 4 show that the mean process quantitative characteristics of pharmaceutical salts by calculating Hotelling's T^2 have no observations that are outside of the upper control limit (UCL) and the lower control limit (LCL). The upper control limit and lower control limit obtained are 6.70 and 0. From the results of these calculations and observations, it can be concluded that the mean process of quantitative characteristics of pharmaceutical salts is statistically controlled so that it can be continued in the next analysis, namely process capability.

3.5 Process Capabilities

The process capability index is a scale that shows how well the product meets the specifications that have been applied by the company. Process capability can be said to be capable if it meets three criteria, namely the process is statistically controlled, a high precision value or an approach size between one observation and another observation with reference to Cp> 1, and a high accuracy value or the closeness of the observation to the target value in the specification with reference to Cpk> 1. If one of these criteria is not met, then the process is said to be incapable.

The process capability analysis in phases 1 and 2 can be calculated using Minitab 18 software. In these calculations, the values of Cp and Cpk can be seen in table 4.In phase 1 it is known that the characteristics of the NaCl content are not capable because the Cpk value is less than 1, while in phase 2 it is known that the characteristics of NaCl and water content are not capable because of the Cp and Cpk less than 1.

Table 4. Cp and Cpk value for each characteristics

No	Characteristic	Phase 1		Phase 2	
		Cp	Cpk	Cp	Cpk
1	NaCl Content	0.53	0.50	0.53	0.50

2	Moisture Content	1.55	0.78	1.55	0.78
3	Bacteria	5.75	4.23	5.75	4.23
4	Fungi	3.11	2.10	3.11	2.10

3.6 Pareto Diagram

Pareto diagram is used to determine which problem is dominant in the production process of PT XYZ pharmaceutical salt. Figure 4.3 is a pareto diagram, where the horizontal axis is the characteristic of pharmaceutical salt products, the left side vertical axis is the frequency or number of samples that do not meet specifications, while the right side vertical axis is the cumulative percentage of non-conformity specifications. Based on Figure 5, it is known that the most frequent mismatch of specifications lies in the characteristics of the NaCl content of 119 samples, 84 samples of sulfate, 75 samples of Barium and 36 samples of moisture content.

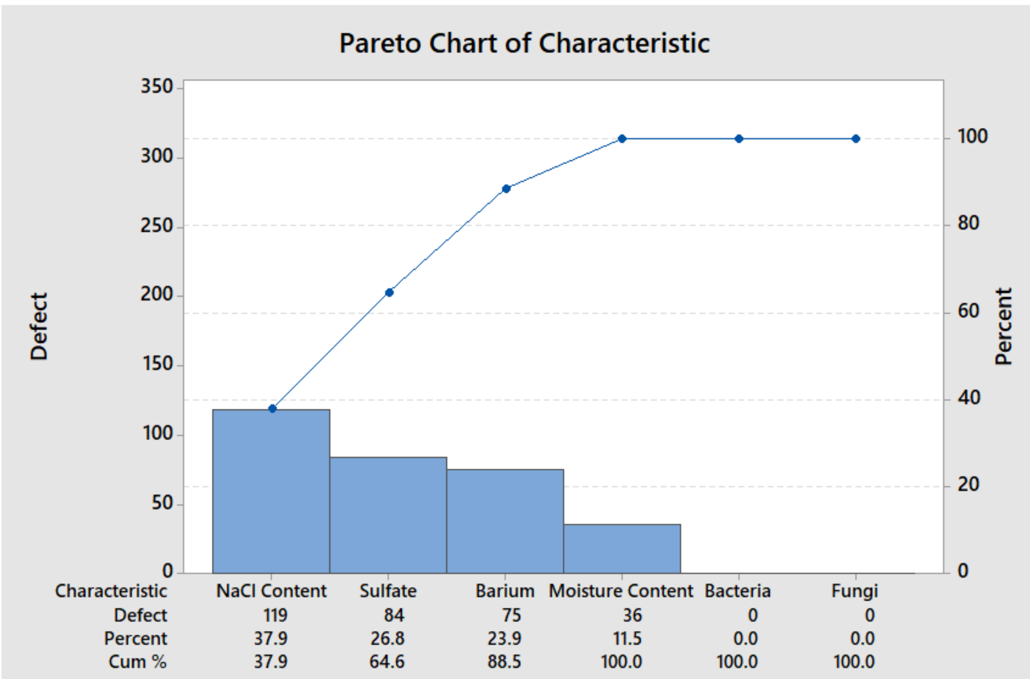

Figure 5. Pareto diagram for the characteristics of pharmaceutical salts

3.7 Diagram Ishikawa/Fishbone

After knowing the characteristics that occur most often, it is necessary to identify the causes of the non-conformity so that improvements can be made.diagram Ishikawa is a tool that can be used to find out the causes of a problem originating from human, machine, method, material, measurement and environmental factors. The factors causing the discrepancy that can be found can be seen in Figures 6 to 10.

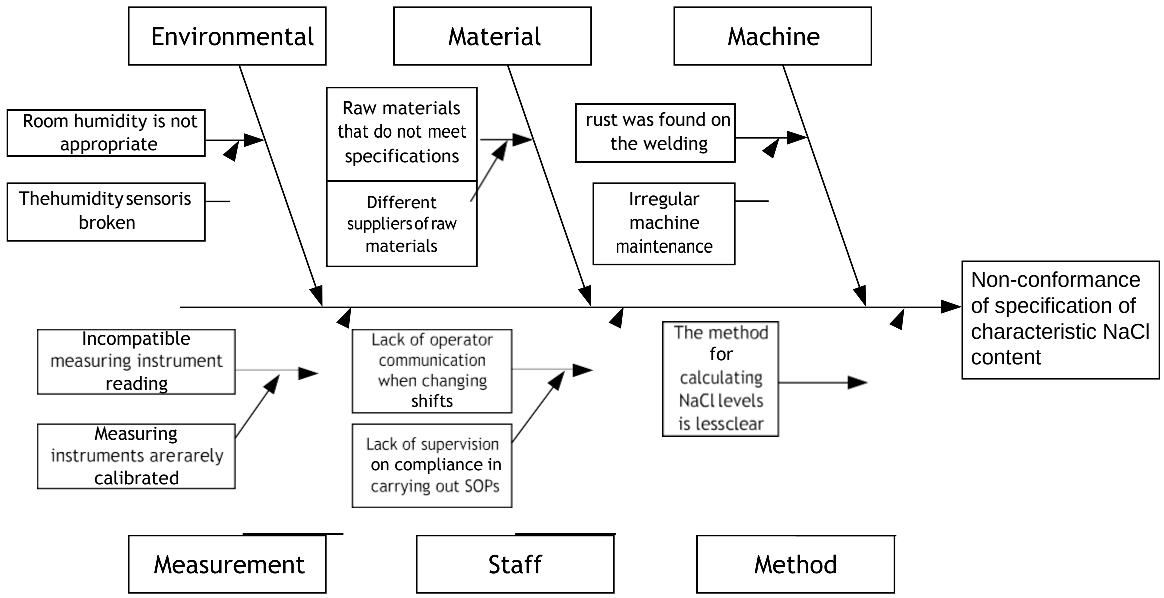

Figure 6. Ishikawa Diagram of NaCl Content Characteristics

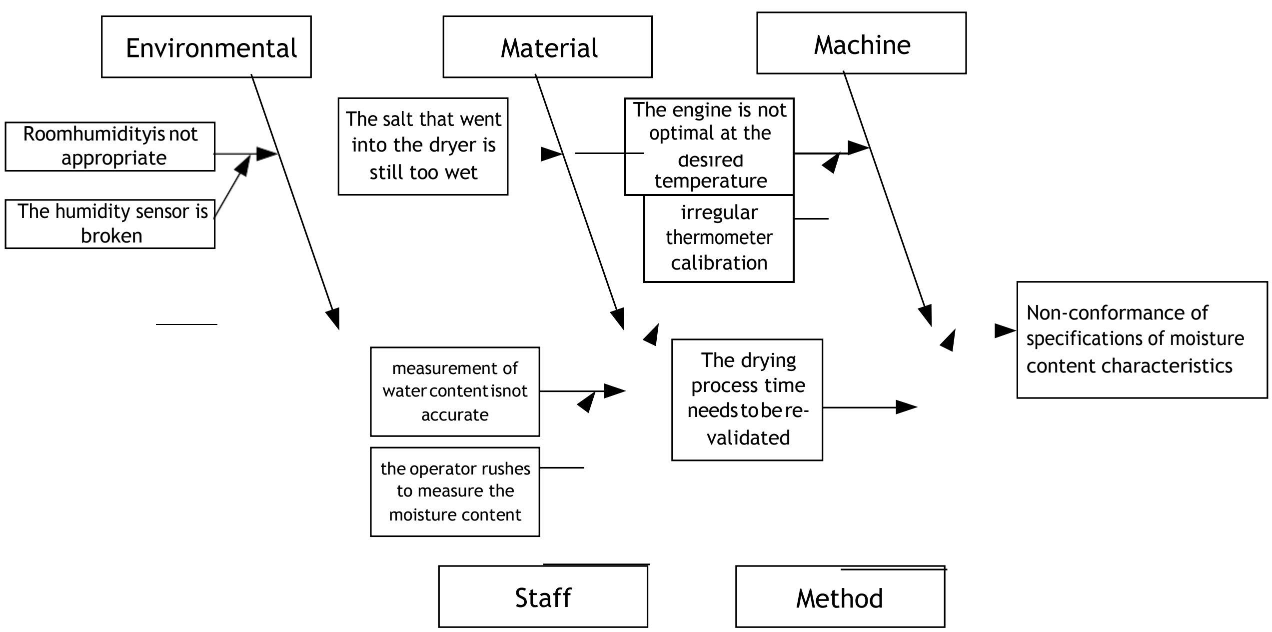

Figure 7. Ishikawa Diagram of Moisture Content Characteristics

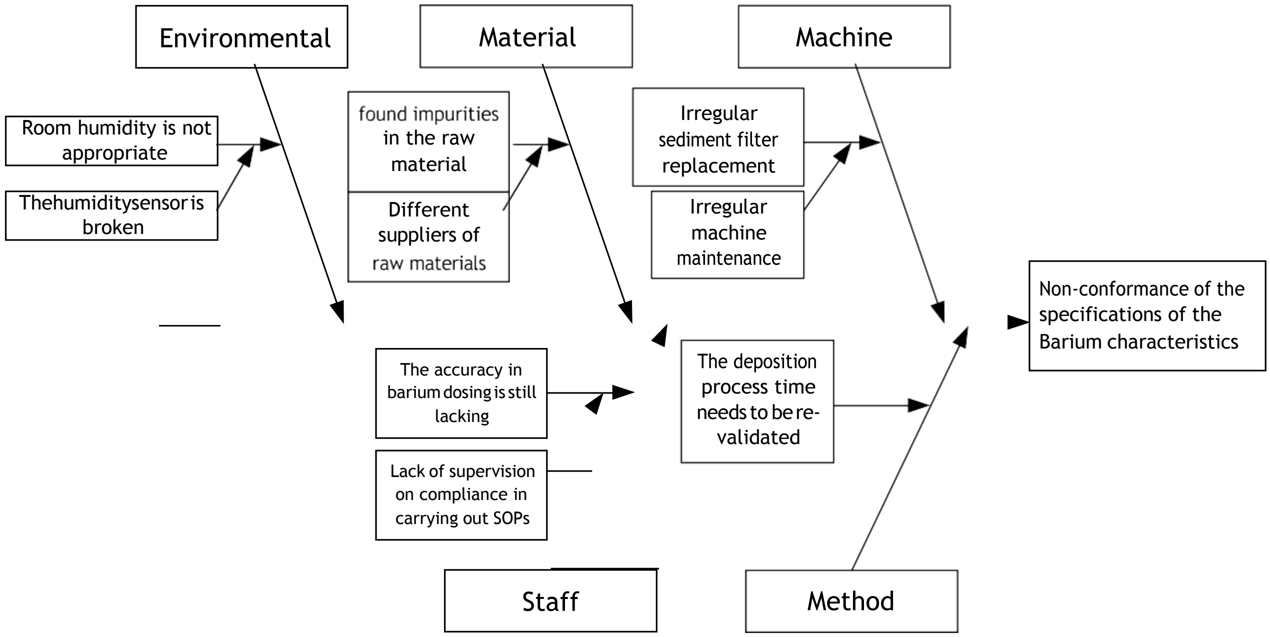

Figure 8. Ishikawa Diagram of Barium Characteristics

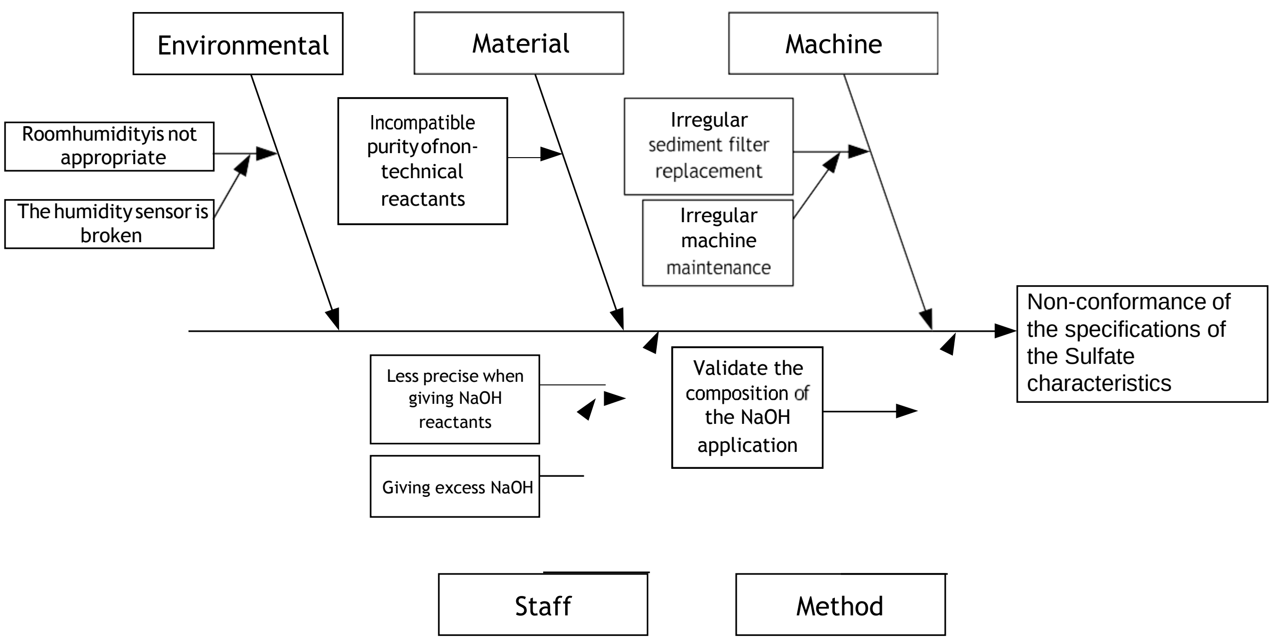

Figure 9. Ishikawa Diagram of Sulfate Characteristics

4. CONCLUSION

Based on the results of analysis and discussion, PT XYZ needs to make improvements based on the causes of incapable processes such as the characteristics of NaCl levels and water content. Based on the Pareto diagram, NaCl content is one that needs to be addressed first, followed by sulfate, barium and water content.

5. ACKNOWLEDGMENT

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6. REFERENCES

Bothe, D. R. (1997). *Measuring Process Capability*. United States of America: The McGraw-Hill, Inc.

Dale H, Besterfield et al .(2003).*Total Quality Management*, 3rd edition, Prentice-Hall Inc, New Jersey

Kotler, Philip. (2000). *Marketing Management*. Milenium Edition, Prentice Hall Intl, Inc New Jersey.

Montgomery, Douglas, C. (2013). *Statistical Quality Control: A Modern Introduction*, Seventh Edition. Asia: John Wiley & Sons, Inc.

Rimantho, D., & Athiyah. (2019). Analisis Kapabilitas Proses Untuk Pengendalian Kualitas Air Limbah di Industri Farmasi. *Jurnal Teknologi*, *11*(1), 1–8.

Sucahyono, Agung Eko & Sunaryo, S. (2014). Analisa Kapabilitas Proses Produksi Air PDAM Surya Sembada Surabaya. *Manajemen Teknologi*, 24, 1–8.

Wooluru, Y., Swamy, D. R., & Nagesh, P. (2014). The process capability analysis - A tool for process performance measures and metrics - A case study. *International Journal for Quality Research*, *8*(3), 399–416.

INCREASING PLANT AVAILABILITY OF SULFURIC ACID PLANT I PT PETROKIMIA GRESIK WITH FMEA

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ABSTRACT

Sulfuric Acid Plant I constitutes the factory which is in charge of fulfilling sulfuric acid internal needs in PT Petrokimia Gresik as raw material for producing fertilizer. This plant has operated since 1984 with production capacity 570.000 ton/year. Since 2018 until now, the production has declined following a decrease in plant availability due to high number of unscheduled shut down from Sulfuric Acid Plant I. This research objective is to analyze the cause of decreased plant availability using several methods. The steps of this research are (1) collecting unscheduled shutdown data, (2) calculate Mean Time to Repair (MTTR) each equipment that run into failure, (3) construct pareto chart of equipment MTTR, (4) analyze the dominant failure equipment using fishbone diagram, (5) develop alternative solutions using failure mode & effect analysis (FMEA). The result shows equipment which has the highest MTTR is B-1104 (waste heat boiler). Then, using a fishbone diagram, there are several failure root causes that make B-1104 fail. FMEA delivers alternative solutions from root cause problems that result from fish bone diagrams. FMEA also generates the priorityof each alternative solution. The solutions of critical failure mode are proposed to eliminate B- 1104 failure that might improve plant availability of Sulfuric Acid Plant I.

Keywords: availability, MTRR, sulfuric acid plant, pareto chart, fishbone diagram, FMEA.

1. INTRODUCTION

Sulfuric acid (SA) is a base chemical product which has many derivative products especially in the fertilizer industry. Petrokimia Gresik (PG), the most complete fertilizer plant in Indonesia, has 2 SA plants. Although it has 2 plants, SA production capacity is not enough to fulfil demand. This has been anticipated by importing sulfuric acid from other sources. Hence, it can be said that the operation of the fertilizer plant in PG will be affected by obstacles of SA plant.

SA plant I has been operated for 30 years, since 1984, so that its potential has decreased. Table 1 shows the maintenance performance of SA plant I from 2017 until midyear of 2020.

Table 1. Availability of SA I Plant

Year	MTBF, days		MTTR, days		Availability,%	
	Target	Real	Target	Real	Target	Real
2017	33,00	40,97	1,00	1,97	97,0	95,4

2018	33,00	23,15	1,00	3,30	97,0	87,5
Year	**MTBF, days**		**MTTR, days**		**Availability,%**	
	Target	**Real**	**Target**	**Real**	**Target**	**Real**
2019	29,67	11,12	1,00	2,21	96,7	83,4
Mid 2020	23,40	12,96	1,00	2,23	95,9	85,3

(Source : Production Report PG)

Availability is a function of reliability, ease of repair, and operation alternatives of the system. This availability affects annual production. Table 1.2 shows the SA plant I availability drop since 2018 and it always below the target from 2017 until now.

This research intend to study the alternative solutions for the SA plant I availability problem. The steps of this research are (1) collecting unscheduled shutdown data, (2) calculate Mean Time to Repair (MTTR) each equipment that run into failure, (3) construct pareto chart of equipment MTTR,

(4) analyze the dominant failure equipment using fishbone diagram, (5) develop alternative solutions using failure mode & effect analysis (FMEA).

1.1 SA plant IOperation Process

SA plant Iconsume sulphur, which is oil & gas industry by product from middle east, as raw material. The type of process used is double contact double absorber with TJ Browder process license. Figure 1 shows the block diagram of SA I process.

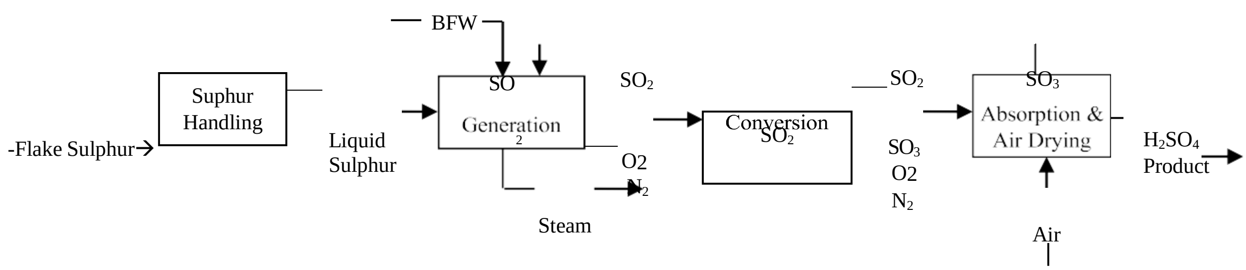

Figure 1. SA Process Block Diagram
(Source: Wahyudi, 2004)

With production capacity 1.800 ton/year, according Wahyudi (2004), production process can be divided into 4 steps:

a. Sulphur Handling, sulphur from the storage is melted by melter and filtered from the impurities until the liquid sulphur is ready to use in the next step.
b. SO_2 Generation, liquid sulphur is burned with the air then generates hot SO_2 gas. The waste hot gas is used to generate steam.
c. SO_2 Conversion, SO_2 gas form furnace is converted to SO_3 gas using catalyst in the multi bed reactor.
d. SO_3 Absorption & Air Drying, SO3 gas is absorbed with concentrated SA then delivers high concentrated SA and is ready to be send to the tank yard. In this section, air from the atmosphere is sucked up with a blower then dried with SA in an absorber.

1.2 SA Plant I Maintenance Program

SA plant I maintenance program aims to maintain the plant availability. There are 2 programs, predictive maintenance and breakdown maintenance. Breakdown maintenance is carried out when the equipment fails, and causing the factory to shut down. Preventive maintenance is planned maintenance based on the schedule of each equipment.

Preventive maintenance programs can be divided into 2, which are routine preventive maintenance while plant operates, and Turn Around (TA) maintenance that plant should be shut down in long duration (more than 10 days). In the TA maintenance program, the job listing varies depending on plant condition. Besides TA maintenance program, plant rejuvenation program is also carried out for improving plant availability. With the factory being 36 years old, some of the equipment have reached their service life limit.

1.3 Availability

Availability is one of the important parameters of reliability performance that measures system maintenance, including the failure rate and repair rate of a system (Elsayed, 2012). Figure 2 shows the correlation between availability, maintainability, and reliability.

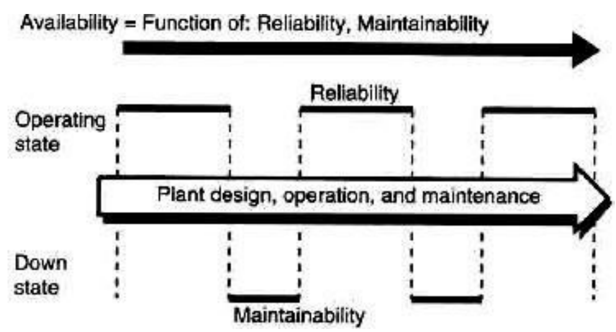

Figure 2. Correlation Availability, Maintainability, and Realiability
(Source : Gupta, S. dan Tewari, P.C., 2011)

Availability can be understood as the probability that a component can operate according to its function at a certain time (Yuhelson, 2010). The availability score shows the component's ability to function after maintenance is taken. Thus, the greater availability score indicates the higher component's ability, or it can be said that if the availability score close to one, then the condition of the component is better to operate according to its function.

In this research, the availability calculation method used is inherent availability because this research focuses on corrective maintenance resulting from unscheduled shut down in the SA Plant I. Inherent availability is the calculation of availability by measuring the corrective maintenance duration of a system. Things like preventive maintenance, waiting time, material supply and set up time are not taken into account (Elsayed, 2012). Equation 1 shows the calculation method of this availability.

$$A = \frac{MTBF}{MTFB + MTTR} \quad \ldots (1)$$

The SA Plant I system availability calculation uses series method since the production systems consist of several equipment in which their function structure are in series mode. According to Oggerino (2001) for the availability of series system, equation 2 shows the calculation method of this system.

$$A = A_{sH} \cdot A_{so_2G} \cdot A_{so_2C} \cdot Aso_3A \quad .. (2)$$

1.4 Pareto Chart

Pareto Chart is a frequency chart assisted by the 80/20 rule adapted by Joseph Juran of Wilfredo Pareto, an Italian Economist (Foster, 2007). The concept of 80/20 rule is that 80% of the problems that arise are due to 20% of the causes. This suggests that the majority of problems can be solved by knowing the vital causes. In numbers 80/20 can vary according to the problem at hand.

Pareto chart is selected to identify and prioritize problems to be resolved. Figure 3 shows the example of pareto charts.

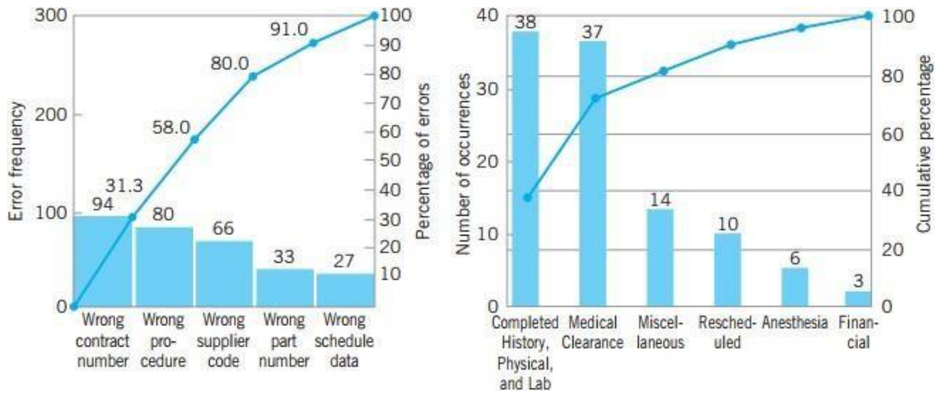

Figure 3. Example of Pareto Chart
(Source : Montgomery, 2013)

1.5 Fishbone Diagram

Fishbone diagram or Ishikawa diagram or cause & effect diagram, shows in Figure 4, is a tool to elaborate problems and then look for solutions (Foster, 2007). This diagram is like a fish bone with a problem that appears on the head. The main cause lies in the ribs of the fish until the root cause is the smallest fish spines. The method of identifying the root causes uses the ‘why’ question word up to 5 iterations, so it is often called ‘5 whys’.

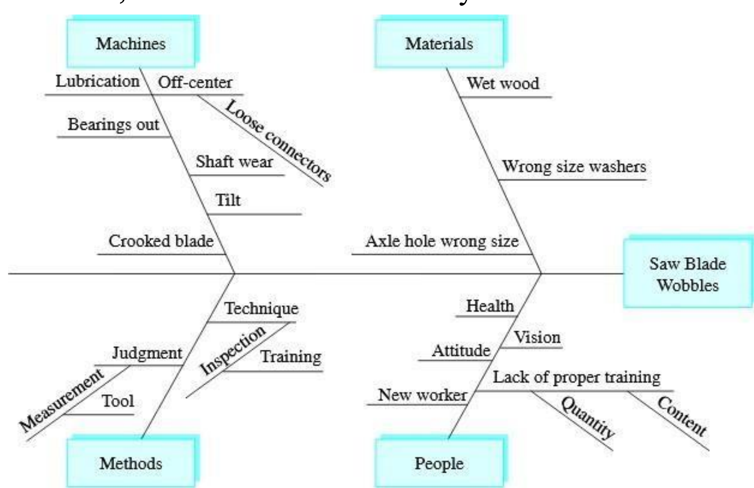

Figure 4. Example of Fishbone Diagram
(Source : Foster, 2007)

1.6 FMEA

FMEA is a technical analysis carried out by a cross-functional team consisting of experts in their respective fields who are in charge of fully analyzing the product design or manufacturing process in the early stages of the product development process (Carlson, 2012). According to Carlson (2012), there are several goals for FMEA, including:

a. Identification and prevention of the safety hazards.
b. Minimize the production loss or production drop.
c. Upgrade test and verification of work plan.
d. Improve process control plan.
e. Consider changes for product design or manufacturing process.
f. Identification of product or process characteristics.
g. Develop preventive maintenance for machines and equipment in operation.
h. Envolve online diagnostic technique.

In the preparation of FMEA, according to Carlson, (2012) there are several points which are further analyzed, among others:

a. Item, things that are used as a subject.
b. Function, starting from the general function of the item until the purpose of the item is there.
c. Failure mode, it can be in the form of not being able to work according to function, decreasing item performance, until the performance is not in accordance with the required function.
d. Effect, it can be identified starting from the effect on the item itself to the system and even the end user of the item.
e. Severity, a ranking effect that indicates the severity of the effect.
f. Cause, it explains the mechanism of an item fail.
g. Occurrence, the probability that an item will fail.
h. Controls, existing methods to mitigate the risk of failure mode and the effects of the item.
i. Detection, ratings about the ease of detecting the failure mode or the cause of the failure.
j. Risk Priority Number (RPN), risk rating of each potential failure mode and the result of multiplying severity, occurrence, and detection.
k. Recommended action, actions that are recommended by the FMEA team to reduce or eliminate the risk of potential failure.

2. METHODOLOGY

Figure 5 shows the various step of this research using pareto chart, fishbone diagram, and FMEA.

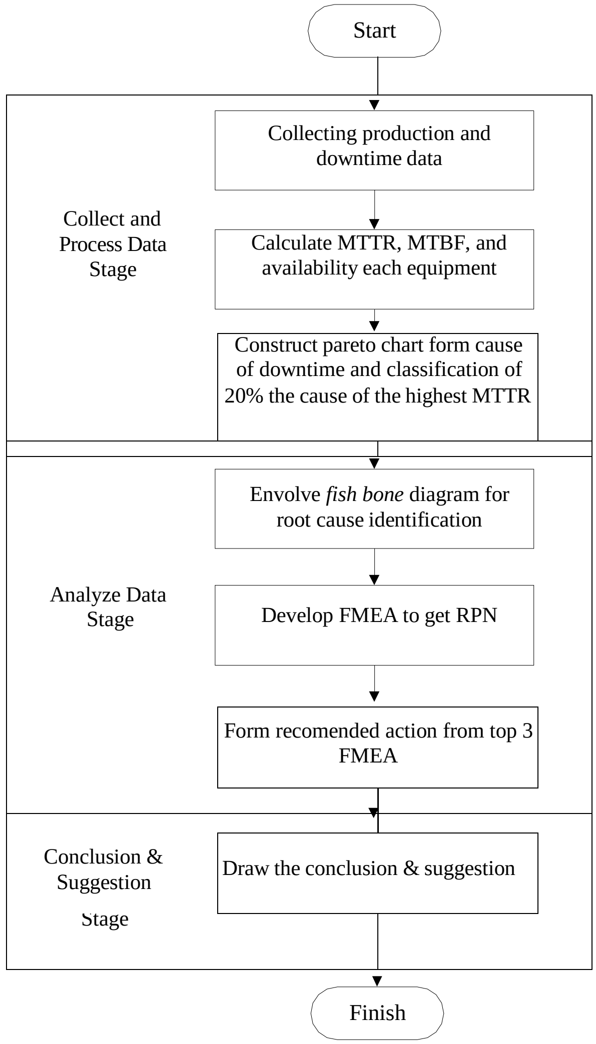

Figure 5. Research Methodology

The data of plant production and downtime was taken from Petrokimia Gresik production report since 2017 until 1st half of 2020. Fishbone diagram and FMEA was made by focuss grup discussion with several experts in respective fields.

3. RESULT & DISCUSSION

Based on data processing, Table 2 shows the MTTR, MTBF, and availability of each equipment which has down time from 2017 until 1st half of 2020.

Table 2. Equipment MTTR, MTBF, and Availability

Equipment	MTTR, days	MTBF, days	Availability
B-1104	9,99	158,93	94,09%
C-1302	2,38	397,33	99,40%
E-1303	2,17	264,89	99,19%
E-1304	2,13	794,66	99,73%
E-1301 A	1,62	198,67	99,19%

Table 2. Equipment MTTR, MTBF, and Availability (Continue)

Equipment	MTTR, days	MTBF, days	Availability
P-1004 A/B	1,30	158,93	99,19%
E-1204	1,11	794,66	99,86%
MP-1303	0,67	794,66	99,92%
P-1301	0,59	132,44	99,56%
T-1301	0,50	794,66	99,94%
T-1302	0,44	158,93	99,73%
E-1302	0,39	794,66	99,95%
D-1301	0,39	794,66	99,95%
E-1203	0,37	794,66	99,95%
B-1101	0,17	397,33	99,96%

From Table 2, pareto chart can be constructed as indicated by Figure

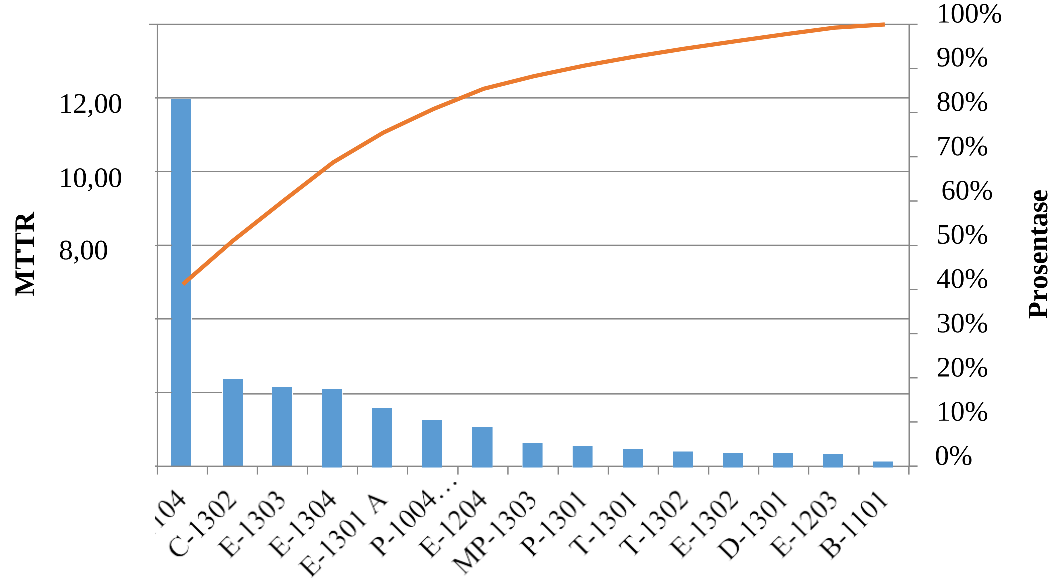

Figure 6. MTTR Pareto Chart

With 80/20 rule, B-1104 (waste heat boiler) is the dominant factor of low plant availability. Then, the root cause from the B-1104 problem can be identified with a fishbone diagram. Figure 7 shows the fishbone diagram from cause of the high value of B-1104 MTTR.

Fishbone diagram was developed by several experts using focus group discussion. There are 11 failure modes generated from fishbone diagram. These failure modes were analyzed until the root cause was found.

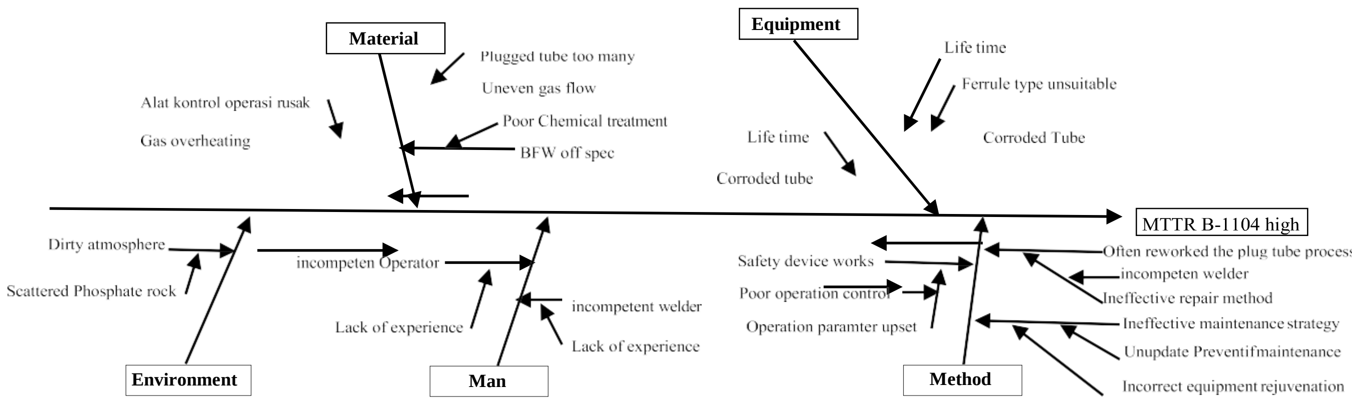

Figure 7. B-1104 Fishbone Diagram

To determine the urgency level of failure mode, the next step of analysis uses FMEA. In this step, recommended action is also identified. FMEA stage generates 5 critical failure modes. The critical failure mode is obtained from the RPN failure mode value which is above the average of the other failure modes. Table 3 shows the critical failure mode.

Table 3. B-1104 Critical Failure Mode

Potential Failure Mode	Potential Effect of failure	Potential Cause of Failure	Current Design Control	RPN	Recommended Action
Corroded tube	Steam goes to the next process reduced catalyst strength plant shut down	Life time	Tube thick inspection once a year	504	Gradual retubing of the thinning tube
Corroded tube	Steam goes to the next process reduced catalyst strength plant shutdown	Ferrule type unsuitable	Ferrule condition inspection once a year	504	More suitable ferrule modification
Corroded tube sheet	Steam goes to the next process reduced catalyst strength plant shut down	Life time	Tube sheet condition inspection once a year	441	Replace the tube sheet
Often reworked the plug tube process	Repair time too long	Welder incompetent	Inspection of plug tube results	392	Do training & sharing with more competent welder
Ineffective maintenance strategy	Repeated failure	Improper equipment rejuvenation	Plant failure history	336	Apply risk- based investment in maintenance rejuvenation

Alternative solutions obtained from the FMEA process, among others :
a. Gradual retubing of the thinning tube
b. More suitable ferrule modification
c. Replace the tube sheet
d. Do training & sharing with more competent welder
e. Apply risk-based investment in maintenance rejuvenation

4. CONCLUSION

Some of the conclusions obtained from this study are:
a. Pareto chart of MTTR indicates the dominant cause of decrease plant availability is B-1104 (Waste Heat Boiler) problem.
b. Based on fishbone diagram, there are 11 causes of B-1104 problem.
c. The critical failure mode from B-1104 which is get from FMEA are:
   i) Corroded tube
   ii) Corroded tube sheet
   iii) Often reworked the plug tube process
   iv) Ineffective maintenance strategy
   d. There are 5 alternatives solution which could overcome these problem, among others:
   i) Gradual retubing of the thinning tube
   ii) More suitable ferrule modification
   iii) Replace the tube sheet
   iv) Do training & sharing with more competent welder
   v) Apply risk-based investment in maintenance rejuvenation

5. ACKNOWLEDGEMENT

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6. REFERENCES

Arabian-Hoseynabadia, A., Oraeea, H., dan Tavnerb, P.J. (2010), Failure Modes and Effects Analysis (FMEA) for wind turbines, International Journal of Electrical Power & Energy Systems, Vol. 32, No. 7, hal. 817-824.

Carlson, C (2012), Effective FMEAs : Achieving Safe, Reliable, and Economical Products and Processing Using Failure Mode and Effect Analysis, John Wiley & Sons, Inc., New Jersey. Foster, S.T. (2007), Managing Quality :Integrating the Supply Chain, 3rd edition, Pearson Education. Inc., New Jersey.

Gupta, S. dan Tewari, P.C. (2011), Simulation Modelling in Availability Power Plant, Journal of Engineering Science and Technology Review, Vol. 4, No. 2, pp 110-117.

Ismanto, A. (2019), Analisa Penyebab Kerusakan pasa Boiler dengan Metode Failure Mode Effect Analisis, Tesis Magister, Institut Teknologi Sepuluh Nopember, Surabaya.

Montgomery, D.C. (2013), Statistical Quality Control, 7th edition, John Wiley & Sons, Inc, New Jersey.

Mzougui, I. dan Felsoufi, Z.E. (2019), Proposition of a Modified FMEA to improve Reliability of Product, Procedia CIRP, Vol. 84, 1003-1009.

Oggerino, C. (2001), High Availability Network Fundamentals, Cisco Press.

PT Petrokimia Gresik. (2017), Laporan Produksi III A Tahun 2017, Gresik : PT Petrokimia Gresik.

PT Petrokimia Gresik. (2018), Laporan Produksi III A Tahun 2018, Gresik : PT Petrokimia Gresik.

PT Petrokimia Gresik. (2019), Laporan Produksi III A Tahun 2019, Gresik : PT Petrokimia Gresik.

PT Petrokimia Gresik. (2020), Laporan Produksi III A Bulan Juni 2020, Gresik : PT Petrokimia Gresik.

PT Petrokimia Gresik. (2020), Laporan Pemeliharaan III Tahun 2017, Gresik : PT Petrokimia Gresik.

PT Petrokimia Gresik. (2020), Laporan Pemeliharaan III Tahun 2018, Gresik : PT Petrokimia Gresik.

PT Petrokimia Gresik. (2020), Laporan Pemeliharaan III Tahun 2019, Gresik : PT Petrokimia Gresik.

PT Petrokimia Gresik. (2020), Laporan Pemeliharaan III Bulan Juni 2020, Gresik : PT Petrokimia Gresik.

Pyzdek, T., dan Keller, P. (2010). The Six Sigma Handbook, Mc Graw Hill, New York

Ridlo, R. (2020), Mereduksi Waste pada Proses Produksi Listrik di Unit Utilitas Batu Bara PT Petrokimia Gresik dengan Aplikasi Value Stream Mapping dan FMEA, Tesis Magister, Institut Teknologi Sepuluh Nopember, Surabaya.

Yuhelson, Syam, B., Sinulingga, S., dan Isranuri, I. (2010), Analisis Realibility dan Availability Mesin Pabrik Kelapa Sawit PT Perkebunan Nusantara III, Jurnal Dinamis, Vol. 2, No. 10., hal 125-139.

Wahyudi. (2004), Proses Produksi Asam Sulfat dan Utilitas III, Gresik : PT Petrokimia Gresik.

ANALYSIS OF THE IMPLEMENTATION OF AN ENVIRONMENTAL MANAGEMENT SYSTEM ISO 14001: 2015 BASED ON THE LEVEL OF IMPLEMENTATION AND OBSTACLES USING QUANTITATIVE AND QFD METHODS
Case study: PT. PLN (Persero) UITJBTB

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ABSTRACT

PT. PLN (Persero) Unit Induk Transmisi Jawa Bagian Timur dan Bali has implemented the ISO 14001: 2015 environmental management system since 2019 and has obtained ISO 14001 certificate in 2020. However, from the results of internal and external audits, thereare still many discrepancies that occur. There must be an analysis related to the level of implementation and obstacles that can affect the consistency and continuous improvementin efforts to improve the quality of the environmental management system's implementation.Benchmarks for applying an environmental management system can be seen from the analysis of the level of implementation as measured by the standard elements of ISO 14001: 2015 and the obstacles that occur. This research uses quantitative methods and Quality Function Deployment (QFD). Quantitative methods are carried out by literature study, distributing questionnaires, and interviews with environmental experts. The output obtained from the quantitative analysis will be followed by the QFD method using House of Quality tools to obtain priority technical response which will be a quality improvement proposal in applying environmental management systems at PT. PLN (Persero) UITJBTB. After analyzing the data, there were seven indicators of implementation level that received the lowest scores and five indicators of the biggest obstacles. Based on these indicators, obtained it thirteen technical response priorities that PT PLN UITJBTB must implement to improve the quality of implementing the ISO 14001: 2015 environmental management system.

Keywords: Environmental Management System , QFD, *House Of Quality.*

1. INTRODUCTION

In the modern era at this time PT PLN (Persero) Main Unit Transmission for East Java and Bali has realized that in the process of operational activities of substations, SUTT / SUTET, laboratories and offices need to pay attention to environmental balance so that the impact of operational activities does not become boomerang to employees and the community around the company. By-Law 32/2009 concerning Environmental Protection and Management Article 1 paragraph 2 (two) that *"Protection and management of the environment are systematic and integrated efforts undertaken to preserve environmental functions and prevent environmental pollution and / or damage life which includes planning, utilization, control, maintenance, supervision and law enforcement"*. To create a company that is environmentally friendly and cares about environmental protection and management, genuine efforts are needed to do this through an environmental management or management system that is reliable, effective, documented and encourages improvements such as the application of the Environmental Management System. SML) which refers to the ISO 14001: 2015 standard.

Management expects quality improvements on the implementation side of the Environmental Management System and also gaps that hinder the application of the ISO 14001 system can be overcome so that the creation of a company business process that is in line with the ISO 14001 System by prioritizing protection and management of the environment that is reliable, effective and documented as well as the financing of insurance premiums on company assets can be minimized. Environmental management system commitment between the top management to the lowest line in the organization PT.PLN (Persero) UITJBTB is needed to realize the environmental policies, goals and objectives that have been made to strengthen the environmentalmanagement system that has been implemented.

Therefore, this research was conducted by measuring the level of implementation and barriers to the ISO 14001 system and listening to employees' needs and determining priority technical attributes for improving the quality of the Environmental Management System. Measurement of the level of implementation and obstacles of the Environmental Management System is carried out using quantitative methods. Attributes that have low scores will be collected, and needs and expectations are mapped. The needs and expectations will later be discussed with experts to obtain technical responses that will be processed using the Quality Function Deployment (QFD) model. The QFD model is used to translate customer requirements into technical responses. Understanding the Voice of Customer (VoC) is the foundation and starting point of QFD. Akao (1990) explains that QFD is a methodology for translating consumer needs and desires into a product design with specific technical requirements and quality characteristics.

This study will provide input to the management of PT PLN (Persero) UITJBTB regarding which elements of the ISO 14001 Environmental Management System need to be improved and what program priorities must be implemented based on the needs of management and employees.

2. LITERATURE REVIEW

2.1 Definition of Management

Management does not yet have an established and universally accepted definition. For example, Terry (1956) defines management as a typical process of several actions, such asplanning, organizing, mobilizing, and monitoring. Meanwhile, Griffin (2002) defines management as a process of planning, organization, coordination, and control of resources to achieve goals effectively and efficiently. Effective here means that the goal is achieved according to plan, and efficient means that management is carried out carefully, organized, and timely. According to Appley (1957), management is expertise in arousing other people to be willing to dosomething. Organizations or groups can also possess management skills.

2.2 Definition of Organization

ISO 14001: 2015 states that an organization is personnel or group of people who have separate functions with responsibility, authority and relationships to achieve their goals. Hasibuan (2011) provides an understanding that an organization is a formal, structured, and coordinated union system of a group of people working together to achieve specific goals. In the environmental management system, the international standard organization (ISO) is a global association consisting of national standardization bodies whose members are not less than 140 countries. ISO is an organization outside the government (Non-Government Organization / NGO)which was founded in 1947. The organization has the following characteristics, which are cited by Handayaningrat (1985):

1. There is a group of people who can be recognized for one purpose.
2. There are various activities but still interdependent parts which constitute a business entity.
3. Each member exerts all his efforts/energy.
4. There are authority, coordination and supervision.

2.3 Definition of Environment

Based on Law No. 32 of 2009, the environment is the unity of humans, objects, conditions and other living things in a place. Talking about the environment, of course, cannot be separated from the environment. Based on Article 1 point 1 of Law No. 32 of 2009, the environment is a spatial unit of all objects, power, conditions, living things, including humans and their behaviour, which affect nature itself, the continuity of life and the welfare of humans and other living creatures. According to S.J. McNaughton and Larry L Wolf (1973), the environment is all external factors that are physical and biological and have a significant impact on human life.

2.4 ISO 14001: 2015 Environmental Management System

The Environmental Management System is part of a management system used to manage environmental aspects in the form of elements of activities or products or services from organizations that interact or can interact with the environment which includes several aspects, namely water, air, land, natural resources, flora, fauna, humans and the relationship between them. The concept of the Plan - Do - Check - Action (PDCA) model underlies this approach to environmental management systems. This is because the PDCA concept provides an iterative process by which organizations achieve continuous improvement. It can be seen more clearly the relationship between the PDCA and the environmental management system framework in Figure 1.

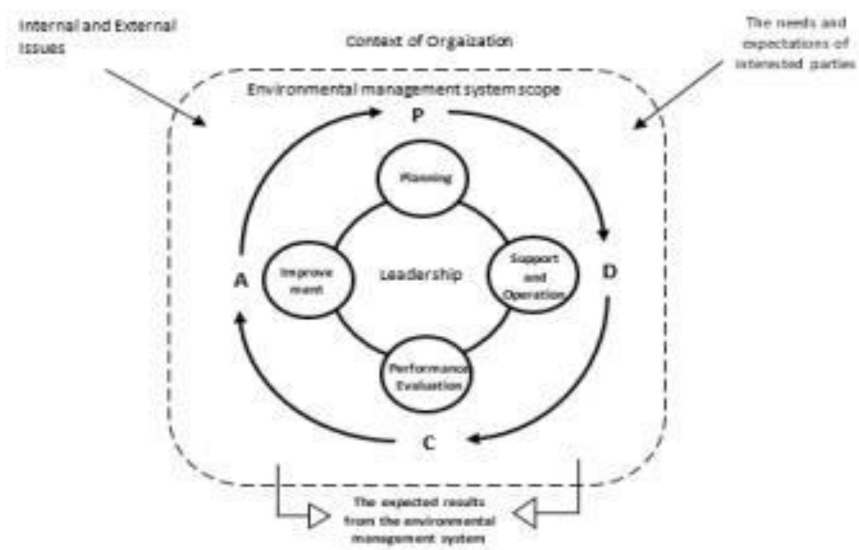

Figure 1. The relationship between the PDCA and the EMS framework (ISO 14001: 2015)
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Every element or element in the environmental management system can apply this PDCA concept with the following explanation:

a. Plan: establish environmental goals and processes needed to achieve results consistent with the organization's environmental policy.

b. Do: apply the planned process.
c. Check monitor and measure processes against environmental policies, including commitments, environmental and operating criteria, and report results.
d. Action: take action for continuous improvement.

Picture. Figure 1 shows how the framework introduced in this standard can be integrated into the PDCA model, which can help new and existing users understand the importance of a systems approach. With the PDCA approach, the ISO 14001: 2015 environmental management system can run well in a company because it continues to improve the process.

The ISO 14001: 2015 SML standard is a standard used for the registration process with requirements consisting of several elements that must be fulfilled as a specification requirement as follows:

1. Scope 6. Planning
2. Normative References 7. Support
3. Terms and definitions 8. Operations
4. Organizational Context evaluation 9. Performance evaluation
5. Leadership 10. Improvement

2.5 Quantitative Methods and QFD

In this research, the method used to analyze the quality of the environmental management system application is quantitative. Then, improve the quality of the environmental management system's implementation using the Quality Function Deployment (QFD) method.

According to Sugiyono (2017), the quantitative method is called a positivistic way because it is based on positivism. This method is called the scientific method because it has met concrete / empirical, objective, rational, measurable and systematic scientific principles. This method is also called quantitative approach because the research data is in the form of numbers, and the analysis is in the form of statistics. It can be concluded that the quantitative method according to Arikunto (2005) can be interpreted as a research method that uses numbers, starting from data collection, interpretation of the data, and the appearance of the results.

Yoji Akao developed quality Function Deployment (QFD) in Japan in 1960. Akao (1990) argues that QFD is a method for developing design quality that aims to satisfy consumers and then translate consumer demand into design targets and the main points of quality assurance used for all stages of the process. According to Heizer Render (2015), the quality function deployment (Quality Function Deployment) refers to determining what will satisfy the customer and translating customer desires into design targets. The idea is to capture a good understanding of what the customer wants and identify alternative process solutions.

According to Ariani (2002), there are three main benefits that companies get when using the QFD method, namely:

1. Reducing Costs
   If the products produced follow consumer needs and consumer expectations, there would be no work repetition, and raw materials are wasted due to mismatching specifications set by consumers. Cost reduction can be achieved by reducing the cost of purchasing raw materials, overhead costs, lowering wages, and simplifying the production process.
2. Increase Income
   With a reduction in costs, the results received will increase. With QFD, the resulting product or service will better meet customer needs and expectations.
3. Reducing Production Time
   QFD will create a product or service development team to focus on the developmentprogram for consumer needs and expectations.

3. RESEARCH METHODOLOGY

The research methodology includes the following phases :

1. Based on the results of field studies, identification of problems in PT PLN (Persero) UITJTB and literature review, the researcher decided to use quantitative methods to measure the level of implementation and barriers to implementing the Environmental Management System at PTPLN (Persero) UITJBTB and to obtain dimensions or indicators that require improvement.
2. Determination of dimensions and indicators is formulated before the questionnaire/survey to determine what factors should be examined. Implementation level dimensions and indicators refer to the ISO 14001: 2015 standard and the Global Environment Management Initiative (GEMI).
3. After the dimensions and indicators are determined, the researchers compile and distribute questionnaires. In the questionnaire's preparation and distribution, several essential things are the population and research samples and data collection.
4. The target population includes all structural levels including General Manager, Senior Manager, Sub Division Manager, Unit Manager, Assistant Manager and Basic Supervisor. The target population of the functional ranks includes all PLN UITJBTB employees who are not structural.
5. The number of samples taken in this study uses the Slovin formula in Ryan (2013). The Slovin formula is expressed by:

   $$n = \frac{N}{1 + Ne^2}$$

   Where : n = Sample size or quantity
   N = Size or number of population
   e = The desired margin of error (5%)
6. The data collection required in this study is obtained through a survey containing a questionnaire. This research questionnaire was conducted with an online survey model using mobile device media to the sample unit.
7. Validity and reliability tests are carried out after the researcher has collected the questionnaire results that the user has filled in.
8. After that, data processing with quantitative methods is done by measuring the central tendency and dispersion. The measurement of central movement in this study is done by measuring the average or mean, which provides an overview of the data. The dispersion measurement is done by measuring the standard deviation of a sample. The analysis results from the quantitative method calculations are then classified into two types, namely the level of implementation and the obstacles to the performance of the ISO 14001: 2015 environmental management system. Implementation level variables and obstacles with low average scores and high standard deviation will be grouped and then considered the primary priority needs and expectations for improving the environmental management system.
9. Collection of technical responses is carried out with the Environmental Management Representative, namely the K3L (Safety, Health and Environment) Control Officer after the researcher has mapped the implementation level variables and barriers.
10. The results of the technical response will be measured based on the relationship or correlation of the level of importance and needs through QFD tools, namely the House of Quality (HOQ) so that repair needs will be obtained that must be addressed immediately and which corrective steps or technical responses are prioritized.

11. At the conclusion stage will explain the research results at PT PLN (Persero) Main Unit Transmission East Java and Bali that have been obtained. At the suggestion stage, suggestions will be conveyed regarding hopes or improvements for the management of PT PLN (Persero) UITJBTB and academics regarding future research progress.

It is more clearly seen in Figure 2, which contains the flow of this study's research steps.

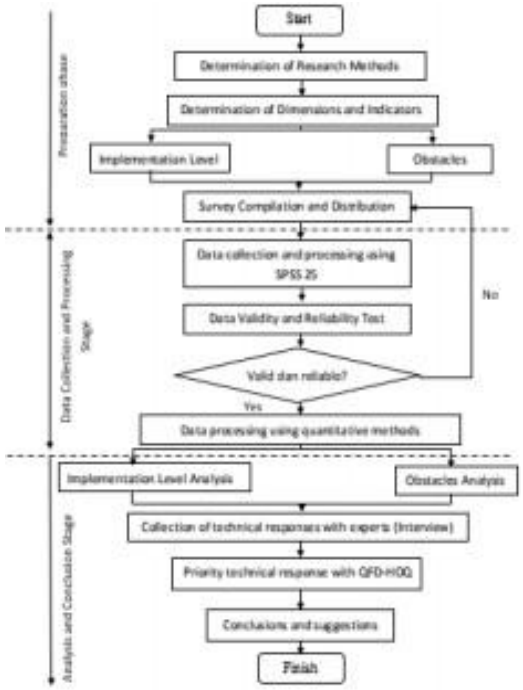

Figure 2. Research Steps

4. RESULTS AND DISCUSSION

4.1 Survey Results

The survey was carried out from 1 December - 20 December 2020 through an online survey method using the google form media. The survey was distributed through the WA media (WhatsApp), assisted by HR management in each implementing unit. In the survey, 46 questions consisted of 28 questions on implementing the ISO 14001 Environmental Management System and 18 questions regarding the obstacles experienced in implementing the ISO 14001 Management System. Of the expected 298 respondents, 406 respondents successfully filled out the survey through the link spread out. Of the 406 respondents, 26 extreme respondent data could not be used as research material because the results of filling out the questionnaire did not match the questions given so that the number of respondents who met the criteria in filling out the surveywas 380 respondents. This means that the percentage of the questionnaire survey performance (response rate) is 127.5% with details of 166% from the UPT Probolinggo sample (78 respondents), 97.9% from the UPT Madiun sample (47 respondents), 102.2% from the UITJBTB sample (46 respondents), 132.5% of the UPT Surabaya sample (57 respondents), 142.8% of the UPT Malang sample (70 respondents), 125% of the UPT Gresik sample (40 respondents), and 123.5% of the UPT Bali sample (42 respondents). Response rates in previous studies related to ISO 14001 environmental management systems include Chan (2008) at 25%, Rodriguez (2011) at 88.9%, and Harahap (2009) at 100%.

4.2 Respondent Profile

The respondents' profiles in this study include the location of the implementation unit, education and position levels shown in Figures 3 - 5. **Figure 3** shows the majority of respondents came from the Probolinggo Transmission Implementing Unit with 78 respondents (21%). **Figure 4** shows that most respondents' educational background is high school education, with 144 respondents (38%). In contrast, **Figure 5** shows most respondents are at functional levels with a total of 218 respondents (57%).

Figure 3. Composition of implementing units (Number of respondents,%)

Figure 4. Composition based on education (Number of respondents,%)

Figure 5. Composition based on position level (Number of respondents,%)

4.3 Analysis of Implementation Level, Obstacles and technical responses

After conducting a quantitative analysis of the survey results as well as discussions with experts from PLN UITJBTB and considering the required resources, it was decided that seven indicators of implementation level got the lowest mean value and the five biggest obstacles in implementing ISO 14001 as the voice of the customer (What) and determining the technical response (How) for each indicator. The results can be shown in Table 1.

Table 1. Types of Implementation level indicators, Obstacles and Technical responses

Indicator (*what*)	***Mean***	**Technical Response (*How*)**
The organization provides the personnel, technology, infrastructure and budget tofunction effectively and improve the EMS.	3,96	- Forming an environmental management team - Prepare infrastructure and budget in an annual RKAU
The organization regularly updates EMS documents and performs document control.	3,98	- Making a schedule for regular annual document updates. - Creation of an online document storage server
The organization provides education, training and experience to employees in the environmental field to improve competence.	3,99	Propose EMS training for all Environmental employees
The organization has ensured that all employees have an awareness of the importance of EMS.	4,00	Conduct an awareness survey related to awareness of the importance of EMS
Top management provides the necessary resources including employee training to contribute effectively	4,01	Provide a knowledge sharing forum regarding the implementation of ISO 14001 EMS
The organization has been evaluating the effectiveness of its Environmental Management System on a regular basis	4,02	Prepare Monthly Management Review Meetings.
The organization has controlled plannedchanges and is reviewing the consequences of unwanted changes	4,03	Conduct monthly inspections in each Implementing Unit
Lack of understanding of the ISO 14001 environmental management system	3,09	Socializing Environmental Management Systems through Web Binar.
Lack of training or knowledge sharing regarding the ISO 14001 standard for employees	3,01	Provide a knowledge sharing forum regarding the implementation of ISO 14001 EMS

Indicator (*what*)	*Mean*	Technical Response (*How*)
Lack of employee awareness of the importance of ISO 14001	2,95	Creating visual management of the environmental management system.
Difficulty in meeting the requirements of the ISO14001 clause	2,89	Creating an ISO 14001 pocket book and interpretation of its requirements
The involvement and commitment of all employees in implementing ISO 14001	2,88	Give awards to employees who are involved in implementing ISO 14001

Furthermore, the researcher carried out the planning matrix calculation to determine the level of importance of each indicator according to the respondent, the level of respondentsatisfaction with the current implementation of the ISO 14001 environmental management system, how much effort PT PLN UITJBTB had to do to achieve the goal and the last was how much each indicator contributed improving the quality of the environmental management system at PT PLN UITJBTB. Information from the planning matrix is then used as the basis for PT PLN UITJBTB to find solutions to existing problems. After formulating the technical response, the following calculation is to determine the ranking of the technical responses. More details are in Figure 6 below.

Figure 6. House of Quality

The result of the House of Quality in Figure 6 is quality improvement. In this study, thirteen technical response priorities were produced as follows:

1. Propose EMS training for all environmental employees.

2. Creating an ISO 14001 SML pocketbook and interpreting the requirements.
3. Providing a Knowledge Sharing Forum regarding the implementation of ISO 14001. 4. Socializing the Environmental Management System through Webinar.
5. Creating Visual Management of Environmental Management Systems.
6. Conduct an awareness survey related to awareness of the importance of EMS
7. Give awards to employees who are involved in implementing ISO 14001.
8. Prepare infrastructure and budget in the annual RKAU.
9. Forming an Environmental Management Team.
10. Creating an online document storage server.
11. Prepare Monthly Management Review Meetings.
12. Conduct monthly inspections in each Implementing Unit
13. Creating an annual routine document update schedule.

5. CONCLUSION

This study aims to provide an overview of the level of implementation and obstacles in applying the ISO 14001: 2015 environmental management system. Based on the analysis results, the implementation level of ISO 14001 PT PLN UITJBTB is 3.96 - 4.69, where the consistency level of implementation is at a reasonably good story and reasonable adoption rate. In an organisational context, the principles of environmental management, leadership, planning, operation, continuous evaluation, and improvement have an excellent implementation level. Simultaneously, the principles of support have an implementation level that is close to good which is also an aspect of environmental management system principles with the lowest level of application consistency. Based on the results of the technical response analysis obtained from the seven lowest levels of implementation and the five biggest obstacles experienced in the application of an environmental management system using the Quality function Deployment method and House of Quality tools, the priority of technical response can be carried out by top management of PT PLN UITJBTB to improve the implementation of the implementation. ISO 14001 on principle aspects of environmental management systems.

ISO 14001 environmental management system certification is not the end, but the beginning of an environmental management system process. The PDCA (Plan-Do-Check-Action)process or Continuous Improvement is a continuous improvement process. Top management needs to show accountability in implementing ISO 14001 by regularly monitoring its implementation effectiveness and identifying any obstacles experienced and taking evaluation actions to overcome them.

6. REFERENCES

Akao, Y., ed. (1990). *"Quality Function Deployment, Integrating Customer Requirements into Product Design."* (1st Edition). Cambridge Mass : Productivity Press.

Appley, A. L. (1957). *"Management in Action:The Art of Getting Things Done Through People"* (American Management Assoc (ed.)). University of California.

Ariani, D. (2002). *"Manajemen Kualitas: Pendekatan Sisi Kualitas."* Departemen Pendidikan Nasional.

Arikunto, S. (2002). *"Metodologi Penelitian Suatu Pendekatan Proposal."* PT. Rineka Cipta.

Chan, E. S. W. (2008). "Barriers to EMS in the hotel industry." *International Journal of Hospitality Management*, *27*(2), 187–196. https://doi.org/10.1016/j.ijhm.2007.07.011

Cohen, L. (1995). *"Quality Function Deployment : How To Make QFD Work For You* (Addison Wesley Publishing Company (ed.)).

Gemi. (2017). *"ISO 14001 Environmental Management System Self-Assessment Checklist."* GEMI, Inc. http://gemi.org/solutions/solutions-interactive/iso- 14001-2015-checklist/.

Griffin, W. R. (2002). *"Manajemen Jilid I"* (I). Airlangga.

Heizer, J. and R. B. (2015). *"Manajemen Operasi : Manajemen Keberlangsungan dan Rantai Pasokan"* (11th ed.). Salemba Empat.

Rodríguez, G., Alegre, F. J., & Martínez, G. (2011). Evaluation of environmental management resources (ISO 14001) at civil engineering construction worksites: A case study of the community of Madrid. *Journal of Environmental Management*, *92*(7), 1858–1866. https://doi.org/10.1016/j.jenvman.2011.03.008

Ryan, T. P. (2013). *"Sample Size Determination and Power."*

John Sons, Wiley and. S, J, McNaughton dan Larry L, W. (1973). *"General Ecology Second Edition"* (Second Edition). Saunders College Publishing.

Sugiyono. (2017). *"Metode Penelitian Kuantitatif, Kualitatif, dan R&D."* Alfabeta CV.

Terry, R. G. (1956). *"Principles of Management."* R.D.Irwin.

Yazeril R.Harahap. (2009). *"Evaluasi Pelaksanaan Sistem Manajemen Lingkungan ISO 14001 Pada PT.Bina Guna Kimia Semarang."* Universitas Diponegoro.

BANK BRI FINANCING PRODUCTS DEVELOPMENT INNOVATION IN SUPPORTING SUPPLY CHAIN BUSINESS WITH MODIFIED QFD METHOD

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ABSTRACT

Innovation is something that absolutely must be done by a company, including business actors in the banking sector. Banks must face the challenges of rapid changes triggered by the adoption of technology usage and increasingly diverse dynamics of customer demand, especially in the supply chain industry sector. In a goods supply chain system, banking has a very vital role in accelerating payment processes and activities so that the flow of finance in the supply chain business runs smoothly and in a balanced manner.

The main obstacle in developing a product and service is how the product is made according to the needs and expectations of consumers. Often companies fail to identify consumer desires, resulting in products being offered less desirable and ultimately sinking in the middle of competition. This is a challenge for banks to determine product development strategies that can attract consumer interest.

In this study, customer perceptions of the quality of products and services that have been provided are measured using the Kano model to obtain the attributes that best maximize customer satisfaction. Furthermore, based on the priority attributes of customer needs, product development innovation is carried out using the Quality Function Deployment (QFD) method which is adjusted to the resources and values possessed by the company as reflected in the Business Model Canvas (BMC).

The final result of this research is the Bank's product and service innovation in supporting supply chain business financing in the form of an integrated platform with a focus on 3 main areas, namely, a user-friendly application interface, complete product features, and a reliable system which can be accessed anytime and anywhere.

Keywords: Quality Function Deployment, House Of Quality, Kano, Business Model Canvas, Supply Chain Financing.

1. INTRODUCTION

Innovation is something that absolutely must be done by a company, including business actors in the banking sector. Banks must face the challenges of rapid changes triggered by the adoption of technology use and increasingly diverse dynamics of customer demand, especially in the supply chain industry sector. In a goods supply chain system, banking has a very vital role in accelerating payment processes and activities so that the flow of finance in the supply chain business runs smoothly and in a balanced manner.

This vital role encourages banks to compete in innovating and launching various types of financing products and services specifically for companies involved in supply chain system relationships called supply chain financing. This product is an integrated banking service to support companies engaged in a supply chain system, both goods and services. Banks are competing to offer superior services and facilities that can be utilized by companies operating in the supply chain system to support their business activities.

PT Bank Rakyat Indonesia (Persero) Tbk. established on December 16, 1895 in Purwokerto, Central Java. As an intermediary institution between customers who have excess funds and those who need funds, BRI Bank has very diverse consumer segments, one of which is the corporate segment. As a state-owned company, currently the majority of BRI's shares are owned by the government, namely 56.75% and the rest are owned by public shareholders.

PT Bank Rakyat Indonesia (Persero) Tbk. is currently serious about increasing credit growth through an innovative financing product scheme in the supply chain business or Supply Chain Financing in order to spur the company's performance. Companies realize that if they can deliver new products earlier than competitors, it will have a better chance of gaining acceptance by consumers and obtaining profits, however, many products that are designed and launched in a short time cannot be accepted by consumers. this is because the product development team does not focus on actual customer needs during the design phase so as a consequence these products have a low level of customer satisfaction.

This study aims to design and implement Supply Chain Financing product innovations in various stages using Quality Function Deployment (QFD). The Kano model is used to obtain product attributes that maximize customer satisfaction. Meanwhile, the innovative Business Model Canvas (BMC) is used as a tool for designing product development based on the value proposition, infrastructure, resources, distribution channels, and the company's financial aspects.

With this research, the product development team is expected to be able to create innovative products more easily, cheaply, and quickly by taking into account which requirements have a big impact on the level of customer satisfaction and in accordance with existing resources and the aspirations of company management.

2. RESEARCH METHODOLOGY

Several stages of the process carried out in this research include literature studies in the form of both local and international scientific journals as well as relevant previous research, including the concepts of QFD, BMC, Kano and Supply chain financing. Next is the collection of data obtained through the FGD process, distributing questionnaires and interviews.

The main stage in this research is the preparation of a QFD matrix based on constumer voices, competitor benchmarks and the company's technical response. Finally, there are product innovation proposals based on data from QFD processing results and company BMC innovations.

2.1 Data collection

Sources of research data obtained from customers and internal data from the company. Customer data is obtained by several process stages, including the process of Focus Group Discussion (FGD) which is carried out to capture as many attributes as customer needs for supply chain financing service products. Furthermore, based on the results of the FGD, an interview process was carried out to determine the priority of customer needs which would be input from the questionnaire to be distributed.

Data on perceptions of the level of interest and customer satisfaction with the Bank's products and services, benchmarks for services owned by competitors are obtained from the results of questionnaires distributed to respondents. While data relating to the preparation of technical responses, development direction, correlation between technical responses, data on organizational difficulty levels in process characteristics, target setting and the correlation between service attributes and technical responses in the preparation of the house of quality (HoQ), were obtained from interviews with the company or the management of Bank as the object of research and from the BMC document which is a description of the company's overall strategy.

2.2 Identification of Attributes and Compilation of Questionnaires

In general, this research will be divided into 2 main parts, including the identification process of customer needs and product development innovation strategies and supply chain financing services. Based on the results of FGDs and interviews with supply chain business players, it was found that 7 key aspects of customer satisfaction with 20 service attributes became the needs and expectations of customers for the services provided by the bank. These key aspects include efficient / reliable service, fulfillment, security / trust, site aesthetic, responsiveness, ease of use and added value to customers. The attributes that are the expectations of customers in this study are as follows:

- Efficient / Reliable Service

1. Cash management website system always accessible
2. Cash management website the system has a fast response time when transacting
3. The cash management system website address is easy to remember and easy to access via the internet

- Fulfillment

1. The features and services on the cash management system website are complete and meet customer needs
2. There is a report that helps admin in managing reports
3. Cash management website the system is interactive and facilitates customer transaction processes

- Security / Trust

1. The proof of the existing transaction is sufficient to be used as a legal basis for payment
2. The security aspect of the cash management system website is guaranteed by the bank
3. The data and information displayed on the website are consistent and accurate

- Site Aesthetic

1. The appearance on the cash management system website is attractive and informative
2. The color and font choices on the website are clear and easy to read
3. The language used is easy to understand and understand

- Responsiveness

1. The Bank's support department makes timely commitments according to what has been promised to customers
2. There is a fast response to customer requests
3. The Bank's support section is easy to access / contact when there are problems related to application services

- Ease of use

1. Instructions on the cash management system website make it easier for customers to use existing services.
2. User Customers are able to operate the cash management system without requiring much effort.
3. Information is conveyed quickly through the cash management system website.

- Added value to customer

1. The services on the cash management system website provide added value to customers.
2. There are excellent features that are only available on the cash management system website compared to other application services

. For the strategic stage of selecting products to be sold, interview methods are used and product priority selection is based on several attributes that are the basis for consideration of corporate consumers (supply chain business actors), including the following:

Table 1. Credit Type Category Selection Attribute

No.	Category	Sub Categories
1	Pricing	- Loan Amount - Credit Guarantee - Interest Rate - Administration Fee - Fines / Penalties
2	Flexibility	- Payment Flexibility - Loan Period
3	Process	- System / Application Support - Process Speed and Approval - Ease of Requirements

Some of the alternative products that can be offered in this segment include:

Table 2. Alternative Credit Types

No.	Choice of Credit Types
1	Working Capital Credit
2	Investment Credit
3	Supply Chain Credit
4	Cash Collateral Credit
5	Bank Guarantee

3. RESULTS AND DISCUSSION

After collecting and processing the data, the results are obtained from the Kano Model data processing. The data obtained in the processing process using the kano model is the result of categorizing attributes in the *kano* model, namely One Dimensional (O), Attractive (A), Must be

(M) , Indifference (I), Reverse (R), and Questionable (Q). Where the categorization determines consumer expectations of the attributes of existing features and services. From the calculation of the Kano Model categorization using Blauth's formula, namely the comparison between (O + A + M) and (I + R + Q) will get the greatest value, then will get the category of the kano model as in Figure 1.Based on the classification results obtained as follows :

- A total of 9 attributes fall into category O
- A total of 11 attributes fall into the M category

The attribute with the Must be category means that consumers will be dissatisfied if the performance value of the attribute is low. But the value of customer satisfaction will not increase even though the value of the attribute performance is high. In the one dimensional or performance needs category, the level of customer satisfaction is linearly proportional to the performance of the attributes, so that the high performance of the attributes will result in a high value of customer satisfaction. So that attributes with this category must get more priority than other attributes.

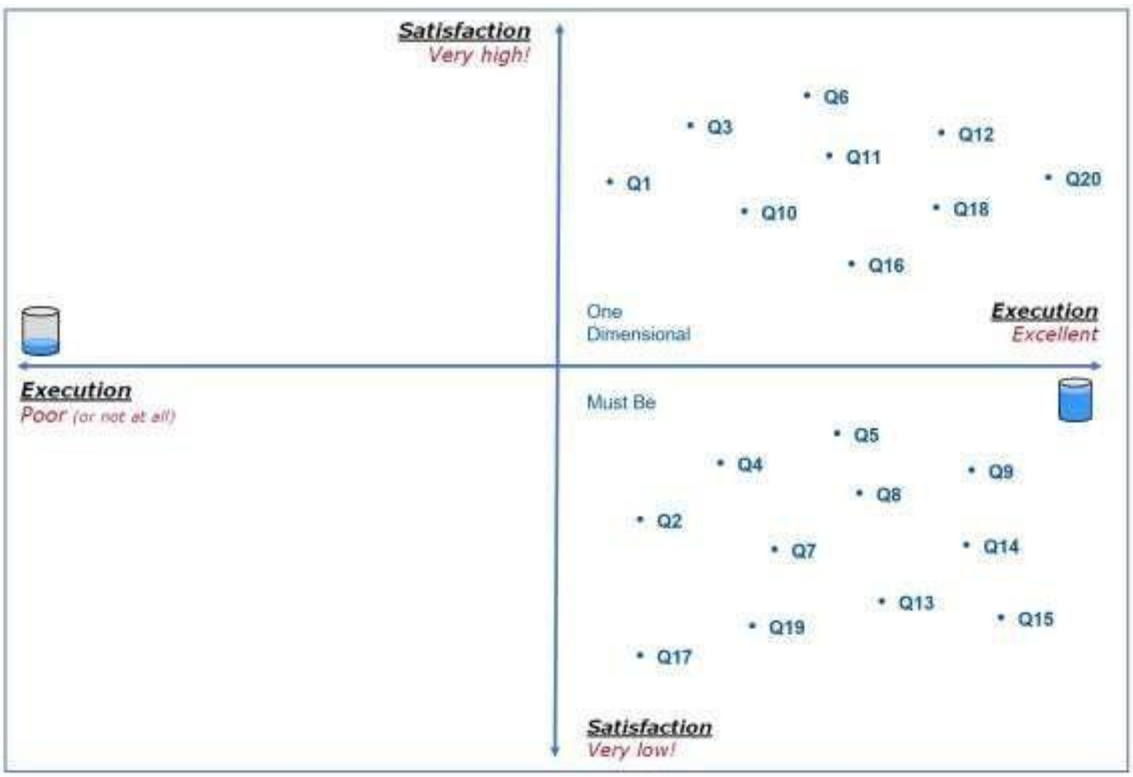

Image 1. Kano Evaluation Result

Therefore, these 2 categories must be the company's priority if you want to maintain and improve customer satisfaction. In connection with the 20 attributes fall into a category that must be developed to get customer satisfaction (O and M), so all of them will be used as input in the QFD matrix as Voice of Customer (VoC).

3.1 Preparation of QFD

In this study, the preparation of QFD is needed in order to develop products and services to be better than what was before. The initial step taken in the preparation of this QFD was the creation of a House of Quality or HoQ. HoQ is the earliest step in the preparation of QFD.

Basically HoQ consists of 2 core parts, namely the consumer table which is in the horizontal part of the matrix and contains consumer wants. And the second table is the technical table which is in the vertical section with the contents of the technical aspects in response to any consumer wants or needs. The results of HoQ's full list can be seen in Figure 2. In the manufacture of HoQ consists of several steps, some of which are:

1. Creating a Consumer Information Matrix, which will be filled in by the consumer table by first determining what attributes the consumer wants (Customer Requirements) or commonly known as the Voice of Customer, determining the level of importance (level of importance) and the level of satisfaction of each service attributes.
2. Determine Technical Requirements
   Technical response is an effort or step taken by the company to improve the service quality of each service attribute that is then developed to fulfill the desires of each consumer so that it is expected to be able to provide satisfaction with consumer desires. Determination of technical response is done by conducting interviews and discussions with the company, especially with people who are competent in their fields. Based on interviews and discussions conducted with the company, a list of technical responses based on VoC attributes was formulated as follows:
   a. *Cash management website* system always accessible
   - Using supporting infrastructure with High Availability configuration
   - Enlarge the capacity of the supporting infrastructure for applications (network, server)
   - Evaluates application functions and ensures there are no bugs

   b. *Cash management website* the system has a fast response time when transacting
   - Using supporting infrastructure with High Availability configuration
   - Enlarge the capacity of the supporting infrastructure for applications (network, server)
   - Evaluates application functions and ensures there are no bugs

   c. The cash management system website address is easy to remember and easy to access via the internet
   - Use a domain with a name that is easy to remember

   d. The features and services on the cash management system website are complete and meet customer needs
   - Identify and add features and services needed
   - Actively communicating with customers to find out what obstacles they are experiencing

   e. There is a report that helps admin in managing reports
   - Identify and add features and services needed
   - Benchmark competitor bank application services
3. Determining Technical Correlation
   After determining the technical response of the company in its efforts to improve the quality of services that exist today. The next step is to determine or create a correlation matrix. Determination or making of this correlation matrix is shown to determine the extent of the relationship or correlation between one technical aspect and another. The determination of the relationship or correlation between one technical aspect and another is determined by the company. And here are the results of determining the correlation matrix based on the results of discussions with management. By using symbols as in table 3 below.

Table 3. Correlation Matrix Symbol

Symbol	Definition
●	Very Strong Positive Influence
○	Positive Influence Is Strong
(Empty)	No Effect
X	The Negative Influence Is Strong
Xx	The Negative Influence Is Very Strong

4. Determine Relationships
The determination of the relationship matrix or relationship matrix is intended to determine the extent of the influence of the technical response that the company has made in its efforts to meet and improve each service attribute of customer needs. The determination of the relationship matrix between the technical aspects and the existing service attributes is made or determined by the Company based on the discussions that have been conducted. By using the values and symbols that are as follows.

Table 4. Matrix Relationship Symbol

Symbol	Score	Definition
●	9	Strong Relationship
○	3	Medium Relationship
Δ	1	Weak Relationship

In this study, a technical response can have a relationship or relationship with more than one attribute. For example, the technical response "Improving the platform design by using UI / UX designer services" has a relationship with 5 voice of customer attributes with different degrees of value between attributes.

5. Calculates Absolute Importance And Relative Importance for determining the priority scale
The calculation of the weight value for technical aspects is a calculation carried out to find out which technical aspects are considered the most influential or important and need to be a priority by the company in an effort to improve the quality of existing services. The weight value from this technical aspect can be divided into two types, namely the weight value of absolute importance and one more, namely relative importance. The value of absolute importance is a value that can indicate a technical aspect whether it is really needed in an effort to improve a service attribute or not. For example, if a technical aspect is of great absolute importance, it can be indicated that the technical aspect is one of the technical aspects which is quite influential or important and must be prioritized by the company in the company's efforts to improve its current services.

After the two main HoQ constituent matrices consisting of a consumer informationmatrix and a matrix of technical aspects have all the criteria compiled or fulfilled. The final stage is to compile the building aspects of the house of quality into a complete HoQ series. In the HoQ in Figure 2, information is arranged about what the features and service attributesare in the application along with the values available to provide information or recommendations regarding what service attributes deserve to be prioritized to improveexisting services so that they can provide satisfaction to every consumer.

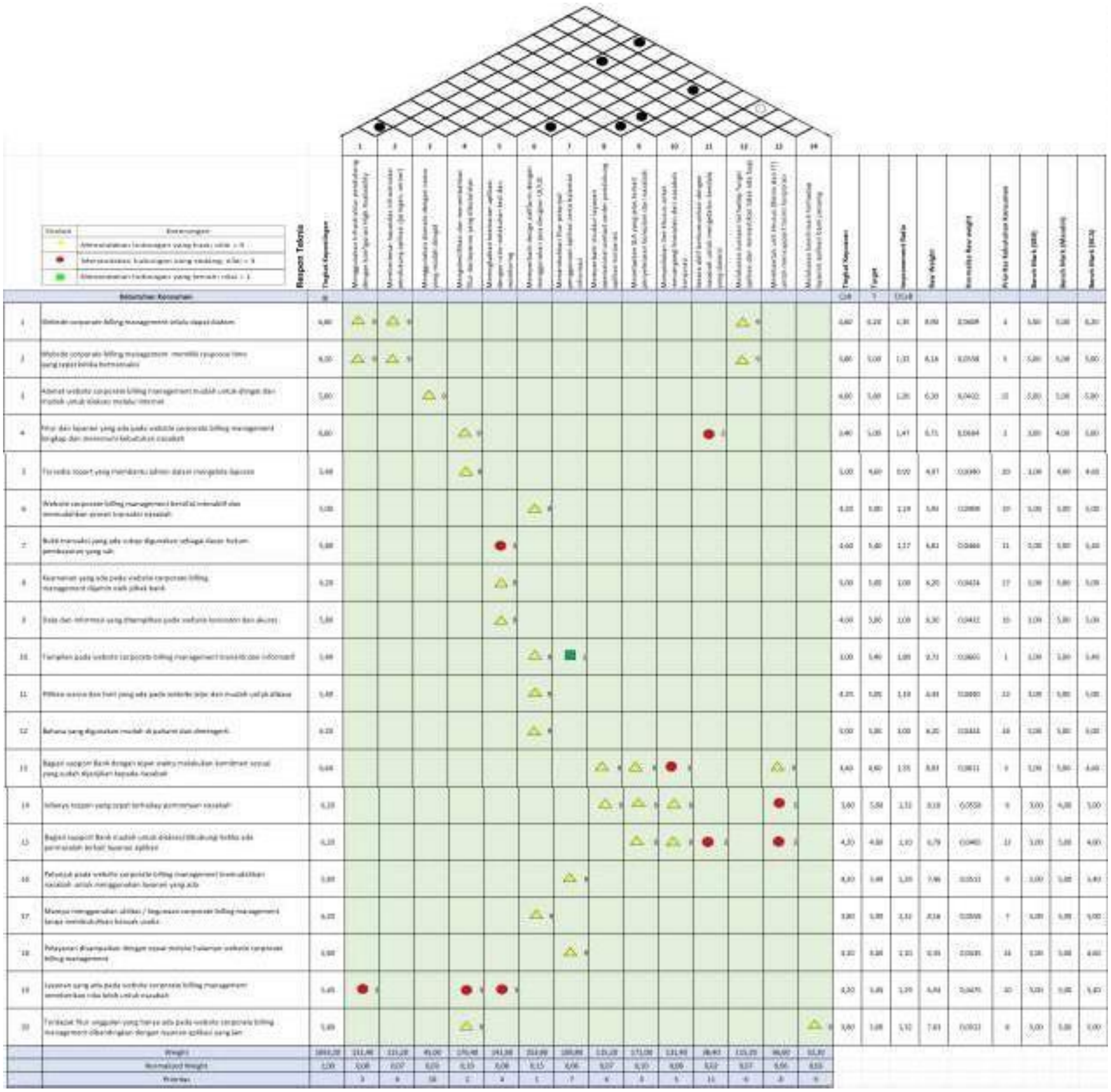

Figure 2. House of Quality

3.2 Proposed Product Development with BMC Innovation

Supply Chain Financing (SCF) is a solution to help meet the capital and financing needs of corporate companies engaged in supply chain business. This solution will provide corporate customers with the ease or flexibility in determining the terms of payment without disrupting cash flow activities from suppliers (vendors) or buyers (distributors). Based on the business model contained in the Business Model Canvas (BMC) document, Bank BRI decided to focus on seizing opportunities in the corporate sector through supply chain credit services. Entering the corporate sector is certainly not an easy task, considering that there are several competitors who have already entered this segment, so companies must be able to provide products and services that have added value to consumers in order to compete with other banks.

Based on the results of research using the QFD method to get the best aspirations that can increase customer satisfaction and apply the BMC innovation model, the following are product development proposals that can be given to companies. There are 2 main aspects in the proposed product development, including:

1. Product Proposals

   Companies can focus on supply chain credit products with 3 main advantages, namely low interest rates, flexibility (timeframe, credit limits and payments) and ease of processing supported by technology through digital application / platform services.

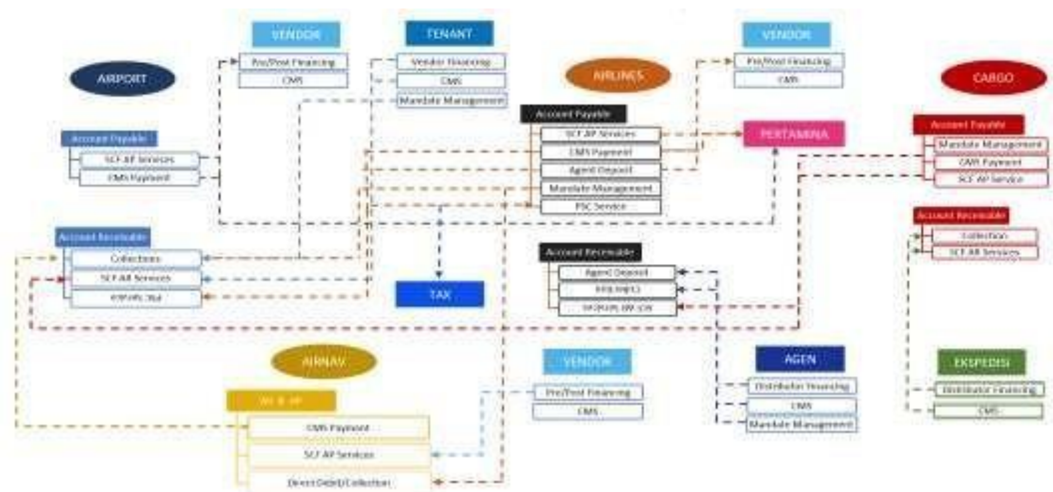

Figure 3. Product Service Scheme

2. Service Concept

   The proposed platforms that the company can develop are as follows:

   - A special platform was developed to accommodate the needs of Supply Chain Financing
   - The platform or application is developed outside the cash management system application
   - The application interface was developed by hiring a UI / UX designer, this is done to provide the best experience to consumers using the platform
   - A special unit was formed in terms of IT, business and operations to provide excellent service to consumers, considering that corporate customers are more sensitive than the retail customer segment.
   - Special call center services are provided to speed up SLA for resolving consumer complaints.

4. CONCLUSION

Based on the results of the analysis and data processing that has been done previously on the data that has been collected. Then the conclusions that can be drawn in this study are as follows:

1. Companies can use the QFD method to produce products and services that canprovide maximum satisfaction to customers, especially corporate customers, in order to support their supply chain business.

2. Based on the research results, it can be seen that there is still a gap between consumer expectations of Supply Chain Financing products and services and the services provided by the company. Based on this, it can be seen that the services that the company has provided to corporate customers in order to support supply chain needs have not been able to provide maximum satisfaction and meet the expectations of every consumer. Some of the attributes that have the highest gap value among others need to be prioritized and prioritized for repair and improvement.
   - The appearance on the cash management website is attractive and informative
   - The features and services on the cash management website are complete and meet customer needs
   - The Bank's service department on time to make commitments as promised
   - *Cash management website* always accessible
   - *Cash management website* has a fast response time when transacting.
3. Based on the value obtained from the calculation of absolute importance and satisfaction, it is known that some technical aspects have a higher value of absolute importance than others so that they deserve to be prioritized and prioritized. Some of the technical aspects include:
   - Improve the platform design by using UI / UX designers
   - Identify and add features and services needed
   - Establish clear SLAs related to the resolution of complaints from customers
   - Increase application security by routine testing and monitoring
   - Using supporting infrastructure with High Availability configuration
   - Providing a special line to handle complaints from corporate customers
   - Enlarge the capacity of the supporting infrastructure for applications (network, server)
   - Improve the operational service structure of the contact center to support corporate applications.
4. Based on the results of benchmarks with competing products, it is known that the service products that have been provided are still below the services of similar products owned by competing banks.
5. The proposed service product innovation is to create a special platform or application outside the cash management system to handle the credit application process up to payment by corporate customers. By utilizing the modified QFD method approach and multi criteria decision making and considering the priority of the company's strategy as reflected in the innovation of the Business Model Canvas (BMC), it can be obtained that the most effective Supply Chain Financing product development proposal to support as well as effective and efficient services to support transactions provide maximum satisfaction in accordance with the expectations desired by consumers.

5. REFERENCES

Aberdeen-Group (2006), Supply chain Finance Benchmark Report: The New Opportunity to Improve Financial Metrics and Create a Cost-advantage Supply chain, Aberdeen-Group, Boston, MA.

Akao, Yoji. 1990. Quality Function Deployment: Integrating Customer Requirements into Product Design.

Baki, B. et al., 2009. An Application of Integrating SERVQUAL and Kano's Model into QFD for Logistics Services: A case study from Turkey. Asia Pacific Journal of Marketing and Logistics, 21 (1), pp.106–126.

Bayraktaroglu, G. & Özgen, Ö., 2008. Integrating the Kano Model, AHP and Planning Matrix: QFD Application in Library Services. Library Management, 29 (4/5), pp. 327–351

Bouchereau, V. and Rowlands, H. (1999). Analytical Approaches to QFD, Manufacture Engineer, 78 (6): 249–254.

Chan, L. and Wu, M. (2002). Quality Function Deployment: A Literature Review, European Journal of Operational Research, 143: 463–497.

Cohen, Lou. 1995. "Quality Function Deployment: How To Make QFD Work For You". Massachussets: Addison Wesley Publishing Company.

Djati, S. Pantja and M. Khusaini. (2003). Study of compensation satisfaction, organizational commitment, and work performance. Journal of Management and Entrepreneurship, 5 (1), 25-41

Fung, RYK, Law, DST & Ip, WH, 1999. Design Targets Determination for Inter-dependent Product Attributes in QFD using Fuzzy Inference. Integrated Manufacturing Systems, 10 (6),pp.376–384

*Font*Ana, Avanti (2011). Innovate we can !. Bekasi: Cipta Inovasi Sejahtera

Gandhinathan, R., Raviswaran, N. & Suthakar, M., 2004. QFD- and VE-enabled target costing: a fuzzy approach. International Journal of Quality & Reliability Management, 21 (9), pp. 1003–1011.

Griffin, A. (1992). Evaluating QFD's Use in US Firms as a Process for Developing Products, Journal of Production Innovation Management, 9: 171–187.

Hauser, JR and Clausing, D. (1988). The House of Quality, Harvard Business Review, 66: 63–67.

Heizer, Jay and Render, Barry. (2004). Operations Management, 7th Edition, Pearson Education. Inc., Upper Saddle River, New Jersey.

Hurley, Robert. F and Hult, G, Tomas. M, 1998, "Innovation, Market Orientation, and Organizational Learning: An Intergration and Empirical Examination", Journal of Marketing, July.

Iranmanesh, Seyed & Thomson, Vincent & Salimi, Mohammad. (2005). Design Parameter Estimation using a Modified QFD Method to Improve Customer Perception. Concurrent Engineering: R&A. 13. 57-67.

Jiang, HM et al., 2012. Modeling Customer Satisfaction for New Product Development using a PSO-based ANFIS Approach. Applied Soft Computing, 12, pp. 726–734.

Lasalewo, Trifandi. (2017). Integration of the Kano Model and the QFD Technique in Product Development Activities: A Critical Review.

Levi, David Simchi, Philip Kamin Sky & Edith Simchi Levi. (2000). Designing and Managing the Supply chain: Concept, Strategies and Case Studies.

Moscowitz, H. and Kim, K. (1997). QFD Optimizer: A Novice Friendly Quality Function Deployment Decision Support System for Optimizing Product Design, Computer Ind.Engng., 32 (3): 641–655.

Pires, et al. (2001). Measuring Supply chain Performance, Orlando

Popa, Virgil. (2013). The Financial Supply chain Management: a New Solution for Supply chain Resilience. Amfiteatru Economic. 15. 140-153.

Pujawan, IN 2005. Supply chain Management. Surabaya: For Widya.

Purbasari Indah Lestari, 2009, Study of Supply chain Management: Analysis of Relationship Marketing between Pamulihan Farm and its suppliers and customers. Bogor Agricultural Institute.

Shen, X .., Tan, K .. & Xie, M., 2000. An Integrated Approach to Innovative Product Development using Kano's Model and QFD. European Journal of Innovation Management, 3 (2), pp. 91–99.

Shin, J. and Kim, K. (2000). Complexity Reduction of a Design Problem in QFD using Decomposition, Journal of Intelligent Manufacturing, 11: 339–359.

Shin, J., Kim, K. and Chandra, MJ (2002). Consistency Check of House of Quality Chart, International Journal of Quality & Reliability Management, 19 (4): 471–484.

Singgih, Moses L., et al. "The Development of Kano-QFD Integration Model To Optimize Customer Satisfaction By Considering Limited Development Funds." Journal of Technology Management, vol. 13, no. 2, 2014, pp. 189-200.

Tan, KC & Shen, XX, 2000. Integrating Kano's model in the planning matrix of quality function deployment. Total Quality Management, 11 (8), pp. 1141–1151.

Temponi, C., Yen, J. and Tiao, WA (1999). House of Quality: A Fuzzy Logic-Based Requirements Analysis, European Journal of Operational Research, 117: 340–354.

Tsuda, Y. (1995). QFD Models for Concurrent Engineer-ing Development Process of Automobiles, Concurrent Engineering: Research and Application, 3 (3): 213–220.

Ulrich, Karl T. & Steven D. Eppinger (2001) Product Design & Development. Salemba Teknika, Jakarta.

Urban, Glen L. & John R. Hauser. 1993. "Design and Marketing of New Products", 2nd ed.Prentice Hall.

Yamit, Z. 2002. Product and Service Quality Management. First Edition.Yogyakarta: Ekonisia Campus, Faculty of Economics, UII.

PERFORMANCE IMPROVEMENT PLANNING IN TURN AROUND MAINTENANCE IMPLEMENTATION FOR FERTILIZER INDUSTRY BY USING MODIFIED QUALITY FUNCTION DEPLOYMENT(QFD)

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ABSTRACT

The fertilizer industry is one of the most strategic industries in Indonesia which has a continuous production process. In the continuous process industries, the maintenance action is mostly carried out simultaneously in a certain duration called Turnaround Maintenance (TAM). This TAM has a vital role in supporting the company's operations because it involves a lot of labor and also a large cost. Implementation of TAM often costs more than the budget because of a longer duration, or work that requires a lot of additional costs. Poor planning will be the starting point for problems like this. In addition, incompatibility of planning will also lead to suboptimal work and TAM targets will not be implemented properly. For this reason, this research was conducted with the aim of finding out the implementation of TAM in meeting stakeholder needs. In addition, this study will optimally design the Technical *Requirements* improvement based on the Quality Function Deployment (QFD) approach. The QFD approach is carried out with several adjustments to find out how TAM is implemented properly. Technical *Requirements* and stakeholder *Requirements* will be deployed into QFD. This deployment will be carried out for each TAM phase consisting of: Start-up, Planning, Execution, and Close out. Each Technical requirement in each phase will be assessed according to data obtained from the interview, and also the FGD. This assessment aims to provide a portion of the performance of each TAM attribute. In the final stage, a new TAM program will be designed, and an estimated time and cost resource needs will be determined.

Keywords: Performance Improvement, Turnaround Maintenance, Quality Function Deployment, Maintenance Cost.

1. INTRODUCTION

The fertilizer industry is one of the strategic industries in Indonesia which plays a very vital role in the national program, especially in the food sufficiency program. In their operational activities, fertilizer factories are required to be able to operate continuously for 24 hours. This is because the fertilizer industry is also considered as a chemical process industry. If one of the equipment in the process fails, all the processes behind it will also fail. Besides, the process of starting up the plant generally takes a long time and is expensive in cost. The normal processof start-up from an empty state can take up to 36 hours to produce finished products with the start-up cost up to IDR 5 billion. With the characteristics of such a continuous process industry, maintenance activities are carried out simultaneously in a certain period called Turnaround Maintenance (TAM).

Turnaround Maintenance is a scheduled shutdown at a process plant to carry out total repairs, major inspections, and equipment overhauls. In a fertilizer factory complex, the number of equipment that must be checked or repaired can reach hundreds to thousands of equipment, ranging from simple equipment such as cables and tubing, to large machines that are very complex. Therefore, the existence of this TAM is very vital for the sustainability of thefactory.

The implementation of this TAM is scheduled periodically within a certain period. Some TAMs are scheduled based on factory production performance, and some are scheduled based on the useful life of the critical equipment of the plant. In a relatively new factory, TAM is carried out every 3 - 4 years. However, in factories that are more than 10 years old, TAM is usually carried out once in 1 - 1.5 years.

TAM implementation has its complexity because it always involves a lot of personnel and very expensive in cost. Poorly managed TAM will result in enormous losses, both from a larger budget and reduced factory production time (onstream days). There are several aspects that can connect TAM with a business context, such as decreasing company income due to decreased total production, because the factory is completely stopped, and production losses cannot be avoided. Another aspect, TAM has the potential to pose a hazard risk to the reliability and safety of personnel. Therefore, companies need to carry out careful planning avoid the risk of overrun and schedule setbacks.

Turnaround Maintenance has attracted the attention of many researchers because of its huge impact on factory performance. However, most focus on the reliability of individual units, not on the overall design and implementation of the TAM itself. Nasution (2010) states that the results of TAM implementation can be seen from the targets in the fields of quality, environmental sustainability, and health and safety. The study also states that the safety factor is one of the most dominant factors to maintain a sustainable production and operation rate. The safety, health and environment (SHE) management strategy studied in this case was guided by loss prevention and plant protection efforts. This research was conducted with a focus on the SHE aspect only. For other aspects, a more detailed study has not been carried out.

Basically, TAM performance assessment has several main aspects that become the center of attention. These aspects include the quality of work, duration, and finances. To assess the overall performance of TAM, it is necessary to have a special method that can accommodate various interrelated aspects. In this study, the QFD method is proposed as one of the tools to measure the overall TAM performance. The implementation of TAM in fertilizer factories is currently not measured in many aspects. The parameters that are used as the main assessment points are the duration of the TAM and the amount of the budget spent. Reviewing the durationof previous TAM, the implementation during the last 5 years can be evaluated to be relatively poor, as seen in Table 1

Table 1. Duration of Previous TAM

No.	Tahun TAM	Target	Realisasi
1	TAM 2014	16 hari	17.5 hari
2	TAM 2016	35 hari	48 hari
3	TAM 2018*	21 hari	21 + 9 hari
4	TAM 2019	17 hari	18.5 hari

TAM implementation tends to be poor because almost every TAM implementation has a duration longer than the specified target. The longest TAM implementation duration occurred in 2016 when TAM was implemented for 48 days or 13 days longer than the target that had been set. With a longer duration of TAM like this, of course, it will affect the company's performance due to the loss of factory running time (on stream days). Apart from the loss of time, the duration also caused considerable financial losses. With the relatively large number of personnel involved, the losses incurred because of additional labor costs could reach Rp. 100 million per day. This does not include the cost of supporting equipment such as mobile cranes, portable compressors, and other equipment which can reach hundreds of millions of rupiah per day. In addition, the company will also lose potential revenue of up to Rp 900 million per day because the factory is not producing.

Some of the obstacles that arise in the implementation of this TAM should have been identified since the planning. Potential barriers must be mapped in groups and alternative solutions are found so that they do not occur or at least not become obstacles when the obstacles arise. In this study, QFD is used as a tool to assess the performance of the TAM implementation in one site of fertilizer factory. Duffua in 2017 said that QFD has been widely used not only to measure the performance of a product against competitors but can also be usedas a tool to measure the performance of a job. In its implementation, the House of Quality matrix will adjust to the performance to be measured. The assessment aspects in the QFD matrix are also adjusted for suitability of the assessment, technical requirements and stakeholder needs. One example of the application of modified QFD can be seen in research conducted on Carmigani (Carmignani, 2008). The results of this study indicate that QFD can be implemented toimprove corrective maintenance work in the event of a breakdown. In addition, QFD can also be elaborated with other manufacturing principles such as Total Productive Maintenance (TPM) (Valavi and Pramod, 2015). With the results of this study, it is hoped that the performance of TAM will be measured properly so that improvements can be made more specifically. This TAM performance information will also be useful to reduce the occurrence of problems thatarise after the implementation of the TAM such as Unscheduled Shutdowns, unsafe conditionsfor workers, or the consistency of output from equipment related to the quality of work.

2. METHODS

In this research we use Quality Function Deployment (QFD) with some modification to match with this purpose of this research. The steps are described below

1. Collecting the Data

   The data in this study consisted of two kinds, namely primary data and secondary data. Primary data is data obtained by researchers directly, while secondary data is data obtained from existing sources. In this study, primary data were obtained through direct observation, interviews, FGDs, and also a study questionnaire. For secondary data, the selected data sources will be obtained from several sources that are already available in the field, namely the Turn Around Maintenance (TAM) report that has been carried out, meeting minutes, to corporate documents related to TAM such as work instructions, procedures, and the like. From this secondary data, the main points of Technical Requirements that have been implemented in TAM will be searched.

2. Develop Technical requirements
   In the Quality Function Deployment (QFD) method, Technical Requirements are defined as elements in the preparation of a product as a form of solving technical problemsfrom customer needs. In this research, Technical Requirements are translated into a broader sense covering managerial and planning aspects. Technical Requirements in this study are made into 3 hierarchies, namely phases, attributes, and technical requirements (detail requirements). At the first level, TAM is divided into 4 phases, namely the Start- up phase, the planning phase, the execution phase, and the post-implementation phase. For the second hierarchy, the TAM implementation attributes will be determined as the main points of the technical needs that are under it, namely at level 3.
3. Develop Stakeholder Requirements
   Stakeholder requirements is determined by literature review and interviews with relevant stakeholders in the fertilizer factory which is the object of research. Broadly speaking, Stakeholder Requirements are divided into 2, namely internal and external.
4. Define relative importance between Technical requirements
   Stakeholder Requirements prepared will be evaluated based on the level of importance in the implementation of the TAM program. In this study, the level of importance will be divided into 5 levels, as follow

Table 2. Relative Importance

Scale	Relative Importance
1	Not Important
2	Less Important
3	Fair
4	Important
5	Very Important

5. Define Relationship between Technical requirements and stakeholder requirements
   This relation is shown by determining the scale factor for each relation point between SR and TR. The determined correlation scale factor will be determined according to the following table

Table 3 QFD Matrix Symbol

Relation	Symbol	Weight
Weak	-	1
Moderate	x	2
Strong	●	3

6. Calculate the weights of each technical requirement
   Weighting is done for each Technical Requirements (TR) by considering the correlation to each stakeholder's Requirements. The weighting is obtained from dividing the Total TRj Value divided by the Total Attribute value. With this equation, we will get the weight for each TR in one attribute

$$TR\ weight = \frac{TR\ Sum}{Atribute\ Sum}$$

7. Evaluate current practice of each TAM attribute based on the Likert scale as follows:
   The TAM evaluation matrix is compiled based on weighted TR for each. The assessment is given based on the implementation of the TAM that has been carried out and how the TAM is running in accordance with the established limits. Each TR will be evaluated using a Likert scale as follows:

Table 4. Likert Scale

Likert Scale	Description
5	Excellent
4	Very good
3	Good
2	Fair
1	Poor

8. Determine the performance level of TAM
   After evaluation with each Likert Scale is carried out for each TR, the next step is to calculate the evaluation value for each attribute using the attribute weighted average score (AWAS). The determination of the AWAS score is obtained by the following formula

$$AWAS_{atribute} = \sum (TR\ weight\ x\ Likert\ scale)$$

   With the value obtained from the calculation of AWAS, each attribute will later be categorized into 3 groups according to their level of performance.

Table 5. Performance Level Based on AWAS

AWAS	Performance Level
$4 \leq$ AWAS ≤ 5	Excellent
$3 \leq$ AWAS < 4	Good
$1 <$AWAS < 3	Fair

9. Conclude improvement planning for future implementation
   The conclusion is drawn based on the results of the analysis and interpretation based on the data obtained. Suggestions will also be given to the company as well as future research for improvement in the future.

3. QFD IMPLEMENTATION

The Quality Function Deployment (QFD) is defined by determining the relationship between Technical Requirements (TR) and Stakeholder Requirements (SR). the relation in each attribute in the TR matrix will be determined by assessing how strong the relationship between the two points. Based on the interviews with management and stakeholders who are directly related to TAM. Detailed Relationship Matrix Images can be seen in the table 6 to table 9 below.

In common QFD method, the steps after determining the relationship between stakeholder requirements and technical requirements are determining the correlation between technical requirements, determining target values, and evaluating new strategies or designs. However, in this research, QFD was modified to suit its purpose for measuring TAM performance. After compiling the relationship matrix and calculating weight in every TR, the next step is to conduct a performance evaluation based on an assessment questionnaire. This assessment will later be calculated in the evaluation matrix based on the weight of each attribute that has been given.

Table 6. Correlation Matrix QFD

Stakeholder	Relative Importance	Stakeholder Requirements	TAM Team		TAM Manager		
			TR1	**TR2**	**TR3**	**TR4**	**TR5**
Top Management	High	Minimize shutdown period	-	●	●	●	●
		Budget efficiency	-	●	●	-	●
		Increasing device reliability	-	-	-	-	-
		Fulfil government regulation	-	-	-	-	-
Production Department	Normal	Increasing Factory's availability	-	●	-	-	-
		Implementation on Schedule	●	●	●	●	●
		Meminimalkan kekacauan jadwal produksi	x	-	-	-	-
Maintenance	Normal	Utilization of Maintenance Resources	-	-	-	-	-
		Safe tools storage in site	-	-	-	-	-
Inventory	Normal	Goods received before deadline	x	x	-	-	-
		Appropriate Specification and Owner estimate	-	-	-	-	-
Human Resource Department	Normal	Good personnel competency	-	-	-	-	-
		TAM on Schedule	-	-	-	-	-
Factory Customer	High	On Time Product Delivery	x	●	-	●	●
		Product availability during TAM	-	-	-	●	-
		Consistent product quality	-	-	-	-	-
Supplier	Low	Appropriate Spare parts quality	-	●	-	●	-
		Accurate Quantity	-	●	-	x	●
		Suitable delivery time	x	-	x	●	-
Contractor	Low	Well defined scope of works	●	●	x	●	-
		On time payment	x	-	-	●	x
Regulator / Another Stakeholder	High	Environment regulation	x	x	-	-	-
		Safety Regulation	x	x	-	-	-
		Personnel Regulasi	x	x	x	-	-
Total Technical Requirements (TR) Correlation			231	288	222	252	234
Total Attribute Correlation			519		708		
Technical Requirements (TR) Weight			0,445	0,555	0,314	0,356	0,331

Table 7. Correlation Matrix QFD

			Scope	Spare parts			Budgetary		Logistic	
			TR6	**TR7**	**TR8**	**TR9**	**TR17**	**TR18**	**TR19**	**TR20**
Stakeholder	**Relative Importance**	**Stakeholder *Requirements***								
		Minimize shutdown period	x	●	●	●	●	x	●	-
		Budget efficiency	●	-	-	-	●	●	-	-
		Increasing device reliability	●	x	x	-	●	-	-	-
Top Management	High	Fulfil government regulation	●	-	-	-	-	-	-	-
		Increasing Factory's availability	●	x	-	-	●	-	-	-
		Implementation on Schedule	●	●	●	●	-	-	-	-
Production Department	Normal	Meminimalkan kekacauan jadwal produksi	●	x	x	-	●	-	-	-
		Utilization of Maintenance Resources	x	-	-	-	-	-	-	-
Maintenance	Normal	Safe tools storage in site	-	-	-	-	-	-	●	●
		Goods received before deadline	-	●	●	●	-	-	-	-
Inventory	Normal	Appropriate Specification and Owner estimate	x	-	●	●	-	-	●	●
		Good personnel competency	x	-	-	-	●	x	x	-
Human Resource Department	Normal	TAM on Schedule	-	●	-	-	x	●	-	-
		On Time Product Delivery	x	●	●	●	●	●	-	-
		Product availability during TAM	x	-	-	-	●	-	-	-
Factory Customer	High	Consistent product quality	x	-	-	-	●	-	●	x
		Appropriate Spare parts quality	●	●	x	●	●	●	-	-
		Accurate Quantity	-	x	x	●	x	x	●	x
Supplier	Low	Suitable delivery time	-	●	●	●	-	x	-	-
		Well defined scope of works	●	-	x	●	●	●	●	x
Contractor	Low	On time payment	-	-	-	●	●	●	-	-
		Environment regulation	●	-	-	-	-	-	x	●
		Safety Regulation	●	-	-	-	-	-	●	●
Regulator / Another Stakeholder	High	Personnel Regulasi	x	-	-	-	-	-	x	●
Total Technical Requirements (TR) Correlation			360	267	261	261	330	246	273	252
Total Attribute Correlation			360	789			576		525	
Technical Requirements (TR) Weight			1,000	0,338	0,331	0,331	0,573	0,427	0,520	0,480

Table 8. Correlation Matrix QFD

Stakeholder	Relative Importance	Stakeholder *Requirements*	Contractor TR10	TR11	TR12	TR13	TR14	TR15	TR16
Top Management	High	Minimize shutdown period	-	-	-	-	-	●	●
		Budget efficiency	-	-	-	-	-	-	-
		Increasing device reliability	-	-	●	-	-	-	●
		Fulfil government regulation	-	-	-	-	-	-	-
Production Department	Normal	Increasing Factory’s availability	-	-	●	-	-	-	x
		Implementation on Schedule	-	-	-	-	-	-	x
		Meminimalkan kekacauan jadwal produksi	-	-	-	-	-	-	●
Maintenance	Normal	Utilization of Maintenance Resources	●	-	●	-	-	-	x
		Safe tools storage in site	●	-	-	-	-	-	-
Inventory	Normal	Goods received before deadline	-	-	-	-	-	-	●
		Appropriate Specification and Owner estimate	-	-	-	●	-	-	●
Human Resource Department	Normal	Good personnel competency	-	●	-	-	x	-	-
		TAM on Schedule	-	●	-	-	x	-	●
Factory Customer	High	On Time Product Delivery	-	-	-	-	-	-	●
		Product availability during TAM	-	-	-	-	-	-	●
		Consistent product quality	●	-	-	●	-	-	●
Supplier	Low	Appropriate Spare parts quality	-	-	-	●	-	-	●
		Accurate Quantity	●	-	-	-	-	-	●
		Suitable delivery time	-	-	-	-	-	-	●
Contractor	Low	Well defined scope of works	-	-	-	-	-	-	●
		On time payment	-	-	-	-	-	-	x
Regulator / Another Stakeholder	High	Environment regulation	-	-	-	-	●	-	x
		Safety Regulation	-	-	-	-	●	-	-
		Personnel Regulasi	-	●	-	-	-	-	-
Total Technical Requirements (TR) Correlation			207	201	201	195	207	177	351
Total Attribute Correlation			1539						
Technical Requirements (TR) Weight			0,135	0,131	0,131	0,127	0,135	0,115	0,228

Table 9. Correlation Matrix QFD

Stakeholder	Relative Importance	Stakeholder *Requirements*	Safety and Quality Assurance		Communication and Reports	
			TR21	TR22	TR23	TR24
Top Management	High	Minimize shutdown period	●	-	●	-
		Budget efficiency	-	-	●	-
		Increasing device reliability	●	-	●	-
		Fulfil government regulation	●	●	x	-
Production Department	Normal	Increasing Factory's availability	-	-	-	-
		Implementation on Schedule	x	x	●	-
		Meminimalkan kekacauan jadwal produksi	x	x	●	-
Maintenance	Normal	Utilization of Maintenance Resources	-	-	x	-
		Safe tools storage in site	-	●	x	-
Inventory	Normal	Goods received before deadline	x	-	●	-
		Appropriate Specification and Owner estimate	●	-	●	-
Human Resource Department	Normal	Good personnel competency	●	●	●	x
		TAM on Schedule	●	●	●	x
Factory Customer	High	On Time Product Delivery	●	-	-	-
		Product availability during TAM	-	-	●	x
		Consistent product quality	●	-	●	x
Supplier	Low	Appropriate Spare parts quality	●	-	-	●
		Accurate Quantity	x	-	●	-
		Suitable delivery time	-	-	●	●
Contractor	Low	Well defined scope of works	●	x	●	-
		On time payment	x	-	●	-
Regulator / Another Stakeholder	High	Environment regulation	●	-	-	●
		Safety Regulation	●	●	-	●
		Personnel Regulasi	-	●	-	●
Total Technical Requirements (TR) Correlation			357	264	366	255
Total Attribute Correlation			621		621	
Technical Requirements (TR) Weight			0,575	0,425	0,589	0,411

4. EVALUATION

The data for evaluating the performance of the TAM were obtained from interviews and questionnaires. Interviews were conducted on subjects with positions that were relatively important to TAM performance and in general in the company. In addition, stakeholders or strategic policy makers who were directly affected by the existence of this TAM were also interviewed. For assessment data by means of a questionnaire obtained from subjects who act as executors of activities or parties involved and directly affected in the implementation of TAM. From all the data that has been collected, the TAM assessment at the fertilizer factory is obtained as follows.

Table 6. Evaluation Matrix Based on Likert Scale

Atribut	Indeks	TR Weight	Skala Likert	Total Nilai pada Atribut	AWAS
Tim Inti TAM	TR1	0,445	3,94	519	3,87
	TR2	0,555	3,81		
TAM Manager	TR3	0,314	3,56	708	3,37
	TR4	0,356	3,31		
	TR5	0,331	3,25		
Ruang lingkup Pekerjaan Optimal	TR6	1,000	2,86	360	2,86
Spare parts	TR7	0,338	4,00	789	3,46
	TR8	0,331	3,38		
	TR9	0,331	3,00		
Kontraktor	TR10	0,135	2,69	1539	3,57
	TR11	0,131	3,38		
	TR12	0,131	3,25		
	TR13	0,127	3,31		
	TR14	0,135	4,13		
	TR15	0,115	4,06		
	TR16	0,228	3,94		
Anggaran	TR17	0,573	3,94	576	3,99
	TR18	0,427	4,06		
Logistik	TR19	0,520	3,63	525	3,36
	TR20	0,480	3,06		
Safety and Quality Assurance	TR21	0,575	4,13	621	4,15
	TR22	0,425	4,19		
Komunikasi dan Pelaporan	TR23	0,589	3,25	621	3,40
	TR24	0,411	3,63		
Pembelajaran dan Improvement	TR25	0,444	3,16	999	2,88
	TR26	0,324	2,81		
	TR27	0,231	2,45		

After evaluation with each Likert Scale is carried out for each TR, the next step is to calculate the evaluation value for each attribute using the attribute weighted average score (AWAS).

Table 7. Performance Assessment of Every TAM Atribute

Fase TAM	Atribut	AWAS	Penilaian
Organization	Tim Inti	3,87	Memuaskan
	Manager	3,37	Memuaskan
Planning	Scope Pekerjaan	2,86	Cukup
	Spareparts	3,46	Memuaskan
	Kontraktor	3,57	Memuaskan
	Anggaran	3,99	Memuaskan
	Logistik	3,36	Memuaskan
Komunikasi dan Pelaporan	Safety dan Quality Assurance	4,15	Sangat Memuaskan
	Komunikasi dan Pelaporan	3,40	Memuaskan
Improvement	Pembelajaran dan Improvement	2,88	Cukup

From the performance appraisal in table 4.14, the company still has the opportunity to improve performance in the scope of work and learning. In these two attributes, there are still many things that can be improved. The low performance of the Job Scope attribute is caused by the number of sudden and urgent work orders. This is due to major findings that can only be discovered after the factory is shutdown and inspection is carried out. A sudden addition of work like this will certainly make it very difficult for the executor to manage his time and labor. The further impact could result in TAM being delayed from schedule or even more inflated costs. Constraints like this can be minimized by improving detailed process analysis on each major equipment so that it can be immediately determined if there are process deviations. In addition, the TAM Team can also use better maintenance methods such as predictive maintenance or it could be time-based maintenance in order to determine more accurately. By determining the mainwork at the beginning of planning, it will be easier for the executor to divide his energy and time in completing the work.

The performance improvement of the Learning and Improvement attribute can be done starting by recording what is done, or also standardizing the work done through standardized procedures at the company level. Things like this will facilitate the transfer of knowledge and also open up more room for improvisation.

5. CONCLUSION

The conclusion that can be drawn from this research is that the Technical Requirements needed to meet stakeholder needs in the implementation of TAM consist of 11 attributes and 28 detailed Technical Requirements which cover 4 phases of TAM implementation.

TAM performance can be improved by improving the performance of attributes that are still at the “adequate” level, namely the Scope of Work and also post-TAM learning, in order to fulfill stakeholder needs optimally.

6. REFFERENCE

Ahyari, A. (2013) *Manajemen Produksi - Pengendalian Produksi*. Yogyakarta: BPFE.

Akao, Y. (1988) *Quality Function Deployment: Integrating Customer Requirement Into Product Design*.1st edn. Portland Oregon, USA: Productivity Press.

Al-turki, U., Duffuaa, S. and Bendaya, M. (2019) 'Trends in turnaround maintenance planning : literature review'.

Aliyulhaq, M. and Sudarso, I. (2016) *Peningkatan Kualitas Layanan Sekolah Menengah Pertama Islam An-Nidhomiyah (SMP-IA) Dengan Pendekatan Service Quality (Servqual) Dan Quality Function Deployment Improving The Quality Of Service High Smp Islam An-Nidhomiyah (SMP-IA) Approach To Servic*. Institut Teknologi Sepuluh Nopember.

Altehmazi, M. M., Suliman, S. M. A. and Alalawi, Y. (2017) 'An Optimization Approach to the Preventive Maintenance Planning Process', 11(9), pp. 20–29.

Andreassen, M. G. and Thorstensen, T. A. (2011) *Shutdown preparedness monitoring – case studies*. Norwegian University of Science and Technology.

Assauri, S. (2008) *Manajemen Produksi dan Operasi*. Jakarta: Universitas Indonesia.

Carmignani, G. (2008) 'Modified QFD and Problem-solving Techniques Integrated Approach Implementing Corrective Actions: A Case Study in an Italian Manufacturing Plant', *Quality and Reliability Engineering International*, 24(August 2008), pp. 501–502.

Cohen, L. (1995) *"Quality Function Deeployment: How to Make Work QFD For You*. 1st edn. USA: ASQC Quality Press. Handayani,.

Duffuaa, S. O., Al-Turki, U. M. and Daya, M. Ben (2019) 'Status of Integrated Turnaround Maintenance', in *Industrial and Systems Engineering Conference, ISEC*. IEEE, pp. 1–4.

Duffuaa, S. O. and Hadidi, L. A. (2017) 'Using QFD to conduct performance assessment for turnaround maintenance in petrochemical infrastructure', *Journal of Infrastructure Systems*, 23(1).

Elfeituri, F. and Elemnifi, S. M. (2007) 'Optimizing Turnaround Maintenance Performance', (PPCOE). Ghazali, Z. and Halib, M. (2015) 'The Organization of Plant Turnaround Maintenance in Process- Based Industries: Analytical Framework and Generic Processes'.

Hakim, T. I. Al and Astuti, S. P. (2018) *Analisis Peningkatan Kualitas Layanan Dengan Menggunakan Metode Quality Function Deployment (QFD) (Studi Kasus Bus Batik Solo Trans Koridor 1).* Institut Agama Islam Negeri Surakarta.

Irawan, Y. *et al.* (2007) 'Peranan Manajemen Resiko Terhadap Kinerja Waktu pada Proyek yang Ruang Lingkupnya Dinamis'.

Irawan, Y. (2007) *Peranan Manajemen Resiko Terhadap Kinerja Waktu pada Proyek yang Ruang Lingkupnya Dinamis*. Universitas Indonesia.

Klingenberg, B. E. (1986) *Effective Shutdown Maintenance Project Management*. Cape Town.

Kurniawan, F. (2013) *Manajemen Perawatan Industri: Teknik dan Aplikasi Implementasi Total Productive Maintenance (TPM), Preventive Maintenance dan reliability Centered Maintenance.* Yogyakarta: Graha Ilmu.

Laporan Pelaksanaan Turn Around Departemen Pemeliharaan I (2014).Gresik.

Manzini, R. (2010) *Maintenance for Industrial Systems*. London: Springer.

Nasution, Zani M. and Budi, Setia and Hadiyarto, A. (2010) *Evaluasi Terhadap Proses dan Prosedur Turn Oround pada Industri Berbasis Kimia (Kajian Aspek SHE di Pabrik Urea Kaltim-2, PTK Bontang)*. Universitas Diponegoro.

Nurcahyawening, T. J. and Singgih, M. L. (2015) *Pengembangan Program Perbaikan Kualitas Pada Usaha Jasa Menggunakan Quality Function Deployment (QFD)*. Institut Teknologi Sepuluh Nopember Surabaya.

Pokharel, S. (2018) 'Turn-around maintenance management in a processing industry A case study', (May 2008).

Prawirosentono, S. (2009) *Manajemen Operasi*. Jakarta: Bumi Aksara.

Putra, A. H. (2006) *Permasalahan yang Mempengaruhi Peningkatan Kinerja Biaya dan Waktu pada Pekerjaan Perawatan Terjadwal (Turnaround)*. Universitas Indonesia.

Valavi, D. G. and Pramod, V. R. (2015) 'A hybrid fuzzy MCDM approach to maintenance Quality Function Deployment', *Decision Science Letters*, 4(1), pp. 97–108.

IMPROVEMENT OF PACKAGING QUALITY AT PT. AGRI MAKMUR PERTIWI USING SIX SIGMA METHOD

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ABSTRACT

This research, entitled minimizing defects and damage to packaging with six sigma, needs to be carried out at PT. Agri Makmur Pertiwi. This research is motivated by the number of defective and damaged packages in the packaging section. The impact was felt, namely the company experienced two losses. The first loss is the cost loss to replace damaged packaging. The second loss is the loss of time in which workers have to repair defective packages and take care of damaged packages which have an impact on the capacity of the packaging process. Six sigma, DMAIC and several quality improvement measures can be used to improve quality. The research was conducted by making critical to quality and describing the packaging process with an operation process chart. Then measure the current quality condition using a control chart, calculate the sigma level and calculate the process capability at the measure stage. After that, look for the root causes of defects and packagingdamage with fish bone diagrams and use failure mode and effect analysis to analyze the riskand determine the priority which need to be repaired at the Analyze stage. The average defect proportion of a 250-gram automatic machine is 5.47%. The average DPMO value is 21,138, which means that out of one million packages, there are 21,138 defective and damaged packages. Recommendations for suggested improvements based on the largest RPN value. To prevent the vertically packaging movement, the solution is to design abuffer. To prevent the horizontally packaging movement, the solution is to equip each axle with cable ties. For work instructions, it is preferable to include prevention of packaging movement. For sensors that are blocked by dust, it is necessary to install a cleaning brush sothat the dust on the package does not contaminate the central sensor.

Keywords: Six Sigma, DMAIC, Statistical Process Control, Capability Analysis, Fishbone Diagram, Failure Mode and Effect Analysis.

1. INTRODUCTION

In this era of rapid industrialization, competition between companies is quite high. That's why the company must make continuous improvements for the company's development. One of the company developments in question is for example, such as reducing defective products or improving quality. Caroll (2013) said that defects are all results that cause consumer dissatisfaction or are not in accordance with the specifications set by a business organization. The success in reducing defective products will have an impact on improving quality. Pochampally (2014) said quality is the extent to which customers are satisfied. Meanwhile, Shankar (2009) said about another definition of quality means the conformity of a product with requirements, while the price is related to the actual costs incurred to deliver a product or service, and delivery with time to market.

As Shankar said about the definition of quality, the condition of the quality of an item can affect the high and low costs. If the product that does not meet quality standards is large enough, the greater the time and cost losses incurred by the company to repair or replace defective products. Vice versa. The good and bad quality of a product will definitely affect the quality cost. Hansen (2009) said quality costs are costs that arise because there may or are already poor-quality products.

The cost of quality affects the efficiency capability of a company. Hansen (2009) said efficiency is a condition in which business processes are carried out by the best method with the smallest possible activity. Sickle (2019) said definition of efficiency is the ability to produce specific results without wasting a lot of energy and wasted activities. That's why quality control is very important to achieve the best level of efficiency. The optimal level of efficiency will definitely have a good impact on the production process. Especially in the field of quality improvement. If a company can control its quality, efficiency will be achieved.

PT. Agri Makmur Pertiwi is an agribusiness company that focuses on selling seeds and targets efficiency in 2020. Efficiency is deemed necessary because you have to make savings in order to develop the company in the midst of the tough competition in the agribusiness industry.

Quality control that needs to be improved first is the packaging department. Because the packaging department is a part that is quite close to the market. Demand from the market is also increasing over time so that if there is a defective or damaged packaging, it will have an internal and external impact. An example of an internal impact is that the packaging activity on the machine must stop first because the operator has to repair the defective packaging and correct the position of the damaged packaging while it is still inside the machine. When the machine stops, it causes time loss and cost loss. Based on the observations of down time on one of the automatic machines specifically for sweet corn, within seven hours of work, the machine stops for one hour to one and a half hours to repair defective products. In one hour, the automatic machine specifically for sweet corn with this type of roll packaging can pack up to 1400 packs.

Because there must be down time to repair defective packaging and remove damaged packaging, the company has to lose one hour or the equivalent of 1400 packs or the equivalent of 35 boxes. If the damaged and defective packaging is not followed up immediately, then in one hundred hours, the company will lose the time equivalent to 14,000 packs or 3500 boxes. This is still not the cost of labor losses that have to repair defective or damaged packaging and losses due to damage to the packaging itself. So there is the potential for an increase in defective and damaged products which will later disrupt the packaging process. Meanwhile, an example of the external impact is if a defective or damaged package reaches the customer, the company must pay two types of expensive losses. The first loss is that the company has to pay compensation and the second loss is that the customer's trust in the company will decrease. For companies, losing trust in quality from customers is the most expensive loss. Srinivisan (2014) said customers are very important to any business, organizations must continue to consistently maintain customer expectations by prioritizing quality, production costs which lead to increased competitiveness and increased market share.

The main objective of this study is to use six sigma to reduce the risk of defects and packaging damage so as to improve packaging quality and packaging capacity. This quality control technique called Six Sigma is the result of management thinking that concentrates on reducing defects as much as possible by applying understanding, measurement, analysis, improvement and control to the process system. The six sigma technique has a quality improvement cycle commonly called Define, Measure, Analyze, Improve and Control or commonly abbreviated as DMAIC. DMAIC is also supported by several tools from seven tools of quality. Namely the statistical process chart and fishbone diagram. The statistical process chart is useful for measuring the current condition of packaging defects and a fishbone diagram to identify the causes of defects and packaging damage from five factors, namely machines, materials, humans, methods and the environment.

This DMAIC also uses the Failure Mode and Effect Analysis (FMEA) method. Chase (2006) said that FMEA is useful for knowing the risk of quality failure by identifying each part, estimating, prioritizing and evaluating each risk at each stage of the process (Chase et al., 2006). Packaging defects and damage are both the impact and the risk of failure. This failure has a cause and a priority level of improvement at each stage. So it is necessary to calculate the risk priority number (RPN) at each stage of the process.

In addition, this research is expected to be able to provide benefits from managerial aspects. One example of its benefits is the implementation of plan, do, control and act (PDCA) in the packaging department, especially by packaging supervisors and seed process managers. Packaging supervisors and managers plan improvements at the plan stage, then implement the plan at the do stage, monitor the extent of success at the check or control stage and tackle whatever results are in the plan stage.

2. LITERATURE REVIEW

Experts have a different understanding of Six Sigma. Linderman (2013) siad six sigma is a problem-solving method for improving the quality of new systems and products that relies on statistical methods and scientific methods to dramatically reduce product defects and product variations. Smetkowska (2018) said sigma is a word taken from statistics which means the standard deviation of a random variable which is around the average value. Gejdos (2015) said means that six sigma is six times the standard deviation distance. The variation itself is caused by two causes, namely general causes and specific causes.

The basic theory of six sigma actually comes from a combination of statistical control processes and total quality management. At this time, Six Sigma is a management system that is quite attractive to improve quality. Cunha (2015) said six sigma focuses on DMAIC to make significant progress using several available tools and has developed into a comprehensive approach to improving business performance.

Define is the beginning of quality improvement in Six Sigma. Rohini (2011) said the initial steps taken at this stage are identifying any problems that need to be fixed, explaining the reasons for the six sigma project objectives and identifying critical to quality. how long the project will take, create a process map and define quality product parameters. The define stageis a critical stage where the discussion focuses on the team and leadership in the organization. Critical to Quality or commonly abbreviated as CTQ are the factors of a production process that can significantly influence the process output. It is used in define phase. CTQ is directly related to hopes, wants and needs. Customer. In addition, it also contains several important parameters of a production process that have a direct impact on customer satisfaction. The team involved inSix Sigma will monitor, control and continuously improve the quality using these parameters.

The second stage of DMAIC is measure or measurement. The team must measure how the current quality of the process is. What must be done is planning data collection to measure input, process and output. After the data has been collected, it is necessary to analyze the data and its distribution. One example of a tool for analyzing data is seven tools of quality, DPMO calculations and process capability analysis.

Analyze is the third stage in the DMAIC cycle. Hakimi (2017) said the purpose of this stage is to find the causes and roots of quality problems. If the root of the problem has been found, the Six Sigma team will know where the critical points need improvement. This stage uses two tools from the seven tools of quality, namely the fishbone diagram and the Pareto diagram. After knowing the root of the problem, determining priority improvements can be designed with the help of FMEA which will be explained later.

Fishbone Diagram is one of the seven tools of quality to investigate the root of a quality problem at analyze stage. That's why the diagram has another name, namely Cause and Effect Diagram. Named fish bones because their shape is similar to a fish carcass that has lived its bones. The way diagrams work is mapping or dividing the causes of quality problems into six determining factors and then analyzing them. Six factors that influence, namely manpower or humans, methods or ways of working, machines or machines, materials or raw materials,mother nature or the environment and measurement or measurement.

Pugna (2016) said that Failure Mode and Effect Analysis or commonly abbreviated as FMEA is an analysis technique for product, process or machine reliability by selecting the type or mode of failure and its cause so that the results can be evaluated quantitatively. The failure mode itself is an event when a product is outside the specified limits or experiences a malfunction so that the function of the product is impaired. It is used in analyze stage after Fishbone Diagram.

The fourth stage of DMAIC is to improve. This stage is the stage where the Six Sigma team has discussions to solve various quality problems. They develop solutions, change processes, implement ideas and collect data to measure how far the quality has progressed after implementation. If the Six Sigma team observes any developments in the quality of the process, then more innovative improvements are needed. Which is expected to produce a positiveimpact, a better working environment and the best service for customers. To achieve these conditions, of course, special stages are needed so that this phase of improvement is more optimal.

The last important stage in the DMAIC cycle is the control phase. This control phase aims to observe how the implementation of the improve stage of the process system is implemented. So that the team knows whether there is an increase in the process system or not. Even though it has reached the six-sigma value, this control stage must also be actively implemented regularly in order to maintain success. Following are the main steps in the control phase. Monitor that the results of improvements are maintained. In order for the system repair process to function as desired by the team and run in the long term, it is very important to createa system that can reduce the occurrence of damage and errors. You can also make mistake- proofing to prevent the same problem from occurring.

3. METHODOLOGY

The preliminary stage contains the initial information collection used to identify and determine the objectives of the quality problem in the packaging department of PT Agri Makmur Pertiwi by considering knowledge based on existing credible sources. The first step that must be done is to design an initial observation activity to determine the actual conditionsof the packaging process and the causes of the damage at PT. Agri Makmur Pertiwi Kediri - East Java. The benefit for researchers and companies is that they can provide information and a clear picture of how a package can be defective or damaged so that later it will be easier to formulate solutions to reduce packaging defects and damage. The second step is to find literature study phase aims to find references and theoretical basis for solving the problem of defects and damage to packaging in the product packaging department at PT. Agri Makmur Pertiwi. Literature is obtained from journals, books and several previous studies discussing six sigma and improving the quality of product packaging. The last step in preliminary step is problem identification. The problem identification stage is to thoroughly and deeply identify some of the quality problems in the packaging department at PT. Agri Makmur Pertiwi. The purpose of this stage is to find the causes and roots of quality problems.

The data processing stage is the application of the DMAIC cycle to primary data and secondary data obtained from the company. The discussion of the stages of data processing with the DMAIC cycle is as follows. The first stage of the packaging quality improvement cycle is the define stage. At this stage, the researcher needs to identify the packages to be studied, especially in the packaging process flow, to the types of defects and damage. The second stage in a series of packaging quality improvement cycles is the measure stage. Data processingbegins by identifying the CTQ factors of a package, making a pareto diagram to determine priorities, making a control map for attribute defects so that it can be up to the end, namely calculating DPMO, sigma and Cp values to find out how the sigma value and process capability value of the current packaging this. The third stage of the series of quality improvement cyclesis the Analyze stage. The main activity at this stage is to analyze the factors that influence the occurrence of packaging defects and damage. Starting from materials related to seeds and packaging, methods related to how to pack, machines related to the smoothness and precision ofmachines and man related to how the operator when. All this can be done with the help of a fishbone diagram. Then proceed with making FMEA to find out which packaging needs to be prioritized. The fourth stage of the series of quality improvement cycles is the stage of improve. This stage aims to implement recommendations for packaging process improvements to reduce the DPMO value and increase the sigma value of each type of packaging. The decision to find out which packaging needs to be repaired first can be seen from the highest RPN results. Thelast step is control step. The goal of control step is to observe that the improvement work or not.

4. RESULT

Define is the first step to minimize packaging defects and damage using the Six Sigma method. At the define stage, it is necessary to make Critical to Quality (CTQ). The CTQ in this study is formulated according to specific standards that can impact all the functions previously mentioned. Table 1 below is the CTQ that affects seed packaging.

Table 1. Critical To Quality

CTQ	**Spesification for Manual and Semiautomatic**
1	Seal the top of the package neatly closed
CTQ	**Spesification for Automatic**
1	The hologram is perfectly attached
2	All seals are closed perfectly
3	Perfectly cutting process
4	Lable printing right in position

After completing the define phase, the next phase is to take the measurement or measure phase. In this phase, the calculation of the proportion of existing attribute defects with statistical control maps, calculating the DPMO value, what is the current sigma condition and finally calculating the value of the process capability for critical packaging processes. Data were collected by counting the number of packages produced per hour and counting the number of packages that were defective or damaged per hour. Each variation in the packaging process was sampled twelve times. Table 2 below is the sigma value and capability value of each packaging process.

Table 2. Sigma Value and Capability Value of Each Packaging Process

No.	Packaging Process	Package Detail	Machine Allocation	Sigma	Capability
1	Automatic	Vegetable Package	Automatic 5-25 Gram	3.72	1.24
2	Automatic	Universal Package	Automatic 250 Gram	3.54	1.18
3	Automatic	1 Kg Package	Automatic 1 Kg	3.64	1.21
4	Semiautomatic	Vegetable Package	Semiauto 25 Gram	3.89	1.30
5	Semiautomatic	Small Pack Package	Semiauto 25 Gram	3.81	1.27
6	Semiautomatic	Vegetable Package	Semiauto 500 Gram	3.97	1.32
7	Semiautomatic	Sweet Corn Vegetable	Semiauto 500 Gram	3.91	1.30
8	Semiautomatic	Universal Package	Semiauto 500 Gram	3.83	1.28
9	Semiautomatic	1 Kg Package	Semiauto 1 Kg	3.86	1.29
10	Semiautomatic	5 Kg Package	Semiauto 5 Kg	3.59	1.20
11	Manual	Small Pack Package	Manual	2.78	0.93
12	Manual	Vegetable Package	Manual	2.68	0.89
13	Manual	Universal Package	Manual	3.26	1.09
14	Manual	1 Kg Package	Manual	2.36	0.79
15	Manual	5 Kg Package	Manual	2.25	0.75

Table 2 is the sigma value and capability value in each packaging process and each type of packaging. In the automatic packaging line, the lowest capability value is in universal package in the Automatic 250 Gram machine, which is 1.18. Even if the semi-automatic and automatic lines are combined. The Universal package on the Automatic 250 Gram machine also received the lowest rating. The capability value in the manual packaging line is also below 1. However, the number of packaging processes in the manual line is very small. But products which processes in manual line are not fast-moving product. So, repairs to Universal Package in the packaging process at Automatic 250 Gram are a priority.

After completing the measure phase, the next phase is to identify the root problems that cause packaging defects and damage and determine the priority of the most important causes of failure to be repaired. This is called analyze phase. Analyze phase use fishbone diagram and then FMEA table. Figure 1 is example of fishbone diagram for label printing dislocation.

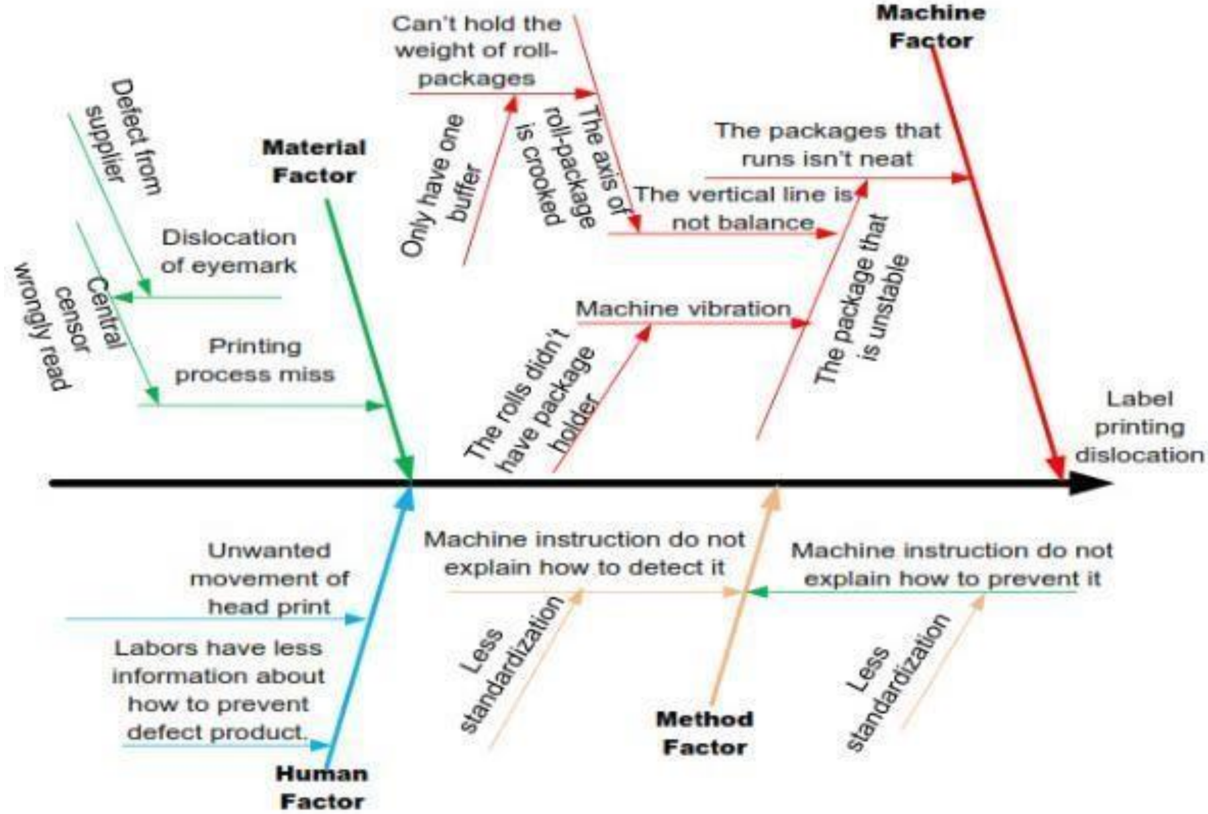

Figure 1 Fishbone Diagram: Label Printing Dislocation

Figure 1 is a fishbone diagram that explains the root cause of the unsuitable printouts. This defect is caused by four factors. The factors are machines, humans, methods and materials.

From the machine factor, the main cause is the uncluttered packaging while driving along the track. This unstable packaging occurs for two reasons. The first reason is due to unbalanced vertical tension. One side of the pack moves upward faster than the other side. This imbalance occurs because the axle of the package rolls is bent because it is not strong enough to withstandthe load of the package rolls. This is because the axles rely on only one support. The second reason is the packaging which is shifted horizontally due to vibration. The shift in packaging is because there is no packaging hold on each axle through which the packaging passes.

From the material factor, namely because the printing process is not in time. This is because the central sensor misreads. The central sensor gives an appropriate command if the sensor has read the black dot on the package. The black dots on the pack are called eye marks. If the eye mark position does not match, the sensor will read incorrectly. This discrepancy is due to apackaging defect from the supplier.

The method factor occurs because of two things, namely that there is still no way to reduce the potential for errors and reduce the impact of errors. This happens because work instructions are still focused on how to run the machine only. There are no clear work instructions to reduce defective products.

From the human factor it occurs because of two things. The first cause is that the print eye is shifted because it is accidentally touched by a human. The second cause is that operators are still lacking information on defect prevention. This has to do with the method factor.

FMEA used after fishbone diagram. Failure Mode and Effect Analysis or abbreviated as FMEA which is useful for the risk of quality failure by identifying each part, estimating, prioritizing and evaluating each risk at each stage of the process. With the help of FMEA, it was possible to determine the packaging quality failure which had the greatest impact in the automatic 250-gram packaging process. The process of working on FMEA tables is obtained by interviewingworkers, staff in charge of automatic packaging machines and staff in charge of packaging.

Table 3. RPN Calculation From All Fishbone

Failure Mode	RPN
Vertical movement	256
Horizontal movement	224
Instruction which have less information	224
Main censor dirty	180

The improve phase is the last stage in quality improvement to reduce defective anddamaged packaging. This stage discusses the recommendations for improvements that have been discussed at the Analyze stage. Improvements will be made to the factors with high RPN values. Table 4 describe recommendations for improvements starting with those with a high RPN.

Table 4. Solution for each failure mode

Failure Mode	Solution
Vertical movement	Make a buffer for the other side
Horizontal movement	Use ties cable to hold left and right side
Instruction has less information	Make standardization for each component
Main censor dirty	Use toothbrush to clean the package

The last phase of the DMAIC cycle is control. In the control section, the packaging department needs to re-measure the quality of the packaging to find out the success rate of the improvement phase that has been carried out. We recommend that the quality measurements in the control phase be more specific than the measure phases. Namely by calculating the proportion of defects according to the type of defect and according to the type of process. To be clearer at the processing stage which parts need to be a priority.

5. RESULT

The average defect proportion of a 250-gram automatic machine is 5.47%. The average DPMO value is 21,138, which means that out of one million packages, there are 21,138 defective and damaged packages. The average sigma value is 3.54 which is still classified as medium. The average value of the process capability is 1.18, which means that it is not sufficient to meet the specifications. From the attribute control chart that has been made, it can be concluded that the second, seventh, ninth and twelfth observations are outside the upper control limit. This is because there are still variations in specific causes that cause defects and packaging damage in theAutomatic 250 Gram machine.

According to the fishbone diagram, the causes of packaging defects and damage on the 250-gram automatic machine vary widely. From FMEA calculations, the four main causes are dueto vertical and horizontal shifting of packaging, the absence of discussion of how to prevent packaging shift in work instructions and dirty central sensors due to dust.

Recommendations for suggested improvements based on the largest RPN value. To prevent the vertically packaging movement, the solution is to design a buffer. To prevent the horizontally packaging movement, the solution is to equip each axle with cable ties. For work instructions, it is preferable to include prevention of packaging movement. For sensors that are blocked by dust, it is necessary to install a cleaning brush so that the dust on the package does not contaminate the central sensor.

6. REFERENCES

Azizi, A., (2015), "Evaluation Improvement of Production Productivity Performance Using Statistical Process Control, Overall Equipment Efficiency and Antonomous Maintenance", Journal of Material, Industrial and Manufacturing Engineering, hal: 186-190.

Bustami, B. & Nurlela, (2006), Akuntansi Biaya, Edisi Keempat, Mitra Wacana Media, Jakarta. Carroll, C.T., (2013), Six Sigma for Powerful Improvement, CRC Press, Boca Raton

Chase, R.B., Jacobs, F.B., Aquilano, N.J., (2006), Operations Management for Competitive Advantage. 11th edition, McGraw-Hill Irwin, New York.

Chen, S., Fan., S., Xiong., J., Zhang., W., (2016), "The Design of JMP/SAP Bases Six Sigma Management System and in Application in SMED", Hal. 416-424.

Cunha, C., Dominguez, C., (2015), "A DMAIC project to improve warranty billing's operations: a case study in a Portuguese car dealer", Journal of Computer Science, hal. 885-893.

Erdogan, A., Canatan, H., (2015), "Literature Search Consisting the Areas of Six Sigma Usage",
Journal of Technology, Innovation and Entrepeneurship, hal: 695-704.

Garvin, D.A., (1987), Competing on the Eight Dimensions of Quality, Harvard Business Review, Boston.

Gejdos, P., (2015), "Continuous Quality Improvement by Statistical Process Control", Journal of Business Economics and Management, hal. 565-572.

Gygi, C., Decarlo, N., Williams, B., (2005), Six Sigma for Dummies, Wiley Publishing Inc., Indianapolis.

Hakimi, S., Zahraee, S.M., Rohani, J.M., (2017), "Application in Six Sigma DMAIC Methodology in plain yoghurt production process", International Journal of Lean Six Sigma.Hansen, D.R., Mowen, M.M., Guan, L., (2009), Cost Management, South-Western Cengage
Learning, Mason.

Indrawati, S., Ridwansyah, M., (2015), "Manufacturing Continuous Improvement Using Lean Six Sigma: An Iron Ores Industry Case Application", Hal 528-534.

Jevgeni, S., Eduard, S., Roman, Z., (2015), "Framework for Continuous Improvement of Production Process and Production Throughput", Hal. 511-519.

Jirasukprasert, P., Garza Reyes, J.A., Kumar, V., Lim, M.K., (2014), "A Six Sigma and DMAIC application for the reduction of defects in a rubber gloves manufacturing process", International Journal of Lean Six Sigma, Vol. 5, No. 1, hal. 3

Linderman, K., Schroeder, R.G., Zahir, S., Choo, A.S., (2003), "Six Sigma: A goal theoretic perspective", Journal of Operations Management, Vol. 21, No. 2, hal. 193-203.

Montgomery, D.C., (1985), Introduction to Statistical Quality Control, John Wiley and Sons, United States of America.

Pochampally, K.K. & Gupta, S.M., (2014), Six Sigma Case Studies with Minitab, CRC Press, Boca Raton.

Pugna, A., Negrea, R., Miclea, S., (2016), "Using Six Sigma Methodology to Improve the Assembly Process in Automotive Company", Hal. 308-316.

Rohini, R., Mallikarjun., (2011), "Six Sigma: Improving Quality of Operation Theatre", Journal of Business Innovation & Technology Management, hal: 273-280.

Selik, S., Taner, M.T., Kagan, G., Simsek, M., Kagan., M.K., Oztek., (2016), "A Retrospective Study of Six Sigma Methodology to Reduce Inoperability among Lung Cancer Patients", Hal. 22-32.

Shankar, R., (2009), Process Improvement Using Six Sigma, Quality Press, Milwaukee.

Sickles, R.C. & Zelenyuk, V., (2019), Measurement of Productivity and Efficiency: Theory and Practice, Cambridge University Press, Cambridge.

Smetkowska, M., Mrugalska, B., (2018), "Using Six Sigma DMAIC to Improve the Quality of the Production Process", Journal of International Symposium in Management, hal. 590-596.

Srinivisan, K., Muthu, S., Prasad, N.K., Satheesh, G., (2014), "Reduction of Paint Line Defects in Shock Absorber through Six Sigma DMAIC Phases", Manufacturing and Management Journal, hal. 2

Walter, O.M., Padhini, E.P., (2018), "Lean Six Sigma in Brazil: Literature Review", International Journal of Lean Six Sigma, Vol. 10, No. 1, hal: 435-472.

DEVELOPMENT OF SHIP MANAGEMENT PLANNING TO GUARANTEE OF SUSTAINABILITY OF SAFETY QUALITY AND SECURITY OF SHIP OPERATION

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ABSTRACT

Ship accidents are events experienced by ships that can threaten the safety of the ship or human life. The growth of domestic sea shipping passengers on the number of passenger ship has increased throughout the year. Therefore, higher levels of transportation safety and security are needed and provide a sense of security for passengers and goods. So that there is trust in the community and other parties involved in using sea transportation for the survival of the community. The reasons for the increase in the number of ship accidents in Indonesia are caused by several causes. The cause of ship accident is caused by human factors, technical factors and natural factors. Risk management planning needs to be done inensuring the safety and security of ships. Because risk planning for shipping transportation in the long term is not yet widely available as a guarantee of ship safety and security. Risk management planning on passenger ships where the cargo is generally human needs to be carried out with good risk management planning. Some of the research about ship accidents have been done a lot, but the approaches are more of a partial nature and not completely related to the accident causes. This paper will more discuss about research reviews relatedto ship accident. The research reviews will further be used in justification of a more comprehensive approach to see ship accident. vehicle in seeing the prospect of sustainabilityof safety and security of ships in a comprehensive manner must be carried out to be able to evaluate each plan for guaranteeing the safety and security of ships. The risk management process is often used only statically by only considering major incidents or accidents. But todynamically process in analyzing risk management is very necessary because it considersall variables in terms of anticipating small incidents and large incidents. Dynamic safety methodology becomes an alternative to solving risk management problems by considering system variables with complex and comprehensive dynamics.

Keywords: Planning Development, Risk Management, Sustainability, System Dynamic, Passenger Ship.

1. INTRODUCTION

Indonesia is an archipelago with abundant natural resources, which is strategically located between the Indian Ocean and the Pacific Ocean, with about two-thirds of its territory being oceans (Rumaji and Adiliya 2019). Departing from the geographic condition of Indonesia, whichis an archipelagic country, there is a need for economic unity throughout Indonesia. So that it can be realized with the existence of an inter-island sea transportation system that allows the movement of goods and people to all corners of the archipelago. Sea transportation as the main route connecting the islands of Indonesia must meet the criteria to support industrial activities and other services. Apart from that, as a node that serves national, regional and international areas. Therefore, the role of sea transportation is very strategic and important so that it can dominantly support the sustainability of the national economy. (Directorate General of Sea Transportation, 2014). As much as possible, this transportation can accommodate people's needs with transportation that is fast, cheap and safe. This requires meeting the needs of the number of ships and improving maritime security. Sea transportation is one of the government's efforts in developing shipping as a means of transportation which is used as a mainstay for enhancing the unity, unity and economy of the country. In its development, the frequency of national shipping has increased quite significantly. However, along with its development, the rate of ship accidents and incidents that occurred in Indonesian waters has also increased (Indonesian National Transportation Safety Committee 2016). There have been several marine transportation accidents, especially on ferries in Indonesia. The accident occurred in the engine room fire at KM. BSP I which is a Ferry ship in the Sunda Strait, Banten on February 7, 2019. In addition, there was a ship fire accident until the ship sank on September 14 2018 at KM. Fungka Permata V. The incident caused 13 people to die and 6 people were declared missing. Another marine transportation accident, especially ships, was on 18 June 2018 at KM. Sinar Bangun 4 which sank in the watersof Lake Toba, North Sumatra. The sinking incident of KM. Sinar Bangun 4 resulted in 3 people dying and 164 people missing (KNKT RI 2020). The number of fatalities that occur due to ship accidents every year needs to be evaluated for good handling. Evaluation is carried out aimed at minimizing the occurrence of accidents and casualties on ship passengers.

The reasons for the increase in the number of ship accidents in Indonesia are due to several causes. The causes of ship accidents are caused by human factors, technical factors and natural factors. The causes of human factors that occur include carelessness in running the ship, the lack of the ability of the crew and deliberate loading of the ship's cargo as well as several other causes. The causes of technical factors include the lack of monitoring of ship maintenance, unsuitable ship design and vessel modification forms that do not meet eligibility standards. The causes of natural factors include unpredictable weather, high waves, storms and other natural causes which result in an increase in the number of ship accidents.

Risk management planning needs to be done in ensuring the safety and security of the ship. Because for risk planning in shipping transportation in the long term there is not much available as a guarantee for the safety and security of ships. With a study on risk management on ships, it can increase the trust of users of sea transportation services, especially ships. Moreover, there is an increase in the number of sea transportation users, both passengers and goods.Therefore, the safety and security of marine transportation users must be given priority. Sea transportation, especially on passenger ships where the cargo is generally human, needs to be carried out with good risk management planning. Risk management planning aims to ensure the safety and security of the ship. A shipping company that has a fleet of ships which are entirely passenger ships has a very big risk of ship accidents. Especially on passenger ships carrying people, so a risk management policy is needed so that ship accidents that have occurred are not repeated. The potential for ship accidents is very large, such as the risk of fire, ship collision, sinking ship and other ship accidents that have occurred repeatedly on several ships in Indonesia. So that a good risk management study can minimize the occurrence of ship accidents so that guarantees are available for ship safety and security.

2. LITERATURE REVIEW

2.1 Ship Risk Management with Fuzzy Approach

The use of Fuzzy methods is more efficient to process the various types of data available in maritime safety for designing risk assessment systems. The use of the Fuzzy method at the same time can define individual ship risk factors that can be used for making a decision. The data considered are not subjective and knowledge is obtained from the analysis of variables affecting the level of casualties. So that the maximum data processing will be obtained using the Fuzzy method to solve problems in ship safety and security. At the completion of the use of the Fuzzy method by performing simulation solutions obtained six input parameters. These parameters include the type of ship, gross tonnage, duration of shipping, year of manufacture, national flag and number of companies. The results of the simulation consider meteorological factors to get good results. For all simulated cases where dynamic risk factors are ignored, it is found that the fuzzy risk factors are higher than the static risk factors. From these results, it is in accordance with ship characteristics and meteorological conditions, that fuzzy risk factors are efficient for providing individual risk assessment factors. (Jean-Francois, et al. 2009). Based on the results of research using the Fuzzy method, it is still not possible to solve dynamic risk factors. So it is necessary to have a new method in solving risk factors with dynamic variables. In order to evaluate the risk assessment approach for maritime safety, a graphical simulation method has been developed which enables the scenario of maritime traffic. Case studies of risk assessment ofvarious types of ships (bulk carriers, passengers, cargo and tankers) have shown that fuzzy risk factors can be used efficiently in risk analysis (Jean-Francois, et al. 2009).

2.2 Ship Risk Management using AHP (Analytical Hierarchy Process) Approach

The use of the AHP (Analytical Hierarchy Process) method requires indicators to show a perspective in validating a value. The indicator value is obtained from expert experts or people who are experienced in their fields. So that it can provide a level of problem perspective. Experts can subjectively judge the importance of each BSC (Balance Score Card) item on a scale of five with linguistic terms, where each term will correspond to a fuzzy number. Each indicator will be weighted. The weight of each indicator / perspective can be evaluated in the context of decision making with many criteria (Multicriteria Decision Making) by utilizing an AHP method (Vinodh 2012). The weights of each indicator / perspective in the individual BSC can be obtained quantitatively. A decision maker can assess his evaluation separately at each level subjectively. Although AHP is based on user experience and judgment, it has objective and realistic results. (K. Park 2008). In the AHP method, the comparison of pairs between criteria has a limited number. The AHP method does not fully take into account the uncertainties associated with mapping a person's judgment to a number. (Ayag and Ozdemir 2006). AHP is consideredinsufficient because it has an imbalance in the appropriate rating scale and is unclear in making comprehensive comparisons. (Zheng, et al. 2012). In addition, the AHP method must rely on the judgment of experts / experts in their field to provide appropriate input on each assessment variable. Experts must assess each variable or criterion using a (equally important / moderately important) linguistic variable. Linguistic variables are variables whose value is not numbers but words or sentences in a language (Zaddeh 1975).

2.3 Ship Risk Management using the FTA (Fault Tree Analysis) Approach

Fault Tree Analysis (FTA) is a deductive analysis approach to solve unwanted events that are the cause. The FTA method has the objective of including in-depth identification of the causes of failure, identifying weaknesses in a system, assessing the reliability design of the security system, identifying the effects of human error (Human Error), prioritizing the contributors to a cause of failure, identifying the effective performance improvement of a system. Calculate the probability of failure and optimize maintenance. Risk analysis using the FTA method is carried out using a risk matrix to identify the risk level of the activities involved. Risk assessment uses the Hazard Identification and Risk Analysis (HIRA) method to determine the activities that have the highest risk (Sunaryo and Hamka 2017). The use of FTA still does not consider sustainability dynamically in the approach to risk management.

2.4 Dynamic Risk Analysis Using the Bayesian Network Method

The priority reason for using Bayesian Network analysis compared to conventional methods such as Fault Tree Analysis and Event Tree is that it has the ability to model complex systems and besides that it has the advantage of reducing parametric by entering new variables. Bayesian Network is used for analysis of data and can be used as a test of expert knowledge, especially in areas of uncertainty, because it allows to treat uncertainty explicitly. This method can be used to create an Expert System by modeling and entering the variables of expertknowledge in complex domains. The Bayesian Network method has a technical aspect that isvery useful for analyzing scanty data. There is no minimum sample size required to carry out the analysis and the Bayesian Network takes into account all available data (Uusitalo 2007). Bayesian Networks make it possible to estimate the likelihood of rare failures in complexstructures in an efficient manner. In addition, this method helps update predictions by using new information available through the measurement process by monitoring or inspection (Yeo, et al. 2016). In the Bayesian Network a conclusion from the probability of an event depends on the evidence observed. Bayesian Network not only implements predictive analysis or forward time analysis, but also can perform diagnostic analysis or backward time analysis (Bhandari, et al. 2015). The probability distribution of certain variables can be calculated through different class inference algorithms such as the tree method in the Fault Tree Analysis by eliminating variables (Abimbola, Khan and Khakzad 2014).

2.5 System Dynamics

System Dynamics modeling is a methodology used to develop models based on historical data and dynamic relationships between important variables for the purpose of describing and modeling the behavior of complex systems over time. This modeling is usually used when a formal analytical model does not exist but simulations can be developed by linking a number of processes, namely, developing structures and systems. (S.-i. Park and YW 2014)**.** In addition, there is another term, namely, System Dynamic is a method that goes beyond a conventional systems approach domain for large-scale engineering complexity problems. Dynamic system deals with the interaction of various elements of the system over time and captures dynamic aspects by including concepts such as availability, flow, feedback and delay and thus provides insight into the dynamic behavior of a system over time. (Tang and Vijay 2001). Dynamic systems can be considered as an extension of engineering systems (System Engineering) and systems analysis (System Analysis). System Dynamic explicitly takes into account the dynamic behavior that results due to delays and inputs in the system. System Dynamic is a perspective anda conceptual tool that makes it possible to understand structures and dynamic complex systems.

System dynamic is a method that has modeling rigor that allows for making formal computer simulations of complex systems and using it to design more effective and organized policies (Sterman 2000) Using system dynamics method can make it easier to solve problems, especially in case studies to predict events which will come. As well as knowing the prospects for sustainability and ship safety in a comprehensive manner. In addition, the use of system dynamics method can be used to determine alternative scenarios for ship operation risk management policies to improve and guard ship safety and security. So that we get an evaluation of the ship's safety and security guarantee plan in a sustainable manner in reducing the number ofship accidents. These aspects are the parameters in describing the use of the Dynamic System such as the number of increases in ship accidents, causes of ship accidents and the potential for ship accidents. Risk management in this case plays a very important role in reducing the rate of ship accidents and as the main objective in modeling with dynamic systems. Several other parameters that are considered in risk management modeling, such as the number of ship extinguishing systems, the availability of safety devices during an emergency and the emergency mitigation pattern in the event of a ship accident. All the parameters that make up a dynamic system model are divided into two distinct groups of constants or auxiliaries. A constant is a permanently fixed amount throughout the system processing time, while helpers are defined as equations between different constants, which may change during system processing. (H. Abbaspur 2018)

In system dynamics, there is a system called a closed system. A closed system is controlled by two kinds of loops feedback are loops of positive and loops. negative loop Positive is a loop that describes the process of strengthening themselves in an act which creates the resultsproduce more action. In a loop positive that results in more actions, more results are obtained. The process of feedback (feedback) is positive can be described as a circle of positive and negative circle. In general, the feedback process (feedback) is positive disrupt the system and cause other variables out of the position of the previous variable. Thus, positive feedback has an influence on the growth or continuation of a system, although positive feedback sometimes stabilizes negative variables and positive variables.

2.6 Risk Management

Risk management is a formal process by which an organization or company establishes risk objectives and targets and identifies and analyzes risks and implements steps to address risksin an organized and coordinated manner. The purpose of risk assessment is the identification and development of a comprehensive understanding of organizational risks. Effective risk assessment involves a systematic and ongoing process to identify and examine risks and decide which risks are important (Young and Tomski 2002). In addition, the risk is recognized as an unknown change in the value of the system in the future. Risk can be viewed as a threat, but there is a way to deal with certain risks (Wu and Olson 2009). The key to organizational success in risk management lies in the ownership and responsibility of risks managed by the management of the organization. The main function is in the level of compliance of the organization in implementingsafety and security regulations. According to the Australian / New Zealand standard on Risk Management principles and guidelines, the risk management process consists of: establishing the context, identifying risks, analyzing risks, evaluating risks, and treating risks. (Sunaryo and Hamka 2017). Risk management is carried out to reduce the unwanted effects of a work plan. So that the level of security and safety in a work plan can be improved. With the increase in safety and security, especially in the field of marine transportation, it will give the public confidence to use this marine transportation mode. Increasing public trust can improve the company's performance to continue providing the best quality. From increasing public trust due to an excellent risk management analysis.

3. METHODOLOGY

The overall step of the research methods has a total 8 steps starts is Problem Identification and Formulation. In this process the planning stage is carried out regarding something that needs to be learned. At the same time planning on the data that will be carried outresearch. Identification of problems regarding the causes of the increasing number of ship accidents in Indonesia. The formulation of the problem was carried out to determine the vehicle used to comprehend the prospects for sustainability of ship safety and security in a comprehensive manner. The main problem that needs to be resolved is the development of a risk management planning model. So that the development of this model can be used to ensure the sustainability of ship safety and security. In addition, problem formulation is used to see alternative scenarios for ship operation risk management policies. Because this scenario serves toimprove and guard the safety and security of the ship. The second step is Literature Study. In the next process, namely conducting a literature study. The purpose of the literature study is to find basic theories as a reference for the research process. Other supporting information from the literature study framework is useful for the process of discussing and analyzing data. Literature studies are obtained from international research journals and national journals and theoretical books related to the scope of research. Previous studies on modelling dynamic systems and risk management have become the focus of literature studies. The theory of the sustainability of the system is needed to determine the risk management analysis on ship safety and security that can be applied to shipping companies. So that the basic research process can have a basis for work, especially in modeling risk management planning. The third step is Determination of Methodology. In the process of determining the methodology, a comprehensive literature review is needed on the basis of theory that has been adjusted in research. The determination of the methodology is based on research problems. The literature review at the previous stage served as a guide in determining the methodology. The methods that have been used in the literature review serve as evaluation materials for problem solving and provide scope for using methods that have not been used to support problem solving. The methodology used in this research uses the System Dynamic method. Because in the literature review in solving risk management problems, it is necessary to use methods that are dynamic and can change. The description of cause and effect using the System Dynamic method in describing the variables used becomes more detailed and complex. The fourth step is Data Collection. The collection stage was carried out throughprevious studies regarding the development of models in risk management planning and the use of methods in the system Dynamic. To get better results of model validation in research analysis, company data is needed. These data are about the potential for ship accidents and the plan for handling ship accidents as well as technical data on ship accident management equipment.Making decisions on policies to improve risk management will affect the completeness ofresearch data. The five step is System Dynamic Modeling. In research problems that aim to determine the risk management sustainability planning regarding ship safety and security, it is necessary to use System Dynamic modeling. The use System Dynamic modeling uses complex variables as model building variables so that it can project the level of risk management in the future. By using System Dynamic modeling in the use of cause and effect functions will be able to describe the supporting variables in a system. The system is built based on data on the potential for ship accidents and data on plans for handling ship accidents. The Six Step is Validation Modeling. Ship accidents needs modeling validation. Modeling validation is done by checking each model forming variable. Modeling variables are checked according to existing data and the calculation of risk management analysis is considered according to the actual object. Modeling must describe the real system behavior in each basic structure of the model and can accurately represent the variable data that is used as a model. The results of the risk management modeling analysis are tested repeatedly to ensure the accuracy, both in terms of the variables being analyzed and the results of the modeling. The Seventh Step is Analysis of Result. Data riskanalysis and risk management modeling after modeling validation, the next stage is to analyze the results of the model. Analysis of the modeling results is carried out by selecting each appropriate modeling variable to be applied to risk management planning for ship safety and security. By analyzing the selected modeling results, a comparison of the level of risk that will occur on the ship with a certain time projection will be obtained. So that from the results of these comparisons it can be seen that the appropriate planning scenario in anticipating ship accidents. Then, the final step is conclusion. In the final results of the study, conclusions will be drawnfrom all the stages in research regarding risk management planning on ship safety and security. The conclusions obtained from a summary of all stages of the research. In addition, the research conclusions contain answers to research problems, namely regarding risk management planning scenarios in ensuring ship safety and security.

4. RESULTS AND DISCUSION

4.1 Making Causal Loop Diagram

In conducting ship management planning analysis by using system dynamics method in order to find out a guarantee of sustainability of safety quality and security of ship operation detail of any variables that are analyzed and interconnected can be seen through the causal loop diagram. With through causal loop diagram, it can be seen the main flow of the ship managementplanning analysis for increase safety quality and security of ship operation.

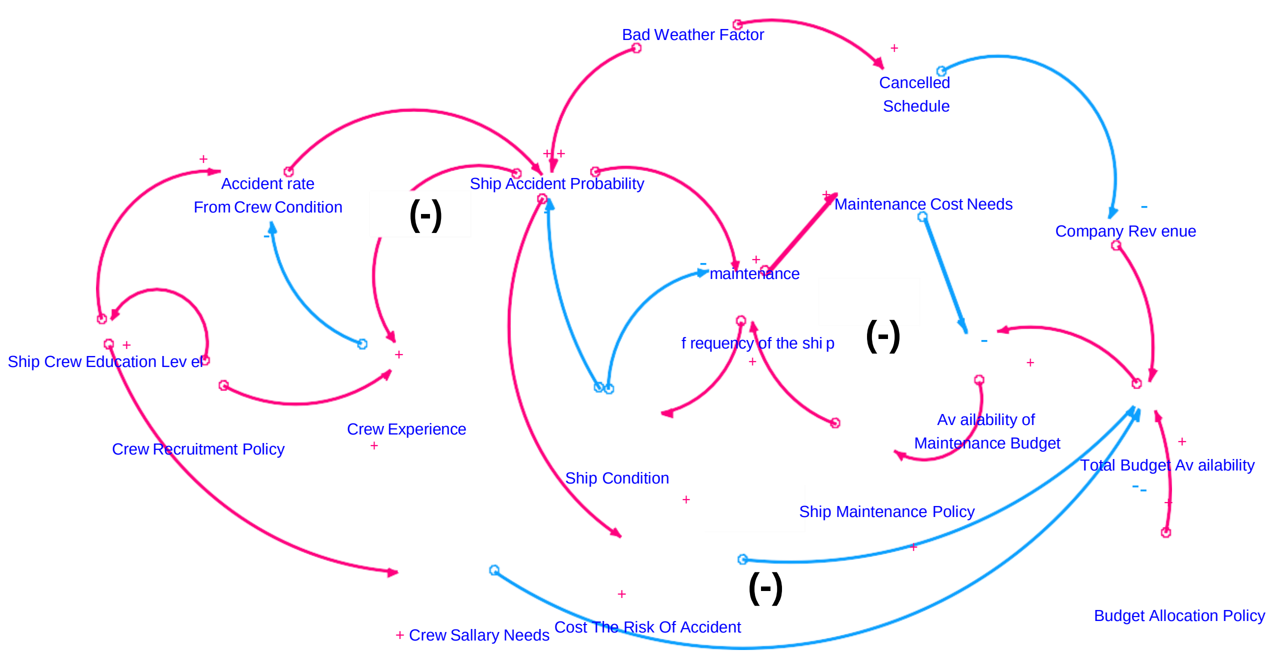

Figure 1. Causal Loop Diagram

From the Figure 1. Causal Loop Diagram can see about the system dynamic approach. Where in this case the ship accident probability is influenced by several factors, including the ship condition. If the ship condition is low, the ship accident will increase. In addition, ship accidents are influenced by Cost the risk accidents. This is if the cost of the risk accident increases, it will affect the increase in ship accidents. Crew experience also has an effect on ship accident probability. With an increase in ship accident probability, the number of crew experience will increase. Accident rate from crew condition can affect ship accident probability. If the accident rate from crew condition increases, the ship accident probability will increase. Bad weather on a cruise will affect the shio accident probability. The higher the intensity of bad weather, the increase will occur in a ship accident probability. In addition, there is a causal relationship between other influencing variables. Bad weather affects the ship's sailing schedule. The higher the bad weather, the more delayed cruise schedule. So that it affects the company's revenue. The company's revenue will decrease. Company revenue will affect the availability of the total budget. The higher the company's revenue, the higher the total budget availability. The availability of the total budget will affect the availability of the maintenance budget. The increasing availability of the total budget will increase the availability of the maintenance budget.So that the availability of maintenance budget will affect the variable maintenance cost requirements and ship maintenance policies. By increasing the availability of maintenance budget, it will increase the ship maintenance policy. so that it affects the frequency of ship maintenance. the higher the ship maintenance policy, the higher the frequency of ship maintenance as well as the effect on the maintenance costs and condition of the ship. thecondition of the ship is getting worse due to an increase in the frequency of ship maintenance. in this case it can reduce ship accident probability. With a decrease in ship accident probability, it will reduce the cost of the risk accident. Thus increasing the total budget availability due to a decrease in the cost of the risk accident. The total budget availability will be affected by the budget allocation policy. In addition, total budget availability is influenced by crew salary needs which come from the ship crew education level. The higher the ship crew education level, the higher the crew salary need. With an increase in the ship crew education level, the crew recruitment policy will increase and will affect crew experience which also affects the ship accident probability.

4.2 Making Stock and Flow Diagram

Making simulation models is used as a basis for designing policy scenarios to support efforts to improve ship safety management. The first stage is to determine variables and entities, then create a conceptual model in the form of a causal loop diagram. From the validated conceptual model then a simulation model or stock and flow diagram is built and verification and validation of the simulation model is carried out to determine the design of the ship safety management policy scenario.

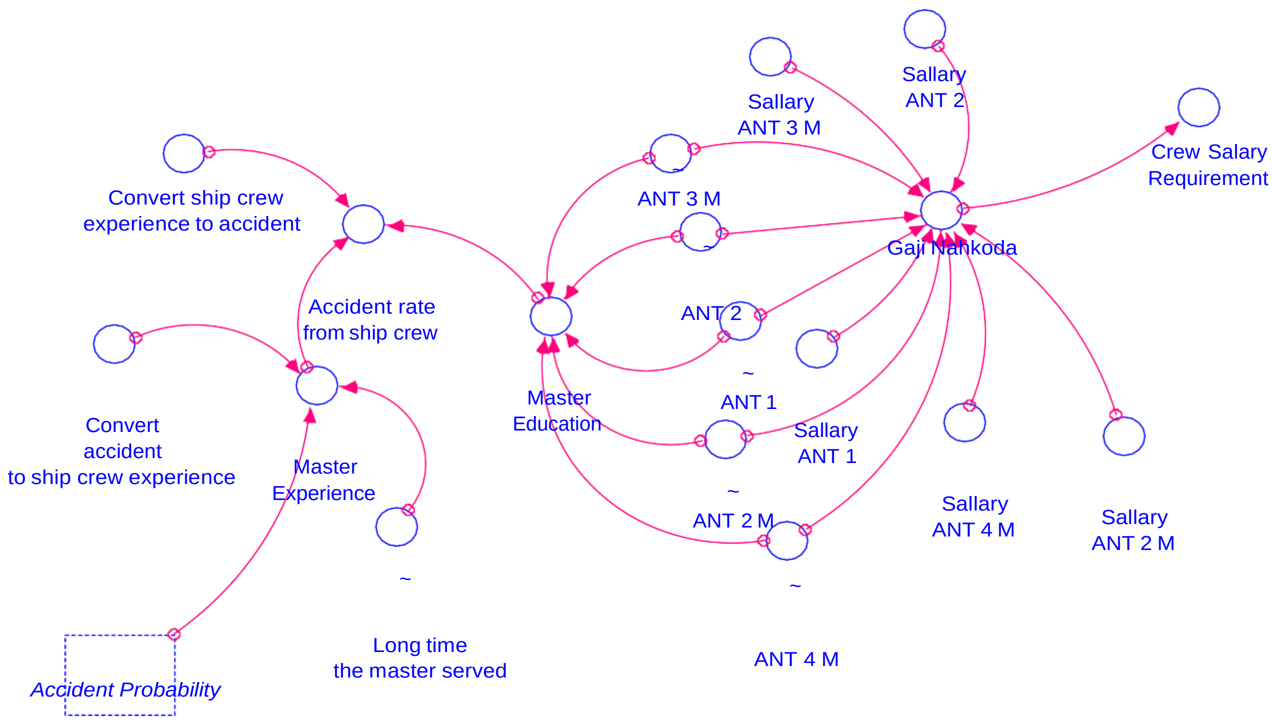

Figure 2. Sub Model Condition About Ship Crewing

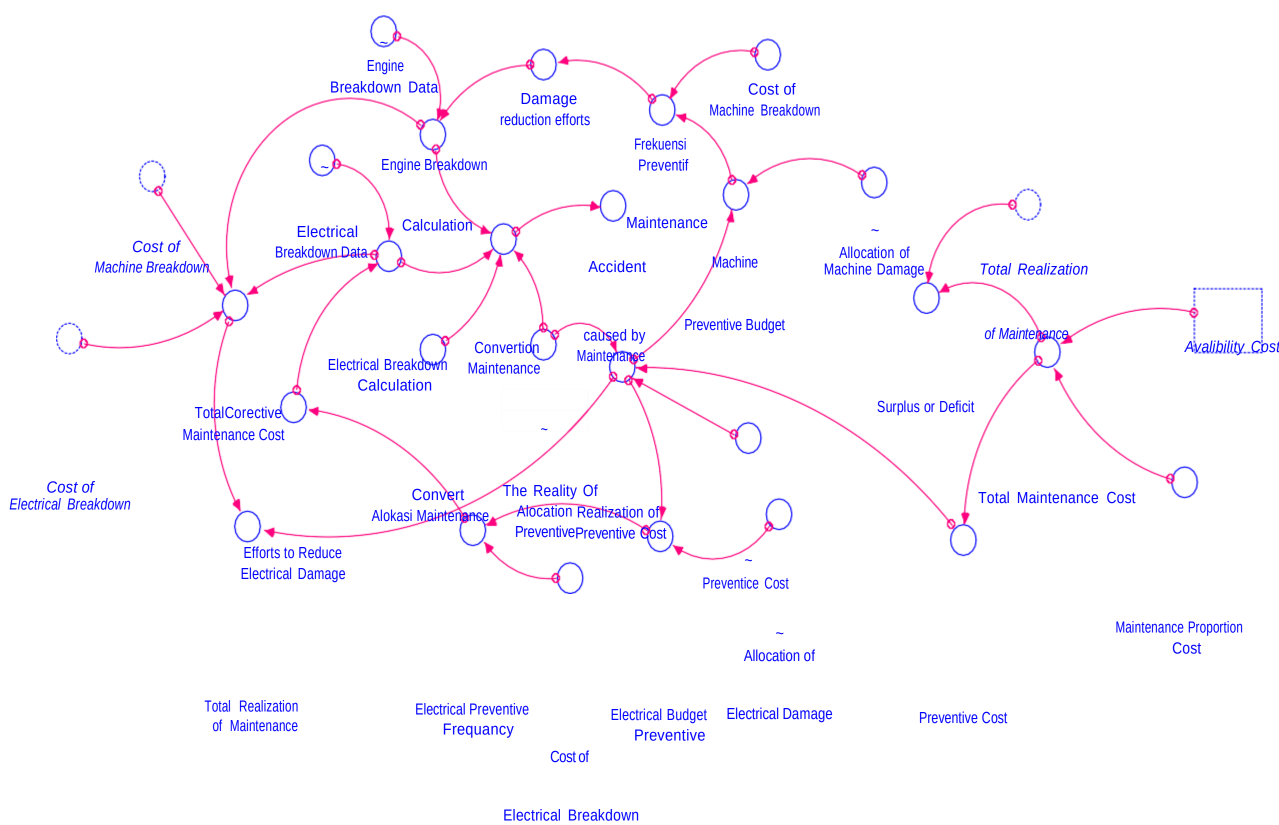

Figure 3. Ship Maintenance Sub Model

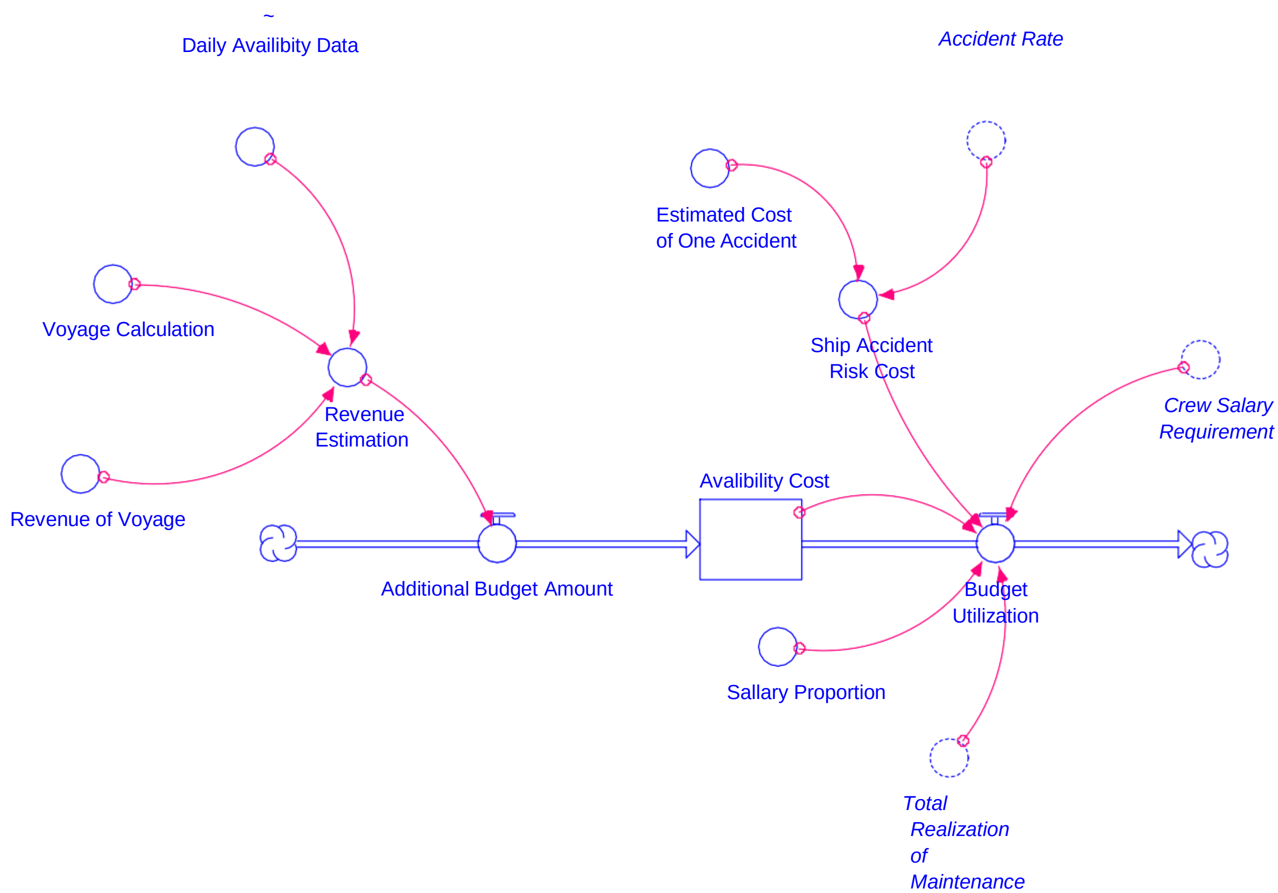

Figure 4. Sub Model of Ship Cost

By looking at the stock and flow diagrams of several models. It can be seen that the variables that affect each part of the causal loop diagram can be transformed in each part of the sub- model. In the crew management sub-model, it can be seen that the higher the master's education will affect the level of ship accidents. other than that the experience of the master will affect the rate of ship accidents. so that the cost of master salaries affects experience and level of education. In addition, in the ship maintenance sub model, it can be seen that the higher the corrective maintenance costs on the electricity and the engine will increase the total maintenance costs of the ship. The increase in maintenance costs can be seen from the data of each expenditure on the annual expenditure of corrective maintenance costs. so that the total maintenance costs will greatly affect the availability of the total budget. the higher the maintenance level of the ship, the more it will reduce the number of ship accidents. Ship revenueis influenced by the level of the ship's departure schedule which depends on the condition of the ship and the weather. With the ship availability level, it will increase ship revenue by taking intoaccount the revenue for each ship voyage. Ship revenue has an effect on budget availability. budget availability will be reduced by crew salary requirements, ship accident risk cost, salary proportion and total realization of maintenance cost. The higher the ship accident risk rate, the more it will affect the availability of the total budget.

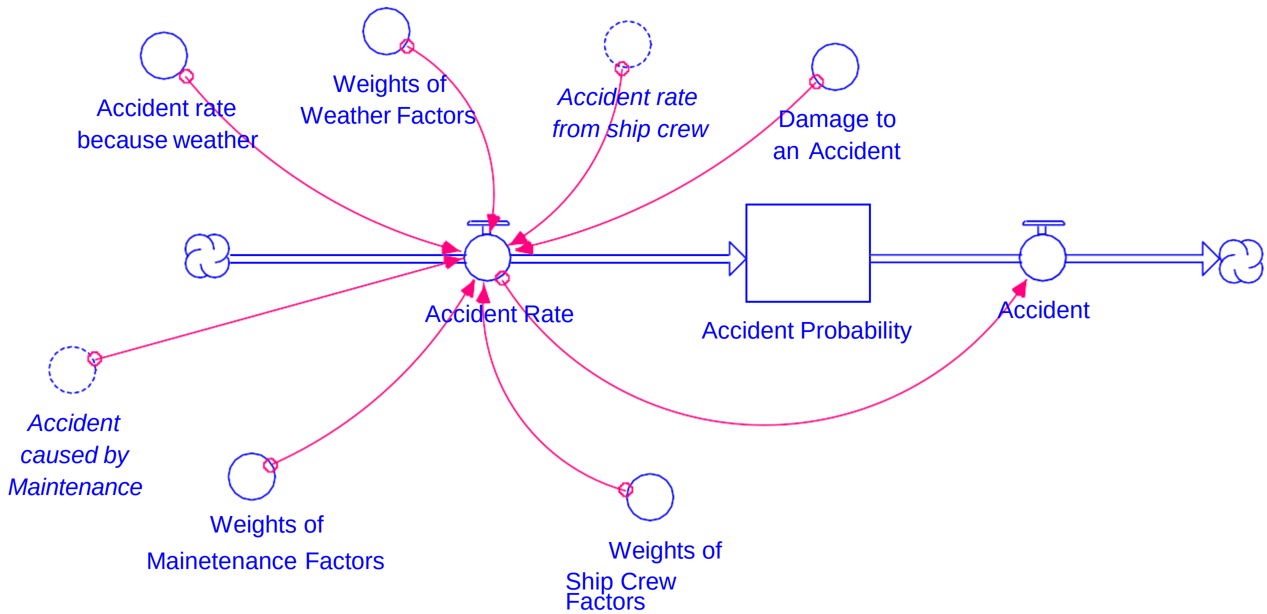

Figure 5. Sub Model of Damage Prediction

The level of accident prediction is influenced by the variable accident damage, the accident rate of the crew, the weight of the weather factor, the accident rate because of weather, the accident cause by maintenance, the weight of maintenance factor and the weight of ship crew factors. of the total variables that are very influential on the level of ship accident prediction are maintenance factor and ship crew. if the higher the level of ship maintenance, the lower the level of ship accidents. If the experience of ship crew education is higher, the level of ship accidents will decrease. Weather factors do not have a significant effect on the level of ship accidents dueto the type of ship and ship maintenance factors and ship crew experience.

5. CONCLUSION

The level of safety and security of the ship is influenced by several factors. These factors include ship crew education level, ship crew experience level, ship maintenance, weather factors and ship operational level. With the ship availability level, it will increase ship revenue by taking into account the revenue for each ship voyage. Ship revenue has an effect on budget availability. Budget availability will be reduced by crew salary requirements, ship accident risk cost, salary proportion and total realization of maintenance cost. The higher the ship accident risk rate, the more it will affect the availability of the total budget. If the experience of ship crew education is higher, the level of ship accidents will decrease. Weather factors do not have a significant effect on the level of ship accidents due to the type of ship and ship maintenance factors and ship crew experience.

6. REFERENCES

Abimbola, M., Khan, F., & Khakzad, N. (2014). Dynamic safety risk analysis of offshore drilling. Journal of Loss Prevention in the Process industries, 74-85.

Ayag, Z., & Ozdemir, R. (2006). A fuzzy AHP approach to evaluating machine tool alternatives. Journal of Intelligent Manufacturing, 179-190.

Bhandari, J., Abbassi, R., Garaniya, V., & Khan, F. (2015). Risk analysis of deepwater drilling operations using Bayesian Network. Journal of Loss Prevention in the Process Industries, 11-23.

Direktorat Jendral Perhubungan Laut. (2014). Laporan Tahunan 2011. Jakarta: Kementrian Perhubungan Republik Indonesia.

H. Abbaspur, C. D. (2018). Optimized Design of Drilling and Blasting Operations in Open Pit Mines Under Technical and Economic Uncertainties by System Dynamic. InternationalJournal of Mining Science and Technology, 839-848.

Jean-Francois, Lafont, F., Maifret, R., & Pessel, N. (2009). Maritime Risk Assessment (MARISA), a Fuzzy Approach to Define an Individual Ship Risk Factor. Ocean Engineering, 1278-1286.

Komite Nasional Keselamatan Tranportasi RI. (2020). Status Laporan Investigasi Kecelakaan Transportasi dan Monitoring Rekomendasi Keselamatan Transportasi Komite Nasional Keselamatan Transportasi Republik Indonesia. Jakarta: KNKT RI.

Komite Nasional Keselamatan Transportasi Indonesia. (2016, Maret 04). Introduction KNKT Dephub RI. Retrieved from KNKT Departemen Perhubungan RI: http://knkt.dephub.go.id/knkt/ntsc_maritime/maritime.htm

Park, K. (2008). A new method for estimating human eror probabilities: AHP-SLIM. Reliability Engineering and System Safety, 578-587.

Park, S.-i., & Y. W. (2014). System Dynamics Modeling for Determining Optimal Ship Sizes and Types in Coastal Liner Services. The Asian Journal of Shipping and Logistics, 31-50.

Rumaji, & Adiliya, A. (2019). Port Maritime Connectivity in South-East Indonesia: A New Strategic Positioning for Transhipment Port of Tenau Kupang. The Asian Journal of Shipping and Logistic, 172-180.

Sterman, J. (2000). Business Dynamics: Systems Thinking and Modeling for a Complex World. Boston: Mac-Graw Hill.

Sunaryo, & Hamka, M. A. (2017). Safety Risks Assesment on Container Terminal Using Hazard Identification and Risk Assesment and Fault Tree Analysis Methods. Procedia Engineering, 307-314.

Tang, V., & Vijay, S. (2001). System Dynamics origin development and future prospects of a method. Research Seminar in Engineering System. Cambridge: MIT Press.

Uusitalo, L. (2007). Advantages and Challenges of Bayesian Networks in Environmental Modelling. Ecological Modeling, 312-318.

Vinodh, S. (2012). AHP - Based Lean Concept Selection in a Manufacturing Organization. Journal of Manufacturing Technology Management, 124-136.

Wu, D. D., & Olson, D. L. (2009). Introduction to the Special Section on “Optimizing Risk Management:Methods and Tools". Human and Ecological Risk Assessment, 220-226.

Yeo, C., Bhandari, J., Abbassi, R., Garaniya, V., Chai, S., & Shomali, B. (2016). Dynamic risk analysis of offloading process in floating liquefied natural gas (FLNG) platform using Bayesian Network. Journal of Loss Prevention in the Process Industries, 259-269.

Young, P., & Tomski, M. (2002). An introduction to risk management. Physical Medicine and Rehabilitation Clinics of North America, 225-246.

Zaddeh, L. (1975). The concept of a linguistic variable and its application to approximate reasoning. Information Sciences, 199-249.

Zheng, G., Zhu, N., Chen, Y., & Sun, B. (2012). Application of a trapezoidal fuzzy AHP method for work safety evaluation and early warning rating of hot and humid environments. Safety Science, 228-239.

TOPIC

Lean Manufacturing

LEAN ASSESSMENT ON DAIRY MANUFACTURE WITH QUALITATIVE AND QUANTITATIVE APPROACH

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ABSTRACT

PT. X is a dairy industry located in East Java province. PT. X has implemented lean manufacture since 2015. Lean manufacture is a continuous process, so it needs to be followed by an evaluation or assessment process of lean implementation. For that, it is very important for PT. X to conduct a lean assessment, because so far it has never been implemented. In addition, the need to conduct lean assessment is also driven by the Overall Equipment Effectiveness (OEE) value of PT. X which only reaches 40% to 60% where the company's target is 75%. This suggests that a process improvement is needed where a lean assessment can identify areas that need improvement. Lean assessment is done by modifying the lean assessment tool from previous research which is quantitative approach. From the qualitative lean assessment results with the aggregate scoring method and quantitative with the fuzzy logic method, it is known that the order of the dimensions with the worst to best Leannes values is time effectiveness, cost, inventory, delivery, quality, process, human resources, customer. The dimension of time effectiveness as a critical dimension with the lowest Leannes value, which is 0.677, is the focus for root cause analysis using 5 whys method. Each root cause of the problem identified from each indicator has made recommendations for improvement plans based on the level of effectiveness and difficulty as well as the priority scale. By compiling an improvement plan such as create a preventive maintenance program outside of production time and arrange standard procedures related to troubleshooting & problem solving, it is expected that after implementation it will increase the ability to implement lean manufacturing and the company's OEE value.

Keywords: lean assessment, lean manufacture, OEE, dairy industry, fuzzy logic.

1. INTRODUCTION

Lean manufacturing is a systematic approach to eliminating all kinds of waste that comes from the manufacturing process. This method originated from Toyota Company and was previously named the Toyota Production System, and was adapted to many other manufacturing companies (Salonitis and Tsinopoulos, 2016). Lean manufacturing is also a concept that aims so that the production process does not produce defective products, reduces costs, meets customer demand according to demand and time, does not have stored stock, and makes continuous improvements by eliminating waste (Arslankaya and Atay, 2015). Waste that must be eliminatedis anything that does not add value to the product (Womack, 2003).

Wilson (2010) states that the application of lean manufacturing can not only be applied to manufacturing companies but can also be applied to several other sectors, such as company management and education also health services or services. Lean manufacturing can also be applied to companies that have a continuous production system or are classified as processindustries. An example is in a food and beverage company, such as dairy products made by companies in Norway (Powell et al., 2017).

Narayanamurthy and Gurumurthy (2016) divide the stages of lean implementation into three phases, which is preparation for lean implementation; lean implementation; and lean assessment. The preparatory phase for lean implementation is the initial stage in implementing lean implementation, which requires readiness and commitment from management. Then the next phase is to implement lean, in which the implementation requires the cooperation of all employeeswith management. This is necessary to identify all activities that do not add value to the company's operations. After these activities are identified, improvements are made to eliminate these activities so that the company's operational processes become more efficient. The last phase in implementing lean is lean assessment, which is a stage that measures the leannes level of a company in implementing lean. Lean assessment is conducted to find out whether the company is getting better after implementing lean, so that the company can make continuous improvements based on the results of the lean assessment that has been done.

PT. X is one of the manufacturing process industries in the food and beverages sector that produces dairy products and is established in East Java, Indonesia. PT. X has implemented lean manufacturing since 2015. The company has two production lines with different capacities but the same process, and as a productivity measure, the overall equipment effectiveness (OEE) value is used as a reference. OEE itself is a parameter that measures the level of effectiveness of a manufacturing industry in terms of time; performance; and quality. Expectations from the application of lean manufacturing by PT. X is able to increase company productivity with the indicator used, which is the OEE value.

In implementing lean manufacturing PT. X has implemented several related tools to eliminate waste, starting from the 5Ss (sort, set in order, shine, standardized, sustain); standardization of processes (work instructions and standard operating procedures); visual management; lay out the production area; and the application of SMED (single minute exchange of die). With the application of these tools, it is still apparent that the OEE value has not reached the target, which is 75%, especially in terms of time, for the OEE value of PT. X in 2019 is still in the range of 40% to 60%. Some problems are seen, such as the unstable time to changeover between products, frequent repeated minor stops, and breakdowns that must overhaul the engine.

With these existing conditions, it is necessary to evaluate the level of implementation of lean manufacturing or lean assessment at PT. X. With a lean assessment, we can find out the level of lean that has been implemented (Pakdil & Leonard, 2014) and then provide direction to make continuous improvements that have an impact on the value of OEE. So far, PT. X has never conducted an assessment of the implementation of lean manufacturing.

This study conducted a lean assessment on lean implementation at PT. X. Leanness measurement is carried out based on a modified lean assessment tool (LAT) published by Pakdil & Leonard (2014). Research from Pakdil & Leonard (2014) is the initial basis for developing the method because in their research they use two approaches, which is qualitative and quantitative. So it is hoped that the method developed will be more comprehensive. The LAT modification process is carried out based on the limitations mentioned in the research by Pakdil & Leonard (2014), which are related to several differences in performance indicators between companysectors and the weight of the criteria for each indicator in companies that carry out lean assessments. In this study, LAT Pakdil & Leonard (2014) modifications were made to suit the conditions of PT. X which is a producer of dairy products. Based on the results of the lean assessment conducted, recommendations for improving the implementation of lean suggested for the company are formulated so that it is expected to improve the OEE value.

2. METHOD

This section will explain the methodology to be carried out in this research. This research is a descriptive study that aims to see the actual conditions in a company, so that with the existing observations, a proposed improvement plan can be prepared. This research is divided into three phases starting from the development of the lean assessment tool, applying the lean assessment tool, and processing the results of the lean assessment tool.

2.1 Lean Assessment Tool Development

The first phase of three phases in this research methodology, is to develop a lean assessment tool. The intended development in this study is to modify the lean assessment tool from Pakdil & Leonard (2014) which is suitable for PT. X as a producer of dairy products. The modifications made are related to the lean assessment indicator in order to adjust the company condition and the available data. Modification of this indicator is carried out in discussions withthe Production Manager and Plant Manager of PT. X. The reason why the LAT developed by Pakdil & Leonard (2014) still has to be developed because it is related to the limitations mentioned in the research by Pakdil & Leonard (2014), which are related to several differences in performance indicators between company sectors and the weight of the criteria for each indicator in companies that conduct lean assessments.

2.2 Lean Assessment Tool Application

After obtaining the lean assessment tool model that has been developed based on the condition of the company and the availability of existing data, direct observation and data collection are carried out to obtain the data needed to carry out the research. The data collection process was carried out twice, which is for qualitative and quantitative purposes. A qualitative approach is used to collect primary data which is data from interviews with the company. Intendedinterviews are conducted indirectly by using a questionnaire to company employees. The list of questions on the questionnaire follows from previous research (Pakdil & Leonard, 2014). From these questions, it will be known the perceptions of the company with the choice of answers to each question including strongly disagree, disagree, neutral, agree, and strongly agree. The quantitative approach is used to collect secondary data which is data from recapitulation of company performance reports. An example of data that can be taken for a quantitative approach is if for the process dimension, one of the indicators is the overall equipment effectiveness (OEE) value. The OEE value itself is also used by PT. X as a measure of productivity, so that this research can be evaluated from the OEE value of PT. X.

The calculation of lean dimensions is carried out to determine the level of lean implementation in the company. The calculation is done using secondary data from the modified indicators and a quantitative lean assessment is carried out using the fuzzy approach (Behrouzi & Wong, 2011), while the qualitative lean assessment is carried out using the aggregrate scoring approach (Almomani et al, 2014). The measurement results of the quantitative lean assessment and qualitative lean assessment will be weighted using the Brown-Gibson method to obtain the value of the degree of lean for each dimension (Wignjosoebroto, 2009). The calculation using the Brown-Gibson method is carried out on only five dimensions, which is quality, process, customer, human resources and delivery. The Brown-Gibson method is needed to analyze decisions that require subjective (qualitative) and objective (quantitative) data, so that by using these two data characteristics more comprehensive decisions can be made. For the dimensions of time effectiveness, cost, and inventory, only quantitative calculations are carried out because the measurement of the leanness value in those three dimensions is more effective by using quantitative measurements.

From the results of the lean assessment calculation, the analysis is carried out to determine which lean dimensions get the critical criteria. Analysis of determining the critical dimensions is carried out by observing the results visualized through the Lean Radar Chart. Critical dimension criteria are discussed with companies, which is Production Manager and Plant Manager from PT. X. The value of leanness is based on the range of values on the Lean Radar Chart, which is zero to one hundred, the dimensions that are said to be critical are those whose values are less than 75. Later, if there is more than one dimension that has a value less than 75, it is in accordance with the company's discussion, which is the Production Manager. and Plant Manager, that the dimension with the lowest leanness value will be taken. By choosing the lowest dimension, so that the improvements made can be more focused.

2.3 Processing of results from the Lean Assessment Tool

After knowing the critical dimensions that exist, an analysis of the root of the problem is carried out. The analysis was performed using the Root Cause Analysis method, which is 5 whys because there was a deeper analysis of the source of the problem. From the results of the analysis that has been carried out to identify the root of the problem, an improvement plan is drawn up based on the level of effectiveness and difficulty in implementing the improvement plan and the priority scale. The determination of the improvement plan adopts the calculations used in the house of risk (HOR) method in the 2nd HOR matrix (Pujawan & Geraldine, 2009).

The level of effectiveness is seen from the magnitude of the impact that can be achieved from implementing the improvements, from a scale of 1; 3; 9 the greater the value, the more effective the repair plan will be. The level of difficulty is seen from the amount of costs that must be incurred by the company in implementing the improvement plan, from a scale of 1 to 5 the greater the more difficult it is to implement the improvement plan. For the classification of effectiveness and difficulty levels which are used as a reference for calculating the priority scale, this is compiled based on the results of discussions with the company. Meanwhile, for determiningthe scale value of the level of effectiveness is taken from previous research (Pujawan & Geraldine,2009), and for the level of difficulty determined the results of discussions with the company.

3. RESULTS AND DISCUSSION

The first phase of this research is to develop a lean assessment tool (LAT). LAT development is meant not to create a new method, but to modify the existing method. In Pakdil & Leonard's (2014) research, LAT was developed using eight dimensions related to waste. The determination of the eight dimensions was carried out by Pakdil & Leonard (2014) based on the literature review process from previous studies. For the qualitative approach, the indicators are selected based on the perceptions of the stakeholders regarding the dimensions being assessed, while for the quantitative approach the indicators are selected based on benchmarks that can be used to measure the achievement related to the dimensions being assessed. In this study, the LAT that has been developed by Pakdil & Leonard (2014) carried out a modification process related to the indicators that will be used as a measure of assessment. The modification process is carried out outbased on discussions from the Production Manager and Plant Manager of PT. X. By modifying the

LAT from previous studies, LAT can adjust to the conditions characteristic of PT. X and the availability of existing data so that it can produce more suitable data.

In this study, the qualitative approach still uses the same dimensions and indicators as previous studies (Pakdil & Leonard, 2014), because of the results of discussions with the Production Manager and Plant Manager of PT. X can still be considered relevant for use at PT. X. Measurements with a quantitative approach are carried out by looking at current data compared to historical data of the company or standards set by the company. From the results of discussions with the Production Manager and Plant Manager of PT. X, with LAT that has been developed in previous research (Pakdil & Leonard, 2014) for a quantitative approach for each dimension thereis a modification of the indicator. The list of indicators from all dimension that been modified which is used in this reasearch as shown in Appendix A.

The second phase carried out in this study is the application of the lean assessment tool (LAT). The application of this study is to collect existing data for both qualitative and quantitative approaches, and to use it to perform lean assessment calculations with modified LAT in the previous stage. Data collection for the needs of a qualitative approach was carried out by distributing questionnaires. In distributing this questionnaire addressed to parties representing eachstakeholder associated with the production process of PT. X, as well as the one who best understands the condition of each dimension being assessed. For technical distribution of the questionnaire using software technology from Google Form, the answers will be collected via email. Data collection for the quantitative approach is carried out by taking recording data from companies. In this study, the time used as the object of observation was November 2020.

Table 1. Leannes value measurement results for the Qualitative approach

Dimension	Aggregate Score (AS)	Number of Question (q)	Total Maximum Score (MTAS)	Leannes Value
Quality	41	11	55	0,745
Customer	10	2	10	1,000
Process	64	15	75	0,853
Human Resources	34	8	40	0,850
Delivery	60	15	75	0,800

The results of LAT calculations with the qualitative approach using the aggregate scoring method are shown in Table 1. Based on the calculation results for LAT with the qualitative approach, it is known that, for the order of dimensions with the lowest to highest Leannes values are quality, delivery, human resources, process, customer. The results of LAT calculations with the quantitative approach using the fuzzy logic method are shown in Table 2. In the calculation of LAT with a quantitative approach to determine the worst value, existing value, and best value using direct observation and historical data from the company and the standard target of the company. The worst score and the best score will be used as a reference in calculating the Leane value of each indicator representing the dimensions being assessed. Based on the results ofcalculations for LAT with a quantitative approach, it is known that, for the order of dimensions with the lowest to highest leannes values are time effectiveness, cost, inventory, delivery, process, human resources, quality, customer.

Table 2. Leannes value measurement results for the Quantitative approach

Dimension	Indicator Code	Existing Value (xi)	Best Value (a)	Worst Value (b)	Leannes Value
Time Effectiveness	T1 (Line A)	58,9 minutes	44,24 minutes	93,28 minutes	0,701
	T1 (Line B)	66,0 minutes	40,5 minutes	102,2 minutes	0,586
	T2 (Line A)	8,2 %	6,6 %	15,9 %	0,827
	T2 (Line B)	9,6 %	7,2 %	14,2 %	0,657
	T3 (Line A)	224,9 minutes	155,17 minutes	280,6 minutes	0,443
	T3 (Line B)	224,4 minutes	155,17 minutes	275,8 minutes	0,426
	T4 (Line A)	26,1 %	26,0 %	35,0 %	0,935
	T4 (Line B)	17,8 %	16,9 %	30,5 %	0,933
	Tx (T1; T2; T3; T4)				0,689
	T5	4 days	3 days	6 days	0,667
Total *leannes* value					**0,677**
Dimension	**Indicator Code**	**Existing Value (xi)**	**Best Value (a)**	**Worst Value (b)**	**Leannes Value**
Quality	Q1	0	0	5	1
	Q2	0	0	3	1
	Q3	99,8 %	100,0 %	0 %	0,998
	Q4	41,7 %	100,0 %	0 %	0,416
Total *leannes* value					**0,853**
Dimension	**Indicator Code**	**Existing Value (xi)**	**Best Value (a)**	**Worst Value (b)**	**Leannes Value**
Process	P1 (*Line* A)	64,5 %	75,0 %	40,7 %	0,693
	P1 (*Line* B)	71,4 %	75,0 %	48,2 %	0,865
Total *leannes* value					**0,779**
Dimension	**Indicator Code**	**Existing Value (xi)**	**Best Value (a)**	**Worst Value (b)**	**Leannes Value**
Customer	C1	Rp. 4.560	Rp. 4.200	Rp. 5.000	0,550
	C2	Rp. 2.100.000	Rp. 1.500.000	Rp. 10.000.000	0,929
	C3	Rp. 14.735.000	Rp.10.000.000	Rp. 25.000.000	0,684
Total *leannes* value					**0,721**
Dimension	**Indicator Code**	**Existing Value (xi)**	**Best Value (a)**	**Worst Value (b)**	**Leannes Value**
Inventory	I1	0,68	1	0	0,680
	I2	1,27	1	2	0,730
	I3	0,24	0	1	0,760
Total *leannes* value					**0,723**
Dimension	**Indicator Code**	**Existing Value (xi)**	**Best Value (a)**	**Worst Value (b)**	**Leannes Value**
Customer	S1	100 %	100 %	0 %	1
	S2	0	0	5	1
Total *leannes* value					**1**
Dimension	**Indicator Code**	**Existing Value (xi)**	**Best Value (a)**	**Worst Value (b)**	**Leannes Value**
Delivery	D1	6 days	5 days	8 days	0,667
	D2	0,8 days	1 days	0,5 days	0,600
	D3	98,8 %	100 %	0 %	0,988
Total *leannes* value					**0,751**

Table 2. Leannes value measurement results for the Quantitative approach (Cont'd)

Dimension	Indicator Code	Existing Value (xi)	Best Value (a)	Worst Value (b)	Leannes Value
Human Resources	H1	0 %	0 %	25 %	1
	H2	0 %	0 %	1,5 %	1
	H3	0,03	0,04	0	0,773
	H4	67 %	100 %	0 %	0,670
	H5	100 %	100 %	0 %	1
	H6	100 %	100 %	0 %	1
	H7	5	5	0	1
	H8	110,87 %	100 %	0 %	1,108
	H9	10,82 %	100 %	0 %	0,108
Total *leannes* value					**0,851**

After knowing the leannes value of each measurement from both the qualitative and quantitative approaches, a leannes value was combined for several dimensions which were assessed using the two approaches. The dimensions that are combined in value are quality,process, customer, human resources and delivery. For the dimensions of time effectiveness, cost, inventory, it is not enough to combine the quantitative approach because the three dimensions are more accurate in interpreting the data by processing numbers rather than perceptions. Combining the Leannes values using a preference index (k) of 0.5 where each factor has the same weight. Thefollowing in **Table 3** is the result of combining the leannes value from the two measurements.

Table 3. Combining Leannes' values for the Qualitative and Quantitative approaches

Dimension	*Qualitative*	*Quantitative*	PMi		
			O,6 (Ofi) & 0,4 (Sfi)	0,5 (Ofi) & 0,5 (Sfi)	O,4 (Ofi) & 0,6 (Sfi)
Quality	0,745	0,853	0,810	0,799	0,788
Customer	1,000	1,000	1,000	1,000	1,000
Process	0,853	0,779	0,809	0,816	0,823
Human Resources	0,850	0,851	0,850	0,851	0,850
Delivery	0,800	0,751	0,770	0,776	0,780

From all the results of the existing calculations to the merging of Leannes values for several dimensions, an assessment was carried out with the two approaches, then an analysis was carried out to determine the critical dimensions that would be used as a focus for improvement. The analysis uses a lean radar chart as a visualization medium to describe the results of the lean assessment that has been carried out at the company. In **Figure 1**, you can see a lean radar chart from the results of calculating the value of Leannes with the lean assessment tool (LAT) whichhas been modified to follow the conditions of the company both qualitatively and quantitatively. Based on the lean radar chart visualization, it is known that the order of dimensions with the worstto best Leannes value is time effectiveness (0.677); cost (0.721); inventory (0,723); delivery (0.776); quality (0.799); process (0.816); human resources (0.851); customer (1). There are severaldimensions that have a leannes value below the target (X <75). These dimensions are timeeffectiveness, cost, inventory and time effectiveness dimensions which are critical dimensions that have the lowest Leannes value. So that this dimension will be the focus in preparing the improvement plan.

Figure 1. Lean radar chart PT. X.

In the time effectiveness dimension, there are five indicators that are measured for the lean assessment. The five indicators have their respective leannes values that contribute to the low dimension of time effectiveness and each of these indicators has its own problems. So it is necessary to do further analysis related to determining the root cause of the problem from each indicator in the time effectiveness dimension. The process of determining the root cause of the problem uses the root cause analysis method, which is 5 whys. The 5 whys method was chosen because it needs a deeper analysis of the source of the problem that occurs. The process of determining the root cause of the problem is carried out on each indicator related to the dimension of time effectiveness, which can be seen in **Table 4**.

Table 4. Root of the problem for each indicator with a plan for improvement

Indicator	The Root Cause of the Problem	Improvement Plan	Effectiveness Level	Degree of Difficulty	Priority Scale
T1 : Average set up / change over time per batch	The existing equipment is incomplete / inadequate	Complete work equipment in each existing work area according to the needs of each process	9	4	2,25
T2 : The ratio of set up / change over time to total production time	There are several materials supplied by only one vendor	Looking for alternative vendors for each product component material	3	3	1
T3 : Average lead time per batch	Non-standard troubleshooting & problem solving procedures	Arrange standard procedures related to troubleshooting & problem solving	3	1	3,0

Table 4. Root of the problem for each indicator with a plan for improvement (Cont'd)

Indicator	The Root Cause of the Problem	Improvement Plan	Effectiveness Level	Degree of Difficulty	Priority Scale
T4 : The ratio of total downtime to total production time	Lack of preventive maintenance activities for production machines	Create a preventive maintenance program outside of production time	9	1	9,0
T5 : Average lead time release finished good	Lab resources are insufficient for faster analysis	Review existing regulations and procedures and technology updates for analytical tools	1	5	0,2

After determining the root cause of each indicator related to the dimension of time effectiveness, the next step is to formulate a plan for improvement of each problem that exists in each indicator. The process of preparing this improvement plan is expected to be able to fix all existing problems related to the time effectiveness dimension, referring to the root problems that have been found. The improvement plan that has been prepared needs to be implemented as a whole in order to improve the dimension of time effectiveness, so that the implementation of lean manufacturing at PT. X can be better and have a positive impact on the company. So that with several improvement plans that have been prepared, it is necessary to calculate the priority scale for its implementation based on the level of effectiveness and difficulty. By compiling an improvement plan such as create a preventive maintenance program outside of production time and arrange standard procedures related to troubleshooting & problem solving, it is expected that after implementation it will increase the ability to implement lean manufacturing and the company's OEE value.

4. CONCLUSION

Based on the results of the analysis and discussion, the following conclusions can be obtained:

1. From the results of the lean assessment that has been carried out using a qualitative and quantitative approach, then a combination of leanness values is carried out with the Brown-Gibson method for the quality dimension; delivery; human resources; process; customer. From the results of this combination and then performed a critical dimensional analysis with lean radar chart visualization, it is known that the order of dimensions with the worst to best Leannes values is time effectiveness, cost, inventory, delivery, quality, process, human resources, customer.
2. Based on the company's target that the critical dimension is the dimension that has a leannes value below 75, then the dimensions that do not meet the target are time effectiveness, cost, inventory and time effectiveness dimensions which are the critical dimensions that have the lowest Leannes value. So that this dimension will be the focus in preparing the improvement plan.
3. From the known critical dimension, which is the time effectiveness, the root cause of each indicator is determined by using the root cause analysis method, which is 5 why analysis. The root causes of the problems found were:

   a. The existing equipment is incomplete / inadequate.
   b. There are several materials supplied by only one vendor.
   c. Non-standard troubleshooting & problem solving procedures.
   d. Lack of preventive maintenance activities for production machines.
   e. Lab resources are insufficient for faster analysis.
4. Then from the results of the root cause analysis, a plan for improvement is prepared based on the level of effectiveness and difficulty as well as the priority scale, which is
   a. Complete work equipment in each existing work area according to the needs of each process
   b. Looking for alternative vendors for each product component material
   c. Arrange standard procedures related to troubleshooting & problem solving if there are problems on the machine
   d. Create a preventive maintenance program outside of production time
   e. Review existing regulations and procedures and technology updates for analytical tools

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6. REFERENCES

Almomani, M. A., Abdelhadi, A., Mumani, A., Momani, A. dan Aladeemy, M. (2014). A proposed integrated model of lean assessment and analytical hierarchy process for a dynamic road map of lean implementation, *International Journal of Advanced Manufacturing Technology*, 72(1–4), hal. 161–172

Arslankaya, S. and Atay, H. (2015), Maintenance Management and Lean Manufacturing Practices in a Firm Which Produces Dairy Products, *Procedia - Social and Behavioral Sciences*, 207, pp. 214–224. doi: 10.1016/j.sbspro.2015.10.090.

Behrouzi, F. and Wong, K. Y. (2011). Lean performance evaluation of manufacturing systems: A dynamic and innovative approach, *Procedia Computer Science*, 3, pp. 388–395. doi: 10.1016/j.procs.2010.12.065.

Feld, W. M. (2001). *Lean manufacturing—tools, techniques, and how to use them*. https://doi.org/10.1016/s0278-6125(01)80022-4

King, P. L., & King, J. S. (2015). *Value stream mapping*. https://doi.org/10.4324/9781315151915-2

Narayanamurthy, Gopalakrishnan & Gurumurthy, Anand. (2016). Leanness assessment: a literature review. *International Journal of Operations & Production Management*. 36. 1115- 1160. 10.1108/IJOPM-01-2015-0003.

Pakdil, F. and Leonard, K. M. (2014). Criteria for a lean organisation: Development of a lean assessment tool, *International Journal of Production Research*, 52(15), pp. 4587–4607. doi: 10.1080/00207543.2013.879614.

Powell, D. et al. (2017). Lean Six Sigma and environmental sustainability: the case of a Norwegian dairy producer, *International Journal of Lean Six Sigma*, 8(1), pp. 53–64. doi: 10.1108/IJLSS-06-2015-0024.

Pujawan, I. N. & Geraldin, L. H., 2009. House Of Risk : A Model For Proactive Supply Chain Risk Management. *Business Process Management Journal*, 15(6), Pp. 953-967.

Salonitis, K. and Tsinopoulos, C. (2016). Drivers and Barriers of Lean Implementation in the Greek Manufacturing Sector, *Procedia CIRP*, 57, pp. 189–194. doi:10.1016/j.procir.2016.11.033.
Wilson, L. (2010). *How to Implement Lean Manufacturing*.
Womack, J. P., & Jones, D. T.. (2003). *Lean Thinking : Banish Waste And Create Wealth In Your Corporation*. New York, NY, USA.
Wignjosoebroto, S., 2009. *Tata Letak Pabrik dan Pemindahan Bahan*. 3rd ed. Surabaya: Penerbit Gunawidya.

Appendix A. Quantitative indicator

Dimension	Code	Indicator
Time effectiveness	T1	Average set up / change over time per batch
	T2	Ratio set up / change over time to total production time
	T3	Average lead time per batch
	T4	Ratio total downtime to total production time
	Tx	Leanness summary line A & B
	T5	Average lead time release finished goods
Process	P1	Overall equipment effectiveness (OEE)
Quality	Q1	Rework rate
	Q2	Scrap rate
	Q3	First time right rate
	Q4	Ratio poka yoke device to total inspection conduct
Cost	C1	Average cost per Kg
	C2	Average product waste cost per batch
	C3	Overtime cost
Inventory	I1	Ratio number of vendor to number of item on inventory
	I2	Ratio total inventory to total sales
	I3	Ratio finished goods inventory to total inventory
Customer	S1	Customer satisfaction index
	S2	Customer complaint rate
Delivery	D1	Average total of days form orders received to delivery
	D2	Ratio order processing time to total order
	D3	On time in fullfillment delivery
Human resources	H1	Labor turnover rate
	H2	Absenteeism rate
	H3	Ratio total manager to total employees
	H4	Ratio total suggestions to total employees
	H5	Ratio total implemented suggestions to total suggestions
	H6	Ratio total of employees working in teams to total employees
	H7	Number of hierarchical levels
	H8	Ratio total indirect employees to total direct employees
	H9	Ratio number of employees involved in lean practices to total employees

IMPLEMENTATION OF LEAN SERVICE TO IMPROVE THE QUALITY OF SALES SERVICES SPARE PART CHAIN CONVEYOR IN INDONESIAN TRADING COMPANY

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ABSTRACT

As a Japanese subsidiary that business of trading spare part conveyor chains for F&B until mining industry sectors, this company must make improvements service to customers,focuses on service response and determination of customer needs, from several surveys to customers in 2019 there were 33% customers not satisfied with the company service provided and there were decreases sales -6.01%. The customers dissatisfaction are long inquiry handling response times, product misidentification, and delay in delivery. It is indicated that occurs because of wasteful activities, such as long processing times due to poor communication. To improve company performance, a Lean service approach will be used. This approach will identify and make recommendations to eliminate or reduce waste. The initial step of this research is to determine the value from the customer's point of view, followed by making Value Stream Mapping identify waste and service efficiency is 54%. Then to analyze the root cause of waste by using fishbone diagram, which shows wastes: waiting in the process of handling orders, waiting for the loading or delivery process and misidentification with some root causes. To determine the waste priority number, it is done by adopting the Failure Mode Effect Analysis method in service. The critical roots that are prioritized for action eliminate waste of waiting and unclear communication. The results of the study are recommendations for improvement, which are obtained from the highest ratio of effectiveness to difficulty level, the three highest ranks were taken as priority corrective actions are adding the control function of document approval from sales SPV before further processing by logistics, making SOP in the order handling must obtain specification approval from the customer as a complementary document orders and increase the accounts logged into the NAV system.

Keywords: Critical Wastes, Lean Service, Value Stream Mapping, Fishbone Diagram,Failure Mode Effect Analysis.

1. INTRODUCTION

In the sales service process, customer satisfaction is an important thing that must be considered. To get good customer satisfaction, good service quality is needed. According to Lopez (2015), customer expectations and satisfaction are very subjective, customers change their role to network value, which makes them partners in value formation. Sale is one type of service process that requires the role of providing good service quality so as not to disappoint customers. In essence, selling is a science and art to influence a person to be willing to buy goods or services offered by this seller, explained by Swasta (2013). One of the ways to influence customers to be loyal and buy the goods offered is by providing quality service.

As a trading company that sells chain conveyor spare parts needed by the industry at large, it has good quality sales service. Companies are more directed to increase the speed and quality of service that can provide customer satisfaction and increase the opportunity to get orders from customer loyalty. From several surveys to customers in the 2018-2019 fiscal year, there was 33% of customers not satisfied with the speed of inquiry handling response. The response in handling inquiries is slow due to poor communication between customer support and sales in the case that the initial inquiry screening can occur. Another problem is the misidentification of the product the customer needs, the delivery time is quite long, even though the initial information on the offer is that the goods are available in the warehouse. From the explanation above, it is indicated that there is an early identification of waste waiting and unclear communication problems that occur in companies, causing disruption of company performance in providing services.

Determining waste in services may be difficult given that operations are intangible. Thus, according to Lopez (2015), one of the main challenges in service companies is developing the ability to recognize waste, through an analysis of the experiences obtained by customers. To improve the quality of services provided, the company must know the waste that occurs in the service process carried out. Companies can use the lean service method to identify and analyze root waste, prioritize the root waste to be repaired and formulate recommendations for improvements that can be used as an alternative by management. Lean service itself is a tool and method used to eliminate waste, which can be in the form of waiting time, improving service performance, and reducing company operating costs. The basis of the goal of lean service is to create customer value, customer satisfaction that can increase the added value of the service products provided thoughts from Leite (2013).

Gaspersz (2017) stated that the waste that exists in the service industry is document errors, document delivery, doing work that is not according to demand, waiting for the next process, the process of getting approval, unnecessary activities, guaranteeing savings in the job queue, and underutilized employees. The problem of waste that is detrimental if it has not been minimized can result in long lead times, decreased work productivity, and decreased quality, while the main goal of the service industry is customer satisfaction where quality is the most important. To reduce waste in this study, tools are used, namely value stream mapping, which aims to see waste and value in service company business processes, identification of wasteful processes and flows can bedone, so that they can be modified or eliminated, and thus the business system can be increased byLovelle's opinion (2001). The waste identified in VSM will be analyzed to find the root causes using the Root cause analysis method proposed by Paradies and Busch (1988), whose purpose isto identify the relationship between cause and effect. Furthermore, the calculation of the waste priority number by adopting failure mode and effect (FMEA), the formula for multiplying the severity x occurrence. In this case, it does not involve a detection scale because seeing the detection service business process is not easy to do for problems that are not in the form of equipment or machines. The purpose of implementing FMEA is to prevent problems from occurring in processes and products.

After that, an analysis of the root causes of waste is carried out and the formulation of recommendations for improvement according to the root causes of waste. Recommendations for improvement are determined by the level of difficulty of realization and effectiveness for the company. Therefore, a ratio value is needed so that it can be ranked, as priority is the recommendation for improvement with the top ranking. From several recommendations for improvements that are given, it is hoped that it will reduce waste waiting and unclear communication in the sales service process.

2. METHOD

The identification stage and determining the waste in the system that occurs are carried outin the company by:

- Questionnaires for customers to determine customer value for the services provided will result in customer satisfaction scores and the causes of customer dissatisfaction, from how to respond to inquiry handling, conformity to customer needs to timely delivery.
- Create a value stream mapping that aims to provide an overview of all systematic information processes to clarify all business processes carried out in company services so that general conditions and problems can be known. Through VSM, it can be seen that the entire service process, as well as the lead time and waste that occurs from each process. The expected result is knowing the activities that cause waste, with indications on seven waste in service, including duplication, delay, lost opportunity, unclear communication, incorrect inventory,movement, and error.
- The next step is to find the root causes of waste and do calculations to determine the priority of the critical root causes, analysis of the root causes of waste by interviewing each department. The analysis will use a fishbone diagram with a grouping of causal variables, namely methods, facilities, management, and human resources that affect the time of the inquiry handlingprocess until the delivery of goods.
- The stage of determining critical waste by determining the scale of severity and occurrence is discussed with management to suit the company's condition, providing a rating grouping by considering the losses incurred if a failure occurs in the service process. Furthermore, the calculation of the waste priority number by adopting failure mode and effect (FMEA), the formula for multiplying the severity x occurrence. In this case, it does not involve a detection scale because seeing the detection service business process is not easy to do for problems that are not in the form of equipment or machines.
- Finding recommendations to reduce or eliminate the root causes of critical waste as a proposal for service process improvement. Formulate recommendations for improvement from literacy studies and focus group discussions with related sections. Furthermore, the results of the formulation of recommendations for improvement are discussed with direct management discussions to ensure the feasibility of implementing the recommendationsfor improvement in the company.
- The result of the research is after all processing and data have been completed. Conclusions will be drawn relating to the waste that occurs, the root of the problem, and recommendations for reducing and eliminating waste in the business process of procuring spare part chainconveyor services at trading companies. After that, suggestions are given for both companies and future research in the form of improvements and developments from the research that has been carried out.

3. RESULTS AND DISCUSSION

3.1 Create of Value Stream Mapping

Value Stream Mapping is used to view physical process flow information in the conveyor chain procurement service business. After all the data is collected, a current state map is created. The Current State Map shows the actual conditions that occur in the service process, which can beseen in **Figure 1**. it appears that the service process starts from customer inquiry. In this case. the customer sends an inquiry via email to request a price quote, Customer support will respond, and an initial screening of the type of inquiry, and make a price quote Quotation. The offer will be followed up by the Salesman with confirmation if the offer has been received, negotiations, and promotions to explain product knowledge. The purchase order will be sent by the customer and processed by CS, the PO traceability document will be forwarded to the logistics to prepare the goods in the warehouse so that they can be sent to the customer. After the goods are delivered, the delivery order and purchase order documents are submitted to the accounting firm to issueinvoices and tax invoices that are sent to the customer as billing documents, the customer will pay the receivables and the accounting will send a deposit slip to receive as proof of payment.

Based on VSM, it is obtained the cycle time of each process and the required transfer time from one process to the next. The process with a high cycle time in the process of confirmation and negotiation of sales offers to customers is 63.25 minutes because the sales will promote the product and discuss with the customer what the customer needs, then if it is appropriate, the sales and customers will carry out negotiation activities. The high cycle time is then processed to input order data to the NAV system of 51.25 minutes, this process is carried out to process customer POs so that they can be followed up on logistics and accounting so that orders can be sent and billed to customers. Delivery of goods to customers has a high cycle time value of 2952 minutes (2 days) this is due to the distance between direct deliveries to customers. The time of transfer from one process to another can be seen as waste, namely waiting with a high time value in the order data input process to the NAV system of 105.5 minutes, the process of loading goods to the truck is 234 minutes and the process of sending goods to customers is 2304 minutes. After the goods are sent, the customer will receive them according to the order they made, but if there is an error a complaint will be made to customer support, this is one of the wastes, namely an error in the order handler. It can be seen when the goods have been received by the customer.

In the chain conveyor spare part sales service process based on VSM, the total cycle time is 3340 minutes, and the lead time is 6167.1 minutes. The percentage of service efficiency obtained from VSM is 54%, so it needs to be improved. The results of VSM were analyzed on processes with high cycle times and waiting times. Waste in the form of waiting and unclear communication on specification errors will be searched for the root waste that causes it. In the order handling process: input order data into the NAV system, loading goods into trucks, and sending goods to customers, while specification errors in the inquiry handling process will be analyzed using a fishbone diagram aimed at getting the roots of waste.

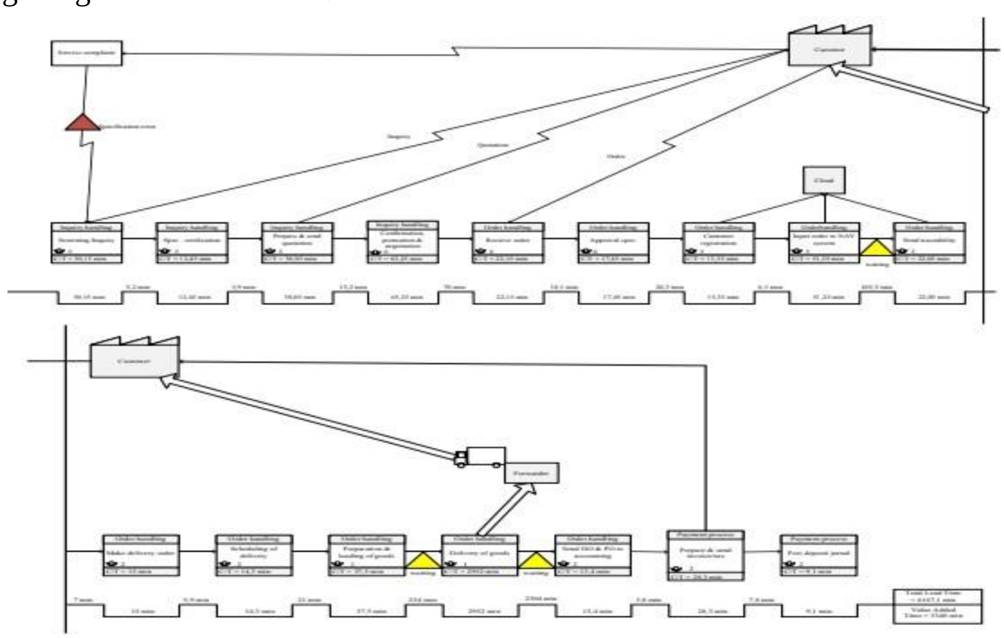

Figure 1. Current value stream mapping

3.2 Analysis of the Root Cause of Waste with Fishbone Diagram

From the analysis of activities that have been carried out using value stream mapping and discussions with related divisions, then at this stage, identification of the root cause of waste that arises at the service stage is carried out. Meanwhile, some wastes are analyzed using VSM and obtained from the discussion, namely waste in the form of misidentification in the order handling specification approval process. The example root cause of waste in the process is as follows in **Figure 2.**

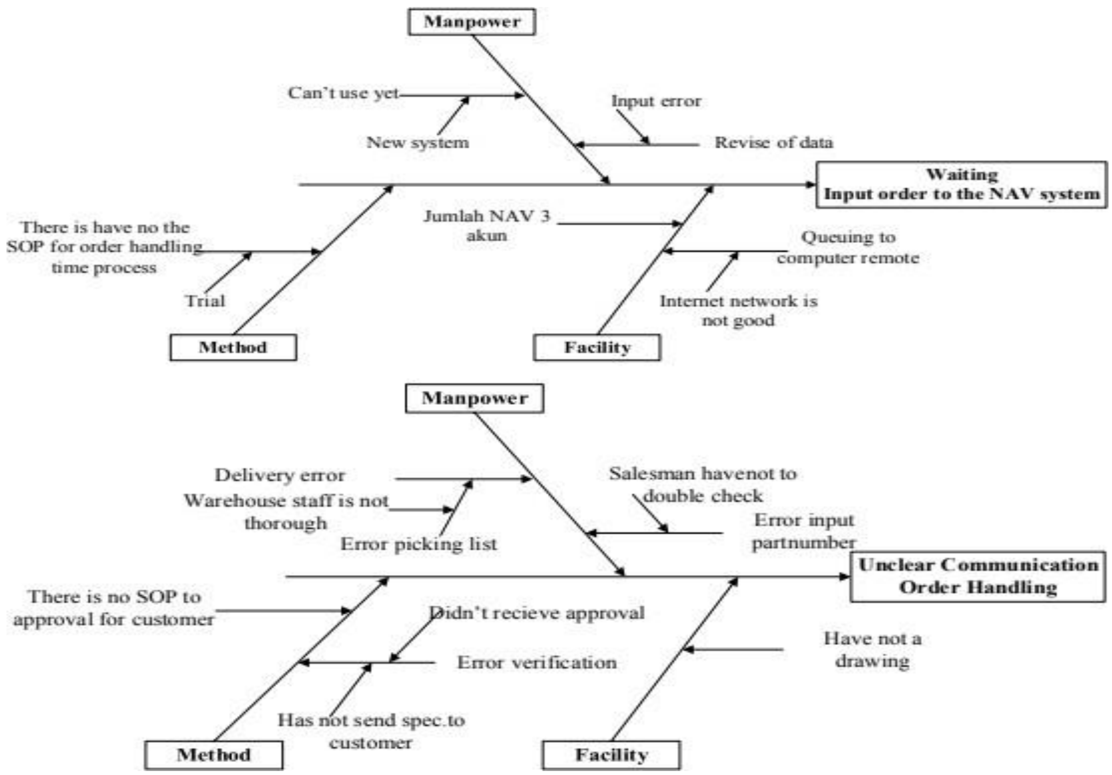

Figure 2. Fishbone diagram

Waste can be generated from several root causes of waste. From the analysis, the root causes of waste will be grouped into two types of waste obtained, namely waiting and unclear communication from the data input process to the NAV system, loading goods to trucks, sending goods to customers, and handling orders, the root causes of waste can be seen in **Table 1.**

3.3 Determination of Critical Waste by Adopting Failure Mode and Analysis

After obtaining the root causes of waste in each waste waiting and unclear communication using root cause analysis - fishbone diagrams, it is then done to determine the priority of waste roots which will be given recommendations for improvement by finding priority waste figures. Furthermore, the calculation of the waste priority number by adopting failure mode and effect (FMEA), the formula for multiplying the severity x occurrence. In this case, it does not involve a detection scale because seeing the detection service business process is not easy to do for waste that is not in the form of equipment or machines.

From the calculation of the value of critical waste, the highest value is obtained at 16 in the process of handling the root waste order because sales do not double-check orders from customers and have not sent specifications to customers. This waste has a high severity value because if an order goes wrong, the customer will feel disadvantaged and the process is repeated starting from re-offering which results in a waste of time for the customer. The root of waste in salesmen who are not careful when serving customer requests because this often occurs, the value of occurrence of root waste is high. Priority improvements will first be made in the order handling process. While there are several waste values obtained by 12 points in the order data input process to the NAV with the waste root, the number of NAV accounts is limited for access, thus creating a queuefor its use from customer support. Besides, the process of loading the root goods is the highest waste because it is waiting for the forwarder to arrive, which often occurs, which can result in delays in delivery to customers. In the process of handling orders, errors in picking up types of goods often occur by warehouse operators because they are not careful.

After determining the priority waste, analysis of the potential failure effect with the root source of wastes which is the root cause of each existing waste, the root of the waste above will bediscussed with priority improvements to the root source of waste in order handling. For waste witha waste value of 12 points, improvement will be discussed afterward. So that every waste with a high value can be eliminated from the root of the problem.

Table 1. Calculation of Critical Waste

No.	Waste	Decription	Activities that Contain Waste	Effect of Waste	Severity	Root Cause	Occurrence	Waste Number
1	Waiting	Input order to the NAV system	Long time process input data order	Treceability PO late more than 1 day	3	Can't use the new NAV system	2	6
						Data input error	2	6
						Limited number of NAV accounts	4	12
						Internet network is not good	2	6
						There is have no the SOP for order handling proccess	1	3
2	Waiting	Loading of goods onto truck	Long time loading process	Delay for delivery time more than 1 day	3	No FIFO tarining yet	1	3
						Operator 1 person	2	6
						Mistake of taking goods off the rack	3	9
						Waiting of forwarder	4	12
3	Waiting	Delivery of goods to customer	Delay delivery process	Goods arrive to customer 1-2 days late	3	Only have one unit truck	2	6
						Small handlifter capacity	2	6
						Only have one handlifter	2	6
						Waiting logistic intruction	3	9
						Current delivery a lot	2	6
						Inaccurate estimation of distance/time for delivery	3	9
						Only have one unit truck	2	6
						Sudden information to forwarder	3	9
						Small handlifter capacity	2	6
						Operator 1 person	2	6
4	Unclear Communication	Order handling	Error specification	Good is not received by the customer	4	Salesman do not double check	4	16
						Warehouse staff is not thorough	3	12
						No reference dwaring for customer	2	8
						Didn't receive specification approval from customer	2	8
						Has not set specification to customer	4	16
						There is no SOP to approval for standard item	2	8

3.4 Formulation of Recommendations for Improvement

The formulation of recommendations for improvement is carried out after knowing the types of waste that must be prioritized for elimination. After that, an analysis of the root causes of waste is carried out and the formulation of recommendations for improvement according to theroot causes of waste. The formulation of recommendations for improvement is obtained from the results of literature studies and discussions with relevant party supervisors to determine alternative improvements, in this case from sales supervisors, customer support, and logistics. After obtaining the proposed improvement recommendation formula, it will be discussed back to management to consider the realization.

The company will consider recommendations for improvement with the ability to make it happen. Aims to determine the level of difficulty of the company in implementing recommendations for improvement. Determination of the level of difficulty is carried out by discussion with sales supervisors, customer support, and logistics. The expected result fromdetermining the level of difficulty is a value with a scale of 3,4, and 5. Each scale has its respective considerations, namely 3 (low), 4 (medium), and 5 (high) with a description of the size of the investment that will be done if the recommendations for improvement are realized based on Pujawan and Geraldin (2009). Meanwhile, the degree of effectiveness eliminates the root causesof waste with a value of 1, 3, and 9 (low, medium, and high) according to Karningsih (2019).

From the recommendations for improvement will be given an assessment based on the level of realization difficulty criteria, **Table 2** is the result of the assessment. The highest assessment criterion is the procurement of a truck unit with an investment cost of IDR 290,000,000 / unit, then adding a NAV account costs IDR 30,000,000 / year by getting 3 new accounts that can be used. Meanwhile, the cost for NAV operation training is IDR 7,000,000 / meeting. Meanwhile, other improvements are only administrative so that they do not require costs,such as improving SOPs for handling orders, creating additional control functions for SPV sales and logistics, and more scheduled deliveries.

The results of determining the recommendations for improvement are based on the results of determining critical waste and the criteria for the level of difficulty in the realization of the recommendations for improvement. From determining the critical waste value with the criteria for the difficulty level of the recommendations for improvement, it will be obtained a priority order which is done first:

Table 2. The results of determining the ratio of effectiveness to the difficulty of recommendations for improvement

Alternative Recommended Improvements	Description of Plan	Total Cost	Realization Difficulty Level	Realized Effectiveness Level	Effectiveness of Difficulty Ratio	*Action Priority Rank*
Increase the number of accounts logged into NAV	Adding a NAV account at a cost of IDR 30 million / year by getting 3 new accounts	Rp 30.000.000	4	9	2.25	2
It is hoped that providing employees with NAV operations training can speed up usage	Make training with the NAV team at a training fee of IDR 7,000,000 / meeting	Rp 7.000.000	3	3	1	3
Adding cooperation with forwarders for more than 3 alternatives	Hold a meeting with the new forwarder to make a commitment agreement and find out shipping costs	-	3	3	1	3
Implement scheduling delivery for a week	Making scheduling plans in advance does not cost money	-	3	3	1	3
Add warehouse truck units	The cost of purchasing a truck is Rp 290 million / unit, the addition will be made in stages and currently 1 unit is planned	Rp 290.000.000	5	3	0.6	4
Added the function of controlling traceability document approval from sales SPV before being processed by logistics	Improving the jobdesk of the organization by adding a control function for checking order documents is submitted to sales SPV	-	3	9	3	1

Added control function for picking list approval documents from logistics SPV before delivery	Improvements to the jobdesk of the organization by adding a control function to check picking list documents submitted to logistics SPV	-	3	3	1	3
Conduct FIFO system training (input-output goods) to operators so that they understand the layout of the goods in the warehouse	Training on the introduction of the FIFO system to warehouse operators is carried out by logistics SPV	-	3	3	1	3
Make a specification approval SOP in the bidding process as a traceability document for order handling	Improved SOP on order handling	-	3	9	3	1

3.5 Implications of Recommendations for Improvement

From the results of the ranking of the ratio of effectiveness to the difficulty of the recommendations for improvement, the three highest ranks can be seen in **Table 3.** while for the fourth rank, the procurement of new truck units is not put into priority because it is waiting for the results of improvements from the third recommendation, namely increasing cooperation with forwarders.

From the three recommendations for improvement, it is hoped that it will reduce waste waiting and unclear communication. The improvement by adding the specification approvalcontrol function and the picking list for the collection of goods aims to double-check the goods so that there are no errors in the delivery of goods to customers. Meanwhile, the addition of NAV accounts along with usage training for customer support, logistics, and accounting aim to speed upthe order handling process, the faster orders can be processed, the faster the goods will be delivered to customers. From the initial state, there is no target order process with this improvement, it is expected that the process can be carried out in 1x24 hours, so that customers will receive their ordered goods as soon as possible and there will be no complaints aboutspecification errors.

Table 3. Implications of recommendations for improvement

Rank	Alternative Recommended to Improvements	Realization Target	Budget	Person in Charge
1	Added the function of controlling traceability document approval from sales SPV. before being processed by logistics	One month with the drafting, discussions were continued with management. Implementation reviews are carried out every quarter of the meeting	Rp 0, - Administrative	Spv. Sales
	Make a specification approval SOP in the bidding process as a traceability document for order handling			
2	Increase the number of accounts logged into NAV	Beginning of the new operational year (April)	Rp 30.000.000,- /year	Assistant manager
	It is hoped that providing employees with NAV operations training can speed up usage	1 day after adding a new NAV account, followed by the customer support, logistics & accounting team	Rp 7.000.000,- /meeting	HRD

Rank	Alternative Recommended to Improvements	Realization Target	Budget	Person in Charge
3	Adding cooperation with forwarders for more than 3 alternatives	One month with the drafting, discussions were continued with management. Implementation reviews are carried out every quarter of the meeting	Rp 0,- Administrative	Spv. Logistic
	Implement scheduling delivery for a week			
	Added control function for picking list approval documents from logistics SPV before delivery			
	Conduct FIFO system training (input-output goods) to operators so that they understand the layout of the goods in the warehouse	Immediately held a day training from Logistics SPV followed by warehouse members and operators	Rp 0, - Training is carried out internally	HRD & Spv. Logistic

4. CONCLUSION

Based on the results of the analysis and discussion, the following conclusions can beobtained:

1. Identified waste from the chain conveyor sales service process is waiting in the process of inputting orders to the NAV system, loading goods onto trucks, sending goods to customers, and unclear communication in the order handling process.
2. The root causes priority of waste that arise in the chain conveyor sales service process include a limited number of NAV accounts, waiting for a forwarder, salesman not double- check orders, warehouse staff are not careful, and the salesman has not sent specifications of items offered to customers.
3. Recommendations for improvements that can be realized according to the level of difficulty and effectiveness of the chain conveyor sales service among others adding the control function of document approval from sales SPV before further processing by logistics, making SOP in the order handling must obtain specification approval from the customer as a complementary document orders and increase the accounts logged into the NAV system.

5. ACKNOWLEDGMENTS

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6. REFERENCES

Gaspersz, V., & Fontana, A., (2017). *Lean Six Sigma for Manufacturing and Service Industries Waste Elimination and Continuous Cost Reduction*, Bogor: Vinchristo Publication.

Karningsih et al, (2019). Lean assessment matrix: a proposed supporting tool for lean manufacturing implementation. *Proceedings of Annual Conference on Industrial and System Engineering (ACISE*), Universitas Diponegoro, Semarang.

Leite, H.D.R., & Vieira, G.E. (2013). Lean philosophy and its applications in the service industry: a review of the current knowledge, Production.

Lopez, Andrez, (2015). Lean service: reassessment of lean manufacturing for service activities, *The Manufacturing Engineering Society International Conference*, Spain.

Lovelle, J., (2001). Mapping the value stream, *IIE Solutions* 33, (2), 26-33

Paradies, M and Busch, D., (1988). Root cause analysis at the savannah river plant, Olivia, 340344.

Pujawan, I Nyoman & Geraldin, Laudine H. (2009). House of risk: a model for proactive supply chain risk management, *Business Process Management Journal*, Emerald Group Publishing Limited. Vol. 15 No.6 pp. 953-967.

Swastha, Basu, (2008). *Manajemen Penjualan*, BPFE, Yogyakarta.

IMPROVEMENT OF THE COAL NOZZLE BURNER PLTU COMPONENT PRODUCTION USING LEAN MANUFACTURING

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ABSTRACT

PT PLN (Persero) PUSHARLIS UP2W VI Surabaya produces coal nozzle burner components by applying a make to order system. The phenomenon of determining the faster lead time to meet the needs of emergency repair in PLTU maintenance, demands quality products and on time delivery. UP2W strives to manage production systems to be more effective and efficient through waste elimination, shortening lead times and continuous improvement processes. This study uses lean manufacturing methods to eliminate 9-waste (E-DOWNTIME). Identify activities using value stream mapping and process activity mapping. Meanwhile, the lean tool uses the Lean Assessment Matrix (LAM) which integrates the House of Risk (HOR) and the Waste Relationship Matrix (WRM). Based on the results of the assessment matrix, critical waste is obtained, namely waiting, defects and excess processing. The root causes of waste are due to the process of handling the material and defect products that have not been determined, the lack of skills in the workforce, and the 5S program is not yet optimal. The priority recommendations for improvement are making SOPs for handling material and defect products, training and certifying workers in the welding process, optimizing the 5R / 5S program for material handling and workshop equipment. The results of waste elimination can contribute to a reduction in lead time by 20% or 1605 minutes, so that the target timeliness is achieved in supporting the needs of the PLTU coal nozzle burner component.

Keywords: e-downtime, lean manufacturing, VSM, PAM, lean assessment matrix

1. INTRODUCTION

PT PLN (Persero) supports efforts to increase the competitiveness of the production of PLTU components through one of the supporting units, namely the Pusat Pemeliharaan Ketenagalistrikan (PUSHARLIS) - Unit Pelaksana Production and Workshop (UP2W). One of the mass aggressive product segments that has been made is coal nozzle burners.

UP2W implements a make to order system in serving customers, where the average fulfillment of the timeliness of the coal nozzle burner product customer orders is still 93% of the 100% target, the average fulfillment time of 1 coal nozzle burner product is 17 working days. The phenomenon of determining the faster lead time on the part of the customer makes UP2W try to shorten the lead time in order to support fast response to customers, increase productivity, and can meet the needs of emergency repair during PLTU maintenance.

Problems in the coal nozzle burner production process indicate that activity does not provide added value and causes an increase in production lead time. First, product repair and rework are often carried out because defects are found during the production process (work in process). Defects in the form of measurement of dimensional geometry and tolerances are not suitable, welding results are often found in welding defects and improper assembly processes. Thus resulting in the need for additional work processes, costs and time to complete the product. The defect value in the production work in process during 2017-2019 production is still 20%, which is at the sigma level between 2 and 3.

Second, often the production line cannot operate quickly due to the waiting time process, including: waiting time for people because workers or experts are not ready, machine waiting time due to changing jobs and incomplete equipment, and material waiting time due to material not ready to do the work process. The machine layout and supporting facilities that are far apart at UP2W further reduce the effectiveness of the work process. This waiting time becomes the downtime as a stop to the operation of the coal nozzle burner production process. The approach that will be taken to improve timeliness, improve product quality, increase productivity, reduce costs, and increase customer satisfaction by eliminating waste is very much needed (Manos-Vincent, 2012). In order to eliminate this waste, the lean manufacturing method will be used in this study.

The lean concept based on timeliness and cost reduction is obtained by eliminating the waste associated with all activities carried out to complete orders from customers. In knowing the most dominant waste, a waste identification improvement model is needed. The model used in this research is the waste assessment model (WAM) using the waste relationship matrix (WRM), which has the advantages of a simple matrix and a commissioner that covers many things and is able to contribute to achieving accurate results in identifying each relationship and cause. the occurrence between wastes (Rawabdeh, 2005). With this research, it is hoped that it can provide recommendations for improvements to the production process, so that it can assist companies in making continuous improvements.

2. METHOD

This type of research used in this research is descriptive analytical research. This method examines conditions in the present and presents a complete picture of the conditions in an object to be studied. This descriptive research is also used to take critical waste analysis and design recommendations for improvement from solving existing problems.

2.1 Identification Phase of Waste and Its Causes

At this stage, the initial identification and observation of the coal nozzle burner production process consists of observation, interviews, questionnaires and compilation of production process flow data. Next, identify the waste as follows:

a. Value Stream Mapping (VSM) Creation
b. Preparation of Process Activity Mapping (PAM)
c. Waste Mapping
d. Waste Root Cause Analysis (RCA) using 5Why's Method.

2.2 Critical Waste Analysis Phase

At this stage, an analysis to determine critical waste will be described with the output of the Lean Matrix 1 preparation, which consists of:

a. Waste Type Weight calculation
b. Determination of Severity Level of Waste

c. Determination of Occurrence Level of Root Source of Waste
d. Lean Matrix 1 Compilation.

2.3 Design Phase Improvement Recommendations

At this stage, the analysis of the preparation of a number of alternative recommendations for improvement will be described that form waste elimination actions (WEA). WEA will be the input of Lean Matrix 2 and will produce an output in the form of rank of action priority which will be submitted.

a. Preparation of Alternative Recommendations for Improvement
b. Determination of Degree of Difficulty Performing Action
c. Lean Matrix 2 Compilation.
d. Recommendations for Improvement Based on Rank Action of Priority

2.3 Conclusion and Suggestion Stage

At this stage the conclusions are given based on the predetermined research objectives. Meanwhile, suggestions are made to improve future research.

3. RESULT AND DISCUSSION

3.1 Identification Phase of Waste and Its Causes

3.1.1 Value Stream Mapping (VSM) Creation

The current state of VSM is a description of the production process that takes place at UP2W which includes the flow of information and materials. This is needed as a first step in the process of identifying waste.

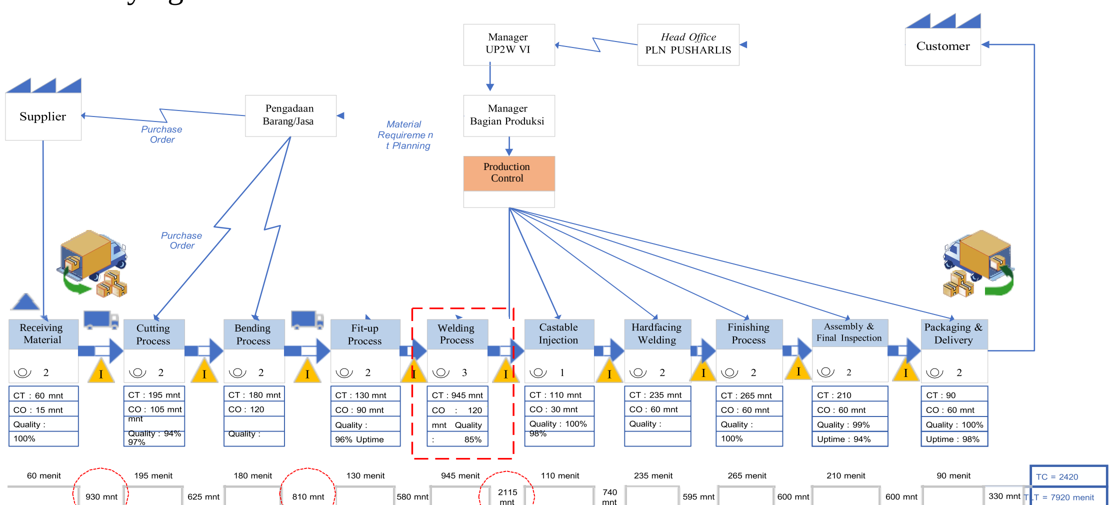


Figure 1. Value Stream Mapping

3.1.2 Preparation of Process Activity Mapping (PAM)

Data Process Activity Mapping (PAM) is used to describe the activities that occur in the Coal Nozzle Burner production line at the Workshop by describing the process, time, distance, manpower and type of activity.

Table 1. Types of Activities in the Coal Nozzle Burner Production Line Process

No	Activities	Total	Time (min)	%
1	*VA*	19	2420	20
2	*NVA*	40	2425	41
3	*NNVA*	38	3075	39
Total		95	**7920**	**100**

No	Types of Activities	Total	Time (min)	%
1	*Operation*	41	3725	47
2	*Inspection*	18	1380	17
3	*Transportation*	11	645	8
4	*Delay*	21	1620	20
5	*Storage*	4	540	7

Operation, inspection, and delay activities are included in non-value added activities and must be eliminated to increase production productivity. Activity mapping in the form of VSM or PAM can analyze the types of activities which include waste and must be eliminated in the production process.

3.1.3 Mapping Waste and RCA using 5Why's Method.

Waste mapping is obtained from the results of activity mapping and discussions with the expert in the production department to obtain an overview of the waste that occurs in the coal nozzle burner production process line. Analyze the root cause of each waste using the 5 why's tool. Based on these results, the analysis of E-DOWNTIME 9-waste (Gazpers, 2011) is as follows:

a. Environmental, Healthy and Safety (EHS)

EHS waste mapping is related to work environment conditions so that it affects the health and safety conditions of workers in carrying out the production process. However, the problem of EHS waste at UP2W has been resolved properly, the work environment is comfortable and the workers already use Personal Protection Equipment (PPE) and are in accordance with the SOP.

b. Defect

Mapping of waste defects is still being found, with the main parameters of coal nozzle burner inspection being Dimensional & Tolerance Geometry (GDT) and the result of welding joints. The results of observation of the production of 1 batch are 4 pieces, with the opportunity for a defect to be carried out 27 times. Waste defects were obtained in 6 production processes, namely during the cutting process, the bending process, the fit-up process, the welding process and the assembly & final inspection process. The most common defect found was weldingprocess with a percentage of 14%, the average percentage of waste defects was 30.8%. Through the Six Sigma approach, the DPMO value is 296,296 and the level 2 six sigma value.

Table 2. Example of an Analysis of 5 why's Waste Defect

Sub Waste	*Why 1*	*Why 2*	*Why 3*	*Why 4*	*Why 5*
Welding defects were found	NDT inspection finds welding defects	Welding parameters have not been met	Welding did not go according to procedure	Workers dont understand WPS	*Welder and WI are not certified*
	The presence of deformation, corrosion and material problems	The quality of the material depends on the supplier	The Inspection Test Plan (ITP) is inappropriate	*There is no SOP for handling defect products*	

The result of the non-conformity must be repaired further and requires a longer rework time.

c. Overproduction

The mapping of waste overproduction was not found because the company's production system is make to order (MTO). UP2W carries out the production process when it is confirmed that it has received an order from the customer. The system for receiving orders from customers can be made an annual forecast according to the maintenance needs of the PLTU and will become a fixed order at the beginning of the year to determine the maintenance budget for generating units.

d. Waiting

Waste waiting mapping occurs when the production process is stopped or delayed due to the unpreparedness of the production machine or the delay in starting work. Because the production machine is not working, this waste is directly related to downtime. Waiting the longest found was waiting for repair of defective products and waiting for work process readinesswith a percentage of 30%, then waiting for workers, namely 26%.

e. Not Utilizing Employees Knowledge, Skills and Abilities

This waste mapping is due to the lack of expertise in the ability of workers to carry out product handling activities and the inability to detect the causes of equipment having problems. Factors related to knowledge, skills, and abilities of workers have a high level of risk because in every production work process, there are workers who are skilled and have certification.

f. Transportation

Waste transportation mapping is found in the cutting and bending processes. This is due to the unidirectional flow of material, and excessive displacement of workers during each process or process change. The reason is that the work area layout is not in the same building, while the tools and warehouse are located in different buildings. In the implementation of cutting and bending plate material using an external workshop because the machine at UP2W is in a damaged condition and the repair costs are the same as a new purchase.

g. Inventory

Identification of found waste inventory is not significant. The material procurementprocess is through the Unit Price Contract (KHS) mechanism with a guarantee of materialavailability from the supplier up to a predetermined period. When the production department requires the main plate and supporting material, the supplier will send the material according to the specified needs and time.

h. Motion

The motion category waste mapping does not significantly influence the productionprocess. There is a possibility of waste motion, which is excessive movement of workers at everychange in the production process. In addition, in one work area it often intersects with other workprocesses, so that it will greatly disrupt the coal nozzle burner fabrication work process.

i. Excess Processing

Waste excess processing will increase the lead time. The root of the waste problem is waste that occurs due to rework due to non-conformity with specifications or product defects, repeated inspections (overinspection). In addition, cleaning of the remaining previous processes (clean up) and handling of the remaining material is not optimal. so that often it will interfere with each other's fabrication work process at UP2W.

3.2 Critical Waste Analysis Stage

3.2.1 Calculation of Waste Type Weight

The calculation of the Waste Type Weight begins with the preparation of the Waste Relationship Matrix (WRM) questionnaire. The questionnaire will be filled in and answered by the Production Manager and Expert (Mechanical Supervisor, PPC, QC, SCM and Engineering).

Table 3. Waste Type Weight Calculation Table

F/T	e	D	O	W	N	T	I	M	E	Score	%
e	**0**	5	0	7	0	4	0	4	5	25	9
D	7	**0**	3	10	0	7	5	6	10	48	16
O	0	1	**0**	5	0	2	3	3	5	19	7
W	2	9	0	**0**	7	6	0	4	10	38	13
N	3	8	0	8	**0**	2	0	4	5	30	10
T	5	6	0	8	0	**0**	0	8	4	31	11
I	5	0	0	5	0	5	**0**	0	8	23	8
M	5	6	0	5	0	5	0	**0**	7	28	10
E	7	10	0	10	4	10	0	8	**0**	49	17
Score	34	45	3	58	11	41	8	37	54	**291**	100
%	12	15	1	20	4	14	3	13	19	100	

The results of the calculation of waste type weight with the highest percentage of waste are waste excess processing (17%), waste defects (16%), and waste waiting (13%).

3.2.2 Determination of Severity Level of Waste

The process of determining the severity level of waste aims to determine the impact that occurs when waste occurs. With a value between 1 - 10. The criteria do not have an effect, namely waste occurs, but it does not affect the production process, while the very dangerous criterion is that the production process cannot be done (stops). The result of determining the severity level of waste by the UP2W expert was obtained that Waste W3, Waste W12, and WasteW15 are waste with the highest severity level of waste with a value of 8.

Table 4. Result of Determination of Severity Level of Waste

Waste	Code	Description	*Level*
E	W1	The work environment is uncomfortable	2
D	W2	The dimensions of the cut-bend plate are out of tolerance	5
	W3	Welding results found defects	8
	W4	Welding assembly dimensions are out of tolerance	7
O	W5	Excessive cut of parts	2
W	W6	Repair of defective products takes too long	6
	W7	Workers are still not ready	5
	W8	Preparation to start the work process takes too long	7
N	W9	Workers who carry out the production process are not quite right	5
T	W10	Unidirectional flow of material	6
	W11	The delivery of goods is experiencing difficulties	4
	W12	Cutting and bending work is done in an external workshop	8
I	W13	Materials are stored in the laydown area first	4
M	W14	Workers move too much to change the production process	4
E	W15	Rework (rework) defect products	8
	W16	Product inspection is repeated (over inspection)	5
	W17	Clean up the remains of the previous production process (clean up)	5

3.2.3 Determination of Occurrence Level of Root Source of Waste

The process of determining the occurrence level aims to determine the possibility or frequency of waste occurring in the coal nozzle burner production line. Criteria determining the value between 1 to 10. Occurance is very low, namely the root cause of waste is very rare (1 time in 5 years), while the occurrence is very high more than 8 times/year, the root cause of waste is very frequent.

Table 5. Results of Occurrence Level Determination of Root Source of Waste

Code	Description	*Level*
S1	Work layouts are not ergonomic and changeable	8
S2	No mall or bend-cut profiles	7
S3	There is no SOP for handling product defects	9
S4	No workpiece holding tool (jig-fixture)	7
S5	Workers do not understand work procedures	8
S6	The number of experts is insufficient	6
S7	There are other urgent work process disruptions	6
S8	Workers are not certified	7
S9	The material moving tool used is small and limited in capacity	6
S10	Machine repair costs the same as purchasing a new tool	8
S11	5S implementation has not run optimally	9

3.2.4 Compilation of Lean Matrix 1

Based on the analysis of 9-waste E-DOWNTIME, the root causes of waste, waste type weight, level of occurrence and severity will be compiled for Lean Matrix 1. The priority results of waste that have the highest priority value are waste defects, waste excess processing and waste waiting. Meanwhile, the waste that has the lowest priority value is waste overproduction, waste inventory and waste moving.

Table 6. Results of Lean Matrix 1

Waste Type	***Non Added Value Activity (Waste)***	***Root Source of Waste***											***Waste Type Weight***	***Severity level of Waste (Si)***	***Aggregate Waste Number***	***Priority Rank of Waste***
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11				
E	W1	9				1						3	9	2	1.379	15
D	W2		9	1		9					1		16	5	12.536	3
	W3		3	9					9				16	8	20.866	1
	W4		9	3	9								16	7	17.666	2
O	W5		1										7	2	107	17
W	W6			9					3				13	6	8.436	6
	W7					1	3						13	5	1.811	13
	W8					3		9					13	7	6.960	8
N	W9						9						10	5	2.876	12
T	W10	9								3		1	11	6	6.679	9
	W11									9		3	11	4	3.595	11
	W12						1				9		11	8	6.232	10
I	W13	3						1					8	4	1.027	16
M	W14	1										3	10	4	1.403	14
E	W15		1	9									17	8	11.360	4
	W16			3		3			9				17	5	10.238	5
	W17					1		9				3	17	5	7.243	7
Occurence Level of Root Source of Waste j		8	7	9	7	8	6	6	7	6	8	9				
Agregate Cause Value (ACV)		701	987	1476	441	745	420	656	952	339	580	453				

3.3 Improvement Recommendation Design Stage

3.3.1 Preparation of Alternative Recommendations for Improvement

Recommendations for improvements submitted have been previously discussed with the production manager and UP2W experts so that they can be implemented with constraints that can still be faced by Management.

3.3.2 Determination of Degree of Difficulty Performing Action

The process of determining the degree of difficulty performing action (Dm) aims to determine the degree of difficulty of UP2W in implementing the recommendations for improvement. The output of determining Dm is a value with a scale of 3 to 5. Each scale has its own considerations, namely 3 (low), 4 (medium), and 5 (high).

Table 7. Determination of Alternative Recommendations for Improvement

Code	Description	Value
WEA1	Relay the coal nozzle burner production	4
WEA2	Make bend-cut profile mall	3
WEA3	Creating SOP for material handling & product defects	3
WEA4	Making a Jig-fixture	3
WEA5	Worker Training and Certification	4
WEA6	Adding Experts	4
WEA7	Added new crane and forklift capacity	5
WEA8	Purchase a new cutting and bending machine	5
WEA9	Optimization of the 5R / 5S program	4

3.3.3. Lean Matrix 2 Mapping Results

The results of alternative recommendations for improvement and determination of the degree of difficulty performing action and the output of Lean Matrix 1 are used to compile Lean Matrix 2. Determine the value of the correlation relationship matrix with conditions, 0: no correlation, 1: weak correlation, 3: moderate correlation and 9: strong correlation.

In the table, it can be seen that the alternative recommended improvements chosen to eliminate waste in the Coal Nozzle Burner production process are WE3, WEA5, and WEA9.

Table 8. Results of Lean Matrix 2

Waste Type	*Root Source of Waste*	*Waste Elimination Action*									*Agregate Cause*
		WEA1	WEA2	WEA3	WEA4	WEA5	WEA6	WEA7	WEA8	WEA9	
EHS	S1	9								9	701
Defect	S2		9	3					3		987
	S3			9	3		1			1	1476
	S4				9						441
Waiting	S5			1		9					745
	S6					9	9				420
	S7	9					1			3	656
Not Utilizing Employees	S8					9	3				952
Transportation	S9	3						9			339
	S10								9		580
Excess Processing	S11	1		1						9	453
Total Effectiveness of Waste Elimination Action (TE)		13.686	13.284	14.509	8.397	19.056	8.768	3.051	8.181	13.833	
Degree of Difficulty Performing Action (D)		4	3	3	3	4	4	5	5	3	
Effectiveness to Difficulty Ratio (ETD)		3.422	4.428	4.836	2.799	4.764	2.192	610	1.636	4.611	
Rank of Action Priority		5	4	1	6	2	7	9	8	3	

3.4 Improvement Recommendations

3.4.1 Selected Improvement Recommendations

1. WEA3: Develop SOP for handling material and defective products

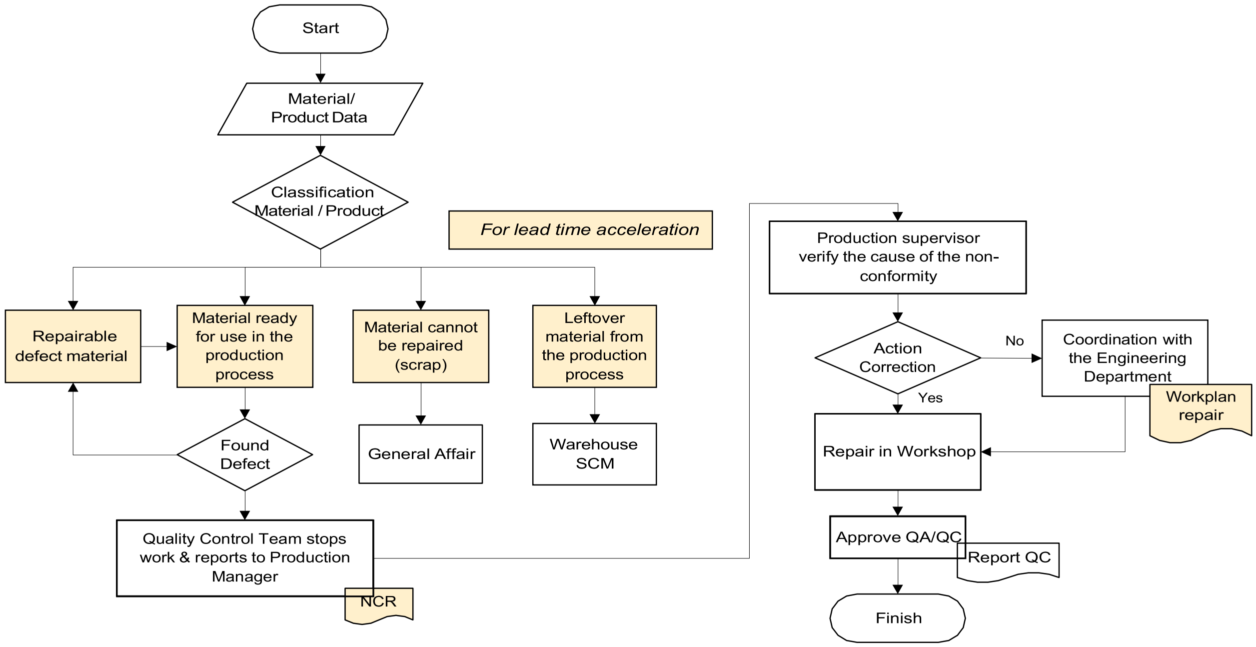


Figure 2. SOP for Handling Material and Defective Products

UP2W does not yet have a Standard Operating Procedure (SOP) or Work Instruction (IK) which specifically handles defect materials and products. So it is necessary to make a main guide for handling the defect material / product. In making this SOP, interviews were conducted to obtain information from UP2W, namely the Production Manager and the Integrated Management Representative Team (WMT) of the Quality Management section of ISO 9001: 2015.

2. WEA2: Worker Training and Certification

In the coal nozzle burner production process, workers in the mechanical production line need to have knowledge, skills and abilities in the fields of machining (machining) and welding (welding). Based on the results of discussions with the manager of the HR department and the expert, it was determined that the criteria for the level of worker expertise were leveled consisting of 5 criteria from low to high. Furthermore, the training will also focus on skills, including:

a. Implementing occupational safety, health and the environment
b. Implementing a quality system
c. Read technical drawings and welding symbols
d. Inspection and testing of welding results
e. Know the characteristics of the use of the material
f. Cutting the main material of welding

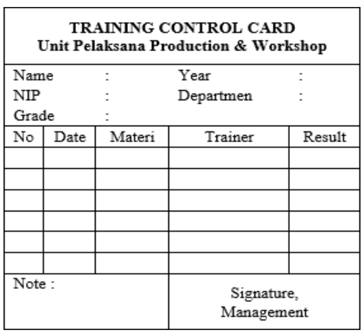
Training will be carried out periodically until all training targets are achieved and skills increase is obtained, the progress of training needs to be recorded on the control card so that training progress is known and planning for further training needs.

3. WEA4 : Optimizing the 5S Program

UP2W has implemented 5S (Seiri, Seiton, Seiso, Seiketsu and Shitsuke) or better known as 5R (Brief, Neat, Clean, Careful, and Diligent).

Japan		Europe/America	Indonesian	
5S		5S	5R	5P
1S	Seiri	Sort	Ringkas	Pemilihan
2S	Seiton	Set in order	Rapi	Penataan
3S	Seiso	Shine	Resik	Pembersihan
4S	Seiketsu	Standardize	Rawat	Pemantapan
5S	Shitsuke	Sustain	Rajin	Pembiasaan

a. Seiri, which is setting aside unnecessary items with those that are necessary or setting aside and disposing of unnecessary items at work.
b. Seiton, namely arranging the work tools used neatly and completely eliminating the activity of searching so that tools can be easily found quickly.
c. Seiso, namely maintaining the cleanliness of the workplace.
d. Seiketsu, namely maintaining seiri, seiton, and seiso so that it can take place continuously.
e. Shitsuke, which is a discipline and has become a habit, so that workers are accustomed to obeying the rules and there are counseling for workers to work professionally.



TRAINING CONTROL CARD
Unit Pelaksana Production & Workshop

Name : Year :
NIP : Departmen :
Grade :

No	Date	Materi	Trainer	Result

Note : Signature, Management

Figure 3. Training Card and 5S Red Tag

3.4.2 Implications of Implementation of Recommendations for Improvement

In designing improvement recommendations, it is necessary to standardize the production process and calculate the total production time in completing the production of the coal nozzle burner. Processes that are considered not providing added value need to be eliminated or eliminated, thereby reducing the lead time of the production process. the results of the future state time required to complete 1 coal nozzle burner production takes 7920 minutes or 17 working days. Meanwhile, eliminating waste through recommended improvements takes 6315 minutes or 13 working days. So there is a difference of 1605 minutes or 4 working days.

4. CONCLUSION

1. Critical waste in the coal nozzle burner production process, namely waiting, defect and excess processing waste, where of the three wastes include non-value added material handling activities, equipment preparation, repair and rework processes at each stage of the production process.
2. Based on the analysis using root cause analysis, the causes of waste waiting, defects and excess processing are due to the absence of SOPs for handling material and defect products, there is no provision of training which causes a lack of skills, knowledge and abilities of workers, as well as the 5S program for equipment and materials not optimal.
3. Recommendations for improvements to the coal nozzle burner production process proposed include: Creating SOPs for handling material and defect products, training and certification of workers in the welding process, Optimizing the 5R / 5S Program for main material handlers and workshop equipment.

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6. REFERENCES

Gasperz, V., & Fontana, A. (2011). Lean Six Sigma for Manufacturing and Service Industries. Bogor: Vinchristo Publication.

George, M. O., (2010). The Lean Six Sigma Guide to Doing More with Less : Cut Costs, Reduce Waste, and Lower Your Overhead. New Jersey: John Wiley & Sons, Inc.

Groover, M. P. (2010). Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 4th edition. New York : John Wiley & Sons, Inc.

Karningsih et al (2019), "Lean Assessment Matrix: A Proposed Supporting Tool for Lean Manufacturing Implementation, Proceedings of Annual Conference on Industrial and System Engineering (ACISE), Universitas Diponegoro, Semarang.

Manos, A. dan Vincent, C. (2012) The Lean Certification Handbook : A Guide To The Bronze Certification Body of Knowledge. Milwaukee, Wisconsin: ASQ Quality Press.

Puji Lestari, Nastiti. (2020). Pendekatan Lean Manufacturing untuk Perbaikan Proses Produksi Speaker. Surabaya: MMT ITS.

Rawabdeh, Ibrahim A. (2005), "A Model for the Assessment of Waste in Job Shop Environments", International Journal of Operations & Production Management, Vol 25 No.8, 2005, hal. 800–822.

LEAN THINKING APPLICATION FOR 60 MVA TRANSFORMER'S SUPPLY AND INSTALLATION PROCESSIN ELECTRICITY TRANSMISSION COMPANY

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ABSTRACT

Based on data on the realization of the procurement and installation of transformers in the first quarter of 2020 at PLN Transmission, East Java and Bali, only 48% of the transformers that have been sent by the vendor (on-site) have been successfully supplied with electricity. The causes of long transformer waiting time to be electrified are non-value-added activities, for example, long coordination lines between fields/sections/units, and repeated revisions to the construction design. For this reason, the Lean Thinking approach is used to identify activities that are not value-added and toformulate recommendations for improvement. The identification of non-value-added activities is carried out using Current Value Stream Mapping (VSM) and Process Activity Mapping (PAM) until the critical waste is found and then analyzed using Root Cause Analysis (RCA) while Solution alternatives are analyzed using Analytical Hierarchy Process (AHP). With the application of Lean Thinking, found that the critical waste is "waiting" followed with "overprocessing". it is also reduced transformer waiting time to be electrified in 168,95 hours long, so recommendations forimprovement can be shown in Formulated FutureValue Stream Mapping.

Keywords: Analytical Hierarchy Process, Value Stream Mapping, Lean Thinking, Transformer 60MVA

1. INTRODUCTION

PT PLN (Persero) Unit Induk Transmisi Jawa Bagian Timur dan Bali (UIT JBTB) was formed in January 2016 managing transmission assets of 384 transformer units with a total capacity of 26,329 MVA, is currently carrying out a project to replace/upgrade the capacity of existing transformers. However, this replacement process has a problem with the long waiting time for the onsite transformers to be powered immediately. Some of the reasons are the lengthof the coordination path between the fields/units, the repeated coordination process and revision of construction designs, and the unpreparedness of the supporting materials for the transformer installation process. As for the energizing process, the change in schedule goes outthat involves many parties and interests, greatly affecting the smoothness of the process. So, to avoid the worst possibility of the long process of replacing or uprating the transformer, it is necessary to evaluate and map the process flow which can provide a complete picture of the ideal processing time, what activities and stages are deemed to not add value, and can provide recommendations for business process improvements which can be done by PLN UIT JBTB. Then by minimizing unnecessary activities/processes (waste) in the internal process using the Value Stream Mapping tool, it is hoped that it can identify the waste that occurs during the 60MVA Transformer Procurement and Installation process and choose the best solution to minimize waste using the Analytical Hierarchy Process (AHP) so that able to improvecompany performance.

2. LITERATURE REVIEW

2.1 Transformer's Procurement and Installation

Based on SE Dir Number: 0010.E / DIR / 2016 concerning "Technical Guidelines for the Procurement of Goods / Services for PT PLN (Persero)", the Procurement of Construction Services accommodates the Procurement of Goods and Installation (Supply & Erect). The type of contract offered to the Vendor is a Turn-Key type of contract to procure a supply erect goods/services that are only needed once, and do not prioritize the need for further technology transfer. This type of procurement is commonly carried out on Main Transmission material contracts such as Power Transformers.

2.2 Lean Services

Lean Services has the same meaning as Lean manufacturing. The difference lies in the concentration of the field of application. Lean Service emphasizes more on service products, administration, and offices, while Lean manufacturing is for goods products. Identification of activities that add value and do not provide added value is an important process in the lean-approach. In manufacturing three types of activity can be categorized according to Monden (1994) namely, as follows:

1. Value-Adding Activity (VA)
   Activities that can provide added value from the customer's point of view on a product material that is manufactured or processed.
2. Non-Value Adding Activity (NVA)
   Activities to create products but not provide added value for customers. This activity is referred to as waste which must be the main focus to be eliminated.
3. Necessary Non-Value Adding Activity (NNVA)
   Activities that do not provide added value but are required in the existing process procedures. For example, moving materials, moving tools from one hand to another, and unpacking deliveries. This activity has no added value but is difficult to eliminate except by changing procedures, creating new structures and standards, and so on.
   Examples of tools from Lean are Value Stream Mapping, Kanban, and Poke Yoke.

2.3 Analytical Hierarchy Process (AHP)

Saaty (2008) in his journal entitled "Decisions Making with the Analytic Hierarchy Process" states that the Analytic Hierarchy Process (AHP) is a theory of measurement through pairwise comparisons and relying on expert judgment to get a priority scale. Descendant priority scales are synthesized by multiplying them by the priority of their parent nodes and adding for all those nodes. AHP stages according to Supriadi (2018) The stages in AHP are as follows:

1. Define the problem and determine the desired solution.
2. Create a hierarchical structure that begins with the main objective.
3. Create a pairwise comparison matrix that describes the relative contribution or influence of each element to the goal or criteria level above it. Comparisons are made by filling in the intensity matrix in pairs with a score of 1 to 1 10, where the explanation of the Interest Intensity Score according to Saaty (2008)

4. Perform Defines the pairwise comparison so that the total number of assessments is obtained where n is the number of elements being compared.
5. Calculate the eigenvalues and test their consistency.
6. Repeat steps 3,4, and 5 for all levels of the hierarchy.
7. Calculate the eigenvectors of each pairwise comparison matrix
8. Check hierarchy consistency.
   The consistency ratio (C.R.) was obtained by comparing C.I. with one of the following series of numbers, each of which is an average random consistency index derived from a randomly generated reciprocal matrix sample using a scale of 1/9, 1/8,…, 1,…, 8, 9.

Table 1.1 Score Intensity of Interest (Saaty,2008)

Intensity of Interest	Description Correlation among components	explanation
1	Equal importance	Both elements are equally important. Two elements have the same influence
3	Moderate importance	One element is slightly more important than the other, Experience and judgment support one element a little more than another
5	Strong importance	One element is more important than another, Experience and judgment strongly support one element over another
7	Very strong or demonstrated importance	One element is clearly more absolutely essential than any other element, One element that is strongly supported and dominant is seen in practice
9	Extreme importance	One element is absolutely more important than the other elements. Evidence which supports one element against another has the highest degree of affirmation possible
2,4,6,8	The values between two values of adjacent considerations, This value is given when there are two compromises	
Reverse	If for activity i gets one point compared to activity j, then j has the opposite value compared to i	

3. METHODOLOGY

This research methodology is divided into 4 stages, namely:

Stage 1: Mapping the procurement and installation process for the existing 60 MVA transformers, which includes:

1) Confirmation of the existing flowchart
2) Collect supporting documents
3) User interviews
4) Making Current Value Stream Mapping

Stage 2: Identifying waste in the process of procuring and installing a 60 MVA transformer, which includes:

1) Group discussions with expert users
2) Making Root Cause Analysis using 5 why's
3) Borda Count Method for determining critical waste Stage

3: Finding the root cause of waste, which includes:

1) Analytical Hierarchy The process of determining the best solution
2) Providing repair solutions for the Procurement and Installation of 60MVATransformers
3) Making Future Value Stream Mapping

Stage 4: Making recommendations to reduce or eliminate waste

4. ANALYSIS

4.1 Current Value Stream Mapping

Process Mapping using Value Stream Mapping (VSM) is useful for viewing the entire flow of processes and information on Transformer Procurement and Installation Supervision activities, so in this case study the authors conducted observations on Transformer #2 60MVA Substation Lamongan so that Value Stream Mapping for Procurement and Installation as Figure 1.1 below

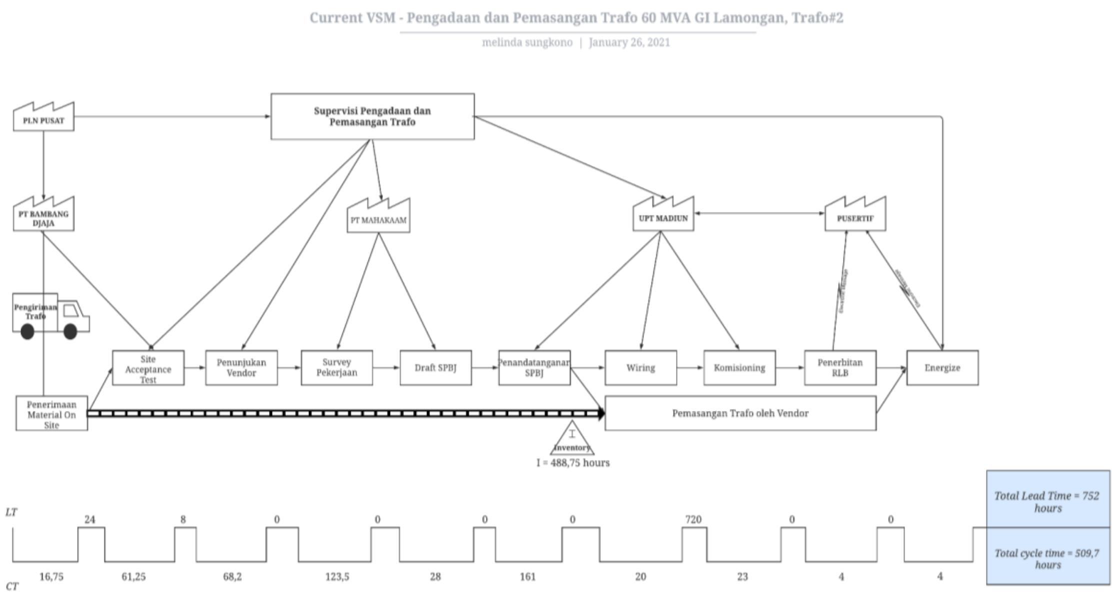

Figure 1.1 Current Value Stream Mapping (CVSM)

The flow of activities in the process of Procurement and Installation of Transformer #2 Lamongan Substation 60MVA is as follows:

1. Receipt of On-Site Materials

PT. Bambang Djaja (B&D) is a transformer supplier located in Ngoro District, Mojokerto, East Java Province. The travel time from the factory to the site (Lamongan Substation) is in 2 hours with an average speed of 80km/hr. However, to deliver a 60MVA transformer takes more than normal time, which is (estimated) for 6 hours.

2. Site Acceptance Test

SAT Minutes (BA SAT) and Minutes of Assembly (BA Assembly) are the 100% payment terms paid by PLN to PT. Bambang Djaja. So that the vendor will send an applicationletter for the implementation of the SAT immediately. The process of coordinating the implementation of the SAT has been instructed by the UPT Construction Sector, so that the implementation of the SAT is managed independently by the UPT, but still coordinates with the UIT Construction. If the UPT personnel cannot carry out the SAT for several reasons, the UPT can ask for assistance from the UIT Construction personnel to become PLN representatives. The process of implementing SAT Transformator #2 Lamongan took 61.25 hours.

3. Appointment of Vendors

With the end of the SAT process, the transformers already on site are recognized as inventory. Furthermore, UPT will submit a request for the appointment of a transformer installation vendor to UIT JBTB, which in this case study is addressed to PT Mahakaam. The process of appointing a vendor can take up to 61.25 hours.

4. Job Survey

PT Mahakaam as one of the four transformer installation vendors has known whichlocations will be the scope of work, but to start the survey process itself will only be carriedout if there is readiness from both parties (Vendors and PLN). In this survey process, the vendor reviews the field conditions and the suitability of the construction design guidelines provided by the UIT Engineering Sub-sector and evaluates whether it is necessary to make re- adjustments related to construction and mechanical electrical work. If re-adjustment is necessary, the vendor must coordinate with the UPT regarding minor design proposals (drawings), while major adjustments (such as design changes and cable duct diameter) must becoordinated with the Main Unit.

1. Preparation of Draft SPBJ

To start the work of installing or replacing transformers, the UPT needs to make an Order for Services Goods (SPBJ) addressed to the appointed Vendor. This SPBJ document is equipped with a Bill of Quantity (BoQ) agreed upon in the previous process. However, it should be noted that currently there is no ideal period or regulation that regulates the maximum period for returning the SPBJ document signed by the vendor to PLN.

2. Signing SPBJ

After the SPBJ document is signed by the vendor and submitted to PLN, that is when the period for implementing the transformer replacement begins. The timeframe for the replacement of the transformer has been stated in the SPBJ document, that the implementation of the transformer replacement by the appointed vendor is carried out for 60 calendar days.

3. Wiring Process

The wiring process is carried out by PLN employees and carried out during the period the transformer installation contract is valid.

4. Commissioning

Commissioning is an activity that involves a team of examiners who work to carry outa complete check of each part of the transformer (function test, protection test, stability test, open-close PMT).

5. Issuance of Operational Acceptable Recommendations (RLB)

The RLB proposal is sent by the Construction Sub-Department in UIT to the Pusertif a maximum of seven days before the energize schedule, if it is less than seven days there is a riskof delaying the energize schedule.

6. Energize

Energize is the activity of multiplying the electric current for the first time to a transformer that has just been installed. This process can be carried out immediately after the Operational Acceptable Recommendation is issued by Pusertif.

Whereas from the CVSM above (Figure 1.1) it is known that the waiting time for transformers to be energized quite long, amounting to 488,75 hours.

4.2 Process Activity Mapping and Value Classification

From the Process Activity Mapping, it is known that the details of the 60MVA Transformer Procurement and Installation activities include 75 activities with a total activity time of 509.7 hours or the equivalent of 73.5 working days. The longest time consumption contributionis in the sub-process of sending the Order for Goods and Services (SPBJ), whichis 161 hours, while the shortest time consumption is in the sub-process of issuing an Operational Acceptable Recommendation (RLB) and Energize. All these activities, then equipped with Value Classification to find out where the details of the waste occurred.

Table 4.1 Recapitulation of Frequency Spreads and Value Classification Duration

Activity	Frequency	Percentage	Duration	Percentage
VA	44	58,7%	201,25	39,5%
NVA	20	26,7%	282,75	55,5%
NNVA	11	14,7%	25,7	5,0%
Total	**75**	**100%**	**509,7**	**100%**

Mapping the Process Activity Mapping in table 4.1, it can be seen that the duration of Non-Value Added activities dominates the entire process of Procurement and Installation of 60MVA Transformers, which is 55.5%.

Furthermore, to see in more detail the types of wasteful activity that occur, the activities are grouped into five categories, namely O (operation), T (transport), I (inspection), S (storage), and D (delay), so that Table 4.1. above can be broken down into nine combinationsof activity classifications, which are as shown in Table 4.2 below.

Table 4.2 Distribution of categories in Value Classification

Activity - Classification	Sum Activity - Classification	Percentage	Duration (hour)	Percentage
O-VA	42	56,0%	185,25	36,3%
I-VA	2	2,7%	16	3,1%
T-NVA	1	1,3%	2,75	0,5%
D-NVA	12	16,0%	263	51,6%
O-NVA	7	9,3%	17	3,3%
D-NNVA	1	1,3%	4	0,8%
I-NNVA	4	5,3%	11	2,2%
O-NNVA	4	5,3%	5,45	1,1%
T-NNVA	2	2,7%	5,25	1,0%
Total	**75**	**100%**	**509,7**	**100%**

4.3 Waste Identification

The observations on the process of Procurement and Installation of Transformer #2 in Lamongan Substation, 263 hours of waste waiting were found, which was dominated by processes influenced by the 2nd Party, namely 240 hours, and the remaining 23 hours related to waiting for the letter approval process by Management (Table 4.3). The waste findings have been verified by the opinion of users who are competent in their fields, adapting the Borda- Count Method concept to determine critical waste that affects the 60MVA transformer procurement and installation process, the first rank of Critical waste is "Waiting" followed by "Over Processing".

4.4 Recommended Formulations to Reduce or Eliminate Waste

Based on the results of the critical waste ranking in the discussion above, a root cause analysis (RCA) will be carried which triggers the waste of "Waiting" and "Over Processing", for "Waiting" waste is divided into 2 processes, namely RCA Sub waste "Waiting between process”, and RCA Sub-waste “Waiting for approval letter”, as shown in Table 4.3 below

Table 4.3 Waste on Procurement and Installation of Transformer #2 60MVA LamonganSubstation

Waste Indication	Description	Activity Code	Activity	Duration (hours)
Waiting	Period of time spent waiting for something to happen	B.4	Waiting for assembly schedule	263
		B.6	Waiting for the SAT schedule	
		C.15	Waiting for the specified survey time	
		D.2	Waiting for the vendor to submit the drawing	
		F.2	Waiting for the Vendor's readiness for the SPBJ process	
		F.7	Waiting for the Details of the Budget from Pusertif	
		B.10	Waiting for MUPT Approval	
		C.2	Waiting for Disposition SRM Kons	
		C.4	Waiting for Disposition MSB Dalkon	
		C.7	Waiting for the Approval of the Vendor Appointment Letter by MSB Dalkon	
		C.9	Waiting for Approval of Vendor Appointment Letter by SRM Kons	
		F.9	Awaiting disposition of Letter from SRM Kons	
Over Processing	processes more than necessary where a simpler approach should be possible	B.2	Iterative coordination: appointment of SAT personnel	10
		C.13	recurring confirmations regarding the schedule of surveys with vendors and related parties	
		F.17	Conduct repeated confirmation with the Pusertif Technical Bid related to the PIC Inspector who will conduct the RLB	
Defect	Damage, errors and rework	D.5	Found designs that should have been approved at UIT but only approved at UPT	6
		D.6	Kons UIT holds additional coordination meetings between the UPT, UIT Engineering and Vendors regarding follow-up findings in the application drawing process	
Waste of Motion	Human movement that does not add value	D.9	Construction UIT sends the original design drawing document (A3) to the Engineering dept.	3,75
		D.12	UIT Engineering returns the original document (A3) with a wet approval stamp	
		F.14	ransferring documents between approval levels (AMN, MSB, SRM)	

Table 4.4 Recapitulation of the root causes of waste "Waiting" and "Over Processing"

Waste	No	RCA	Suggested Solutions	Solutions Code
Waiting between Processes	1	No 3-way integrated information system (vendor, UPT, UIT)	An online application is made to supervise procurement and installation contracts	(W1)-1
	2	There is no online fieldwork schedule	Realtime schedule and location creation	(W1)-2
	3	There are no regulations regarding the deadline for returning SPBJ documents	proposal for additional clauses in the main contract related to the maximum deadline for signing the SPBJ	(W1)-3
	4	There is a minimum MTU purchase order	Planning for the Safety Level for MTU Stock	(W1)-4
	5	There is no minimum planning for MTU stock level	Planning for the Safety Level for MTU Stock	(W1)-4
	6	there is no online system regarding the status of the proposed RAB, RLB, and Inspection	An online application to supervise procurement and installation contracts	(W1)-1
Waiting Approval Letters	1	Incoming letters and official notes are not equipped with automatic priority	Proposed improvement for the AMS application to the PLN Holding	(W2)-1
	2	Do not transfer AMS functions to secretary / PLH	an IK will be created in the event of a transfer of AMS function to Secretary / PLH in a sudden condition	(W2)-2
	3	Error in editorial and word choice in the TLSK	TLSK training	(W2)-3
Waste Over Processing (Coordination and Recurring Confirmation)	1	Limited qualified human resources	Training	(OP)-1
	2	Relying on skilled human resources	Training	(OP)-1
	3	Accidental negligence	Implementation of 5S	(OP)-2

4.5 Recommended Formulations to Reduce or Eliminate Waste

The Analytical Hierarchy Process (AHP) is one of the decision-making methods introduced by Thomas L. Saaty, who performs pairwise comparisons for each criterion to obtain an Eigenvector which is the weight in determining priority. In this case study of Supervision of Procurement and Installation of 60MVA Transformers, the criteria used are:

1. Ease of implementing alternative solutions
2. Cost-Effective, in other words, the cost is relatively cheap
3. Speed of execution

Of the three criteria above, weights between the criteria will be made, namely by adding up all the values in the criteria column in the matrix, dividing each value from the column by thetotal column concerned to get the matrix normalization. The matrix normalization value is thenaddedup each row and dividing by the number of elements to get the final value, the Eigen Value as Preference Value of each solution alternatives.

Table 4.5 Best solution preference on Waste “Waiting between Processes”

Solution	Solution Code	Preference Value	Rank
An online application is made to supervise procurement and installation contracts	(W1)-1	0,10	4
Realtime schedule and location creation	(W1)-2	0,41	1
proposal for additional clauses in the main contract related to the maximum deadline for signing the SPBJ	(W1)-3	0,26	2
Planning for the Safety Level for MTU Stock	(W1)-4	0,23	3

Therefore, the proposed improvements based on the ranking of the Analytical HierarchyProcess on “Waiting” waste (Waiting between processes and Waiting for approval letters), and “Over Processing” waste can be used as a reference for the description of Future Stream Mapping.

4.6 Future Value Stream Mapping

The improvement that might be obtained from the application of the first and second rank solutions for waste "waiting" and "over processing" is estimated at 273 hours. Where activities change, namely:

1. Site Acceptance Test activities have decreased by 29 hours
2. The activity of the Appointment of Vendors was decreased by 63 hours
3. The job survey activity has decreased by 40 hours
4. Signing the Order for Goods and Services for 141 hours

With this improvement, the waiting time for transformers to be energized will be shorter, amounting to 168.95 hours

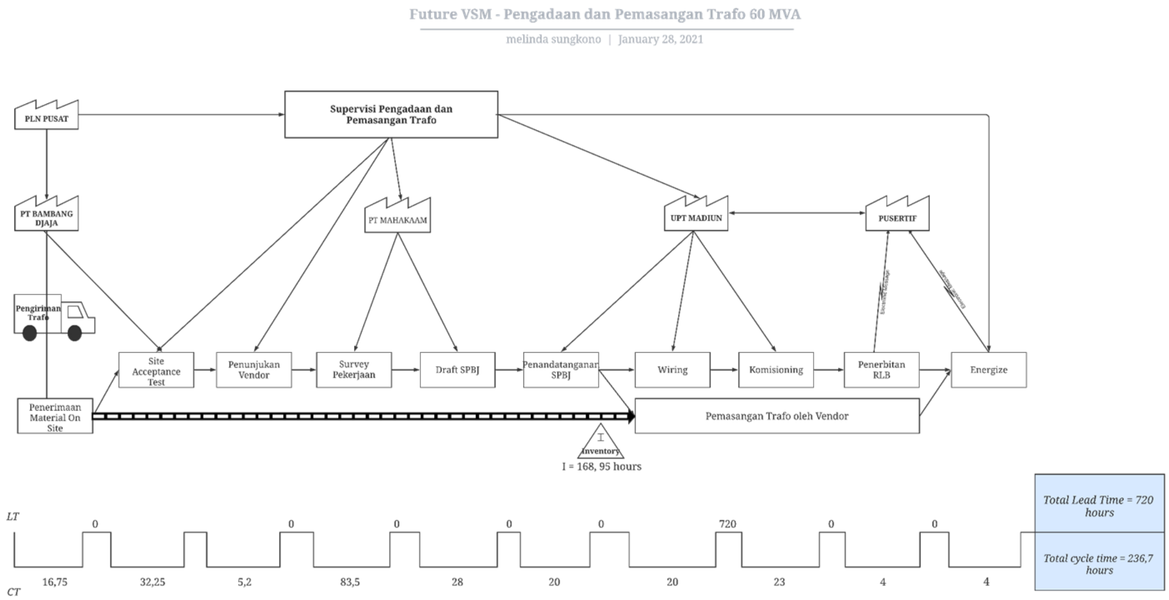

Figure 1.2 Future Value Stream Mapping

5. CONCLUSION

Based on the research and evaluation that has been carried out on the Procurement and Installation of 60MVA Transformers in Electricity Transmission Companies, it can be concludedthat:

1. Along the current value stream in the 60MVA Transformer Procurement and Installation activities, using the Process Activity Mapping method, there are four types of waste, namely Waiting, Over Processing, Defect, and Motion. Of the four types found, based on the evaluation using the Root Cause Analysis and the Borda Count Method, critical waste ranks 1 and 2 are Waiting and Over Processing.
2. The causes of “Waiting” waste are divided into 2 groups, namely waiting for waste between processes and waiting for approval letters. Each waste has more than one root cause so that it has more than one proposed solution.
3. Alternative solution proposals for waste "Waiting" and "Over Processing" are analyzed using the Analytical Hierarchy Process so that it is known that the best-proposed solutionto minimize waste is by making schedules on work locations online (real-time), making Work Instructions related to the transfer of AMS functions under certain conditions, and providing Education and Training and Training to Human Resources in related Sectors / Divisions so that new teams of experts will emerge.
4. With the proposed solution to the waste that occurs, it is expected to be able to produce improvement in the form of reducing the time needed to install the transformer and readyto be supplied since the transformer is available on site, which is 168.95 hours.

6. REFERENCES

Astuti, R. D., & Apriliana, F. S. (2018). Penerapan Value Stream Mapping (VSM) Untuk Mengurangi Keterlambatan Proses Pengadaan Barang dan Jasa di PT X (Studi Kasus Pengadaan Barang dan Jasa A4100000121). *PERFORMA : Media Ilmiah Teknik Industri*, *17*(1), 61–69.

Arunagiri, P., & Gnanavelbabu, A., (2014). “Identification of Major *Lean* Production *Waste* in Automobile Industries using Weighted Average Method”, *Proceedia Engineering 9.* Elsevier.com, Hal 2167-2175

Faisal, & , Purnawan Adi. W, S.T., M. T. (2018). Using Value Stream Mapping To Support *Lean* Supply Implementation : Aircraft Engine Maintenance. *Jurnal Studi Teknik Industri*, 1–8.

Gasperz, V. (2012). *Production and Inventory Management.*Bogor: Vinchristo Publication. Harliwantip. (2014).” Analisis *Lean Service* Guna Mengurangi *Waste* pada Perusahaan Daerah Air Minum Banyuwangi”, *Spectrum Industri*, Vol.12, No.1, Hal 1-112

Hudori, M., (2016). “Identifikasi dan Eliminasi *Waste* pada Proses Receiving di Gudang”, *MalikussalehIndustrial Engineering Jurnal*, Vol 5, No.2, Hal 38-45

Karadova, Jaroslava & Demecko, Michal. (2016).New Approaches in *Lean* Management.*Procedia Economics and Finance,* Vol 39, Hal 11-16.

Lubis, Riski Imansyah., (2016). *Perbaikan Proses Konstruksi Pembangunan Pipa Gas dengan Penerapan Metode Lean Construction untuk Mereduksi Waste*, Thesis, MMT-ITS, Surabaya.

M.L, George., (2002). *Lean Six Sigma: Combining Six Sigma Quality with Lean Production Speed,* McGraw-Hill Companies. US.

Mahendrawathi. (2018), *Business Process Management.* Andi, Yogyakarta.

Manoharan, Thulasi & Azizi, Amir. (2015).” Designing a Future Value Stream Mapping to Reduce Lead Time using SMED - A case study”. *Journal of MIMEC.* 2nd Internasional. Hal 153-158.

Maleyeff,J. 2006. *Exploration of Internal Service System Using Lean Principles.* Managemen Decision 44, hal 674-689.

McCue, Clifford & Waterman, Jason. (2012). ”*Lean Thinking* within Public Sector Purchasing Department: The Case of the UK Public *Service*”. *Journal of Public Procurement*, Vol.12, Issue 4, 505-527.

Musthofa, Sarfina. (2014). *Pendekatan Lean Manufacturing untuk mereduksi waste menggunakan value stream mapping: Studi Kasus Pada PT X Bangil*. Thesis. Universitas Brawijaya, Malang.

Monden, Yosuhiro., (1994). *Toyota Production System: An Integrated Approach to Just-In- Time.* Chapman&Hall. New York.

Nash, K., Zhang, H., & Strawderman, L. (2011). Empirical Assessment of Decision Making Behaviorin Multi-Criteria Scenarios. *Industrial Engineering Research Conference*. Mississippi.

Oliveira, M.S., Moreira, H.D.A, Alves, A.C., & Fereira, L.P., (2019). “Using *Lean Thinking* Principles to Reduce *Waste*s in Reconfiguration of Car Radio Final Assembly Lines”. *Manufacturing Engineering Society Internasional Conference*. Procedia *Manufacturing* 41, Hal 803-810.

Winanda, Ariani Putri. (2017). *Upaya Peningkatan Kualitas Pelayanan Jalan Tol Semarang-Bawen dengan Integrasi Motode Importance Performance GAP Analysis, Lean* dan *Six Sigma.*Tugas Akhir.Universitas Diponegoro.Semarang.

Wiyasani, Niluh., Kertahadi., dan Riyadi. (2014). “Analisis Business Process Reengineering untuk mengevaluasi, merekayasa ulang, dan memperbaiki monitoring kontrak pada PLN Distribusi Jatim Area Malang”, *Proceeding Jurnal Administrasi.*Universitas Brawijaya Malang.Vol 8, No.1 KEPDIR No.0520-2.K/DIR/2014.”Buku Pedoman Trafo Tenaga”.PLN Pusat.Jakarta

KEPDIR No.149.K/DIR/2013.”Kriteria Penggantian Peralatan Utama Gardu Induk di Lingkungan PT PLN (Persero)”.PLN Pusat.Jakarta

Saaty, Thomas L., Vargas, Luis G. (2012).”Models, Methods, Concepts & Application of the Analytic Hierarchy Process”.Vo.175.Springer. US.

Saaty, Thomas L. (2008).” Decision Making with the Analytic Hierarchy Process”. Int. J. Services Sciences, Vol. 1, No. 1.

Supriadi, Apip. (2018). *Analytical Hierarchy Process (AHP)Teknik Penentuan Strategi Daya Saing Kerajinan Bordir.* Deepublish, Yogyakarta.

SEDIR No.0010.E/DIR/2016.”Petunjuk Teknis Pengadaan Barang/Jasa PT PLN (Persero)”.PLN Pusat.Jakarta

Singh, J., & Sharan, A. (2015). Relevance Feedback Based Query Expansion Model Using Borda and Semantic Similarity Approach. *Computational Intelligence and Neuroscience*.

LEAN MANUFACTURING ANALYSIS ON THE PRODUCTION OF TUG BOAT 2X1800 HP AT PT. XYZ

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ABSTRACT

The domestic shipbuilding industry must receive serious attention in order to become a competitive industry as a component of the marine industry. The shipbuilding industry is the most important in supporting marine transportation in the context of maritime development. The ability of a shipyard to obtain new ship orders lies in the level of productivity, namely the ability to build ships according to specifications and quality requirements, competitive prices, and short delivery times. This study aims to identify and analyze Non Value Added Activities and Value Added Activities, in the production process of 2x1800HP Tug Boat construction at PT. XYZ. The formulation of the researchproblem is how to reduce production activities that do not provide added value or waste. With research data in the form of the results of filling out questionnaires that were distributed to respondents who were then processed by the Value Stream Mapping (VSM) method and Value Stream Analysis Tools (VALSAT). The results showed thatthe production flow of 2x1800HP Tug Boat construction is Input Transfer, Press & Bending, Sub Assembly, Quality Check by Internal QC, Assembly Process, External Quality Check, Erection, External Quality Check. And the waste that often occurs is Defect (19.23%), Innapropriate Processing (16.15%), and Overproduction (14.62%). Prior to the improvement of the Value Added Ratio was 88.07%, and after improving the production process the Value Added Ratio increased to 89.64%.

Keywords: *Tug Boat, VALSAT, Lean Manufacturing, waste, Value Added Ratio.*

1. INTRODUCTION

The domestic shipbuilding industry must receive serious attention in order to become a competitive industry as a component of the marine industry. The shipbuilding industry is an industry that is most important in supporting marine transportation in the context of maritime development. The ability of a shipyard to obtain new ship orders lies in the level of productivity, namely the ability to build ships according to specifications and quality requirements, competitive prices, and short delivery times. (Ma'ruf, 2014).

For several shipyards in Indonesia, there is still a process of rework, the emergence of relatively excessive waste, and relatively long shipbuilding times. Seeing this condition, an effort is needed to increase the competitiveness of companies that meet three main criteria, namely: (1) competitive selling price of ships, (2) relatively good process speed and quality of ship building, (3) smaller rework and goods remainder in each production process. With these criteria,product-oriented production methods will always strive to increase productivity related to input efficiency, process quality, and the effectiveness of work results in the development process. At this time there is an increase in time without added value and residual material along with the increase in the quality of one product and service. (Mulyanto, 2004).

Tug Boat is a type of guide boat that is commonly used to tow and push large ships in ports, guide large ships on dangerous routes, repair ships at sea, carry out water rescue such as extinguishing fire and salvage (Djaya, 2008). In addition, Tug Boat is a ship whose function is to attract or push other ships. There are several types, including ocean tugs, harbor tugs and others. The terrain traversed by the Tug Boat are usually quite difficult, such as winding small rivers and shallow craggy seas to wide seas between large islands, so Tug Boat must perform good maneuvers. (Prakoso, 2010). The problem in this research is how to increase efficiency in the production process of 2x1800HP Tug Boat ships using the Lean Manufacturing method. The purpose of this research to be achieved is to identify the causes of waste in the 2x1800HP Tug Boat production process to provide recommendations for improvements to the company inincreasing efficiency with the Lean Manufacturing method.

2. LITERATURE REVIEW

2.1 Basic Lean Concepts

This Lean concept is applied to manufacturing and service companies, because basically the concept of efficiency will always be used and a target of a company so that companies can increase profits (Arum, 2017). The goal of lean is to continuously increase the added value of the product for customers through increasing the ratio between added value to waste (Nyata 2017).

2.2 Lean Manufacturing Activities

The Lean method has an important process, namely identifying activities that provide added value and do not provide added value (Ririyani, 2015). In the Lean method there are three types of activities which are important processes in this method, including: a.Value Adding Activity which is an activity that provides added value for a customer to a product that is processed. b. Non - Value Adding Activity which is an activity that does not provide added valuefor a customer to a product being processed. This activity must be eliminated as waste. b. Necessary Non – Value Adding Activity which is an Activities that do not provide added value, but need to be done to simplify the production process. For example, moving the input material, moving the output results to facilitate further processing

2.3 Seven Waste

According to Gaspersz & Fontana (2015) waste is all company or industrial work activities that do not provide added value in the process of transforming inputs into outputs alongthe value stream. There are seven types of waste according to Taichi Ohno, a manufacturing company that usually calls DOWNTIME (Defect, Overproduction, Waiting, Transportation, Inventories, Motion, Excess processing).

Defect is the type of waste that occurs because the resulting product is defective or the product fails, this will cause a loss in production costs, labor, time, and other costs. Overproduction this type of waste occurs due to excess production or orders requested bycustomers, this type of waste is common in companies that have product quality problems, because to replace defective products, companies replace them with an amount that is more than consumer demand. Waiting type of waste occurs when an employee or machine is not doing an activity or job, this status is called waiting, this type of waste usually occurs due to waiting for material to arrive, machines being repaired or some things that make the production process hampered.

Transportation are waste that occurs due to the transportation process or excessive transfer of goods due to poor layout and poorly planned. Inventory are waste that occurs because the storage of finished goods, semi-finished goods, or raw materials is too excessive in the production process so that it requires costs for storage, supervisors and documentation work. Movement this is waste occurs because of unnecessary movement of workers, so it must be repaired or eliminated, such as the laying of components, tools, or materials that are far from the reach of workers, so that it requires a long take-away movement, or active workers who are too busy and have a lot of movement. not effective to do. Excess Processing is waste occurs because the processing or production process is too long than it should be. This waste will not provide added value, because customers want good product results, rather than a long and repetitive process.

2.4 Value Stream Mapping

According to Michael L, et al. (2005) Value Stream Mapping is a visual method for mapping and information from each work station. This Value Stream Mapping can be used as a starting point for companies to recognize waste and identify its causes. Using value stream mapping means starting with the big picture in solving problems not only in single processes and making overall improvements and not just on specific processes. Value Stream Mapping is depicted with symbols that represent activities. Where there are two activities, namely value added and non-value added.

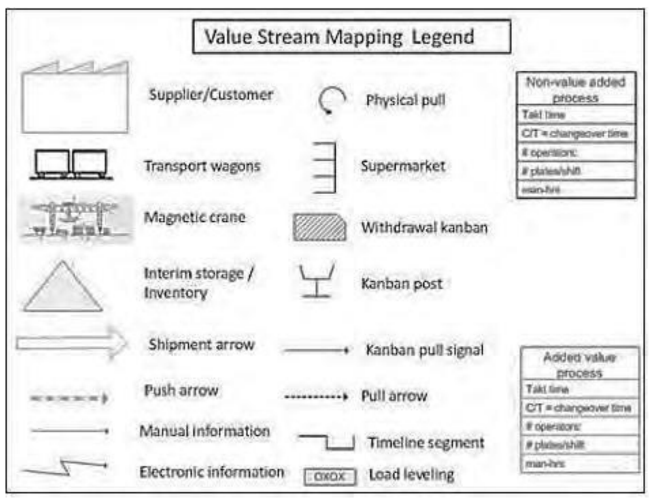

Figure 1. Value Stream Mapping Symbols.

2.5 Value Stream Analysis Tools (VALSAT)

According to Hardianza (2016) Value Stream Analysis Tools (VALSAT) is a tool that can be used to map in detail and in detail a waste in the value stream that focuses on the value adding process. This visual image helps understand a production process that can identify non- added value.

Table 1. Value Stream Analysis Tools.

WASTE	MAPPING TOOLS						
	Process Activity Mapping	*Supply Chain Response Matrix*	*Production Variety Funnel*	*Quality Filter Mapping*	*Demand Amplifying Mapping*	*Decision point Analysis*	*Physical Structure*
Transportation	H						L
Waiting	H	H	L		M	M	
Over Production	L	M		L	M	M	
Defective Parts	L						
Unnecessary Inventory	M	H	M		H	M	L
Unnecessary motion	H	L		H			
Excess Processing	H		M	L		L	

2.6 Root Cause Analysis (RCA)

Detailed analysis of the identification of non-value added activities can be done by using a Root Cause Analysis known as RCA (Jucan, 2005). Root Cause Analysis is a methodology for identifying and correcting functional causes. The RCA method is very useful for analysis a system failure about the unexpected thing that happened, how it was could be, and why it could be. The purpose of this study is to evaluate the process of receiving orders until the process of sending goods using lean thinking approach using Root Cause Analysis method. Benefit from This research is to minimize the processing time of receiving the ordered goods the goods are sent by identifying the process that is not value added (non-value added activities) there by reducing lead time.

3. METHODOLOGY

In this research method chapter, we will describe how the process flow of research is carried out from initial identification to suggestions for improvements to the object of researchfor the next project.

3.1 Early Identification

Initial identification is to determine the problems to be worked on. In this study choosing lean manufacturing because this method is a good method to increase the efficiency of a production. Then by conducting a field study to identify directly how the production process in the 2x1800HP ship building project is carried out. Based on the type of production, the shipbuilding project at PT. XYZ shipyard is make to order.

3.2 Data Collection and Research

At this stage, the process of collecting data from the problems that the company is facing is explained. The data collected consists of primary data, namely data obtained from interviews, questionnaires, and data from production process activities and secondary data, namely data taken when making observations from shipyards ranging from company history to labor.

3.3 Research Data Processing

Data processing This research is known in advance the initial conditions of the company, in order to understand the steps taken for the next process. The data processing of this research applies VALSAT (Value Stream Analysis Tools), to produce improvements and increase efficiency.

3.4 Evaluation stage and improvement

This stage is a continuation of the previous stage, where at this stage evaluation and improvement of the results of existing data processing are carried out.

4. RESULT

In Figure 2 is a Current State Value Stream Mapping which describes the mapping during the first condition of the construction production process activity on a Tug Boat ship where there is an information flow and a physical flow.

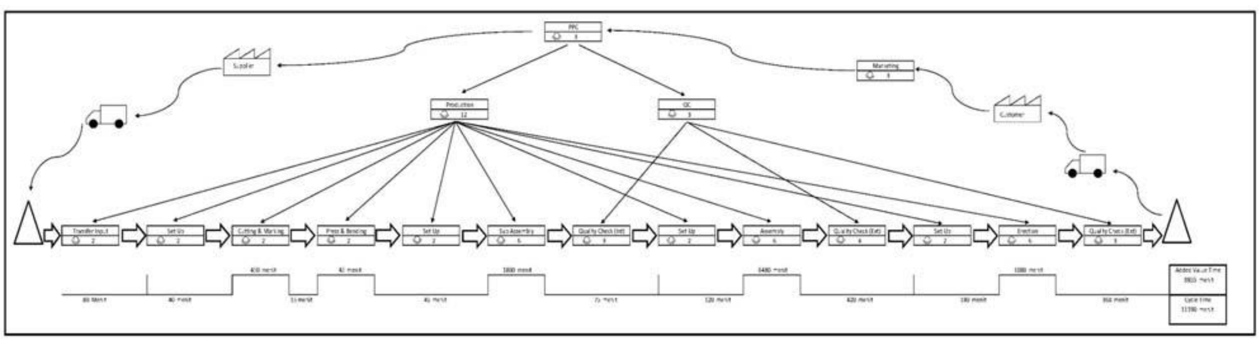

Figure 2. Current State Value Stream Mapping

Figure 2 shows that each production process has a processing time and the number of executors or workers so that the Cycle Time can be taken from the average processing time for each process. To calculate the Value Added Ratio, use the following formula:

$$\textit{Value Added Ratio} = \frac{\textit{Added Value Time}}{\textit{Cycle Time}} \times 100\%$$

$$\textit{Value Added Ratio} = \frac{9855}{11190} \times 100\% = 88{,}07\ \%$$

4.1 Waste ranking by BCM (Borda Count Method)

Determination of waste ranking using data taken from filling out a questionnaire addressed to workers or executors of the Tug Boat construction production section who are directly related to the construction of the Tug Boat Ship.

Table 2. Borda Count Method

Waste	*K1*	*K2*	*K3*	*K4*	*K5*	*Total*	*%*	*Rank*
Overproduction	5	2	4	6	2	19	14.62	3
Defect	6	2	6	5	6	25	19.23	1
Unnecessary Inventory	4	2	3	4	3	16	12.31	5
Inappropriate Processing	5	2	6	3	5	21	16.15	2
Transportation	3	2	3	3	3	14	11.02	7
Waiting	3	4	3	3	4	17	13.08	4
Unnecessary Motion (Movement)	3	2	3	3	4	15	11.54	6

Based on the results of the Borda Kount Method questionnaire and included in Table 2, it is known that the highest waste is in the types of waste Defect (19.23%), Inappropriate Processing (16.15%), and Overproduction (14.62%). And determination of tools Based on the results of the Value Stream Analysis Tools Matrix conversion and entered into Table 3, it is known that the highest and most appropriate tool used to identify waste is Process Activity Mapping with a percentage of 38.06%.

Table 3. Value Stream Analysis Tools Matrix conversion

Waste	*Process Activity Mapping*	*Supply Chain Response Matrix*	*Production Variety Funnel*	*Quality Filter Mapping*	*Demand Amplifying Mapping*	*Decision point Analysis*	*Physical Structure*
Transportation	126						14
Waiting	153	153	17		51	51	
Overproduction	19	57		19	57	57	
Defects	25						
Unnecessary Inventory	48	144	48		144	48	16
Unnecessary motion (Movement)	135	15		135			
Inappropriate Processing	189		63	21		21	
Total	695	369	128	175	252	177	30
Prosentase	38.06	20.21	7.01	9.58	13.80	9.69	1.64
Rank	**1**	**2**	**6**	**5**	**3**	**4**	**7**

4.2 Process Activity Mapping

Process Activity Mapping in the construction of 2x1800HP Tug Boat ships is shown in Table 4.

Table 4. Current State Process Activity Mapping

No.	Steps	Machine/Tools	Distance (m)	Time (minute)	Operator	Activity					Category		
						O	T	I	S	D	VA	NVA	NNVA
1	Receiving Material to Warehouse	Fork lift	150	35	2				S				NNVA
2	Delivery of Material from the Warehouse	Fork lift	200	45	2		T						NNVA
3	Set Up above Jig CNC	Over Head Crane	10	40	2	O					VA		
4	Cutting & Marking	CNC Machine	-	450	2	O					VA		
5	Delivery Part from CNC Cutting warehouse	Trolly	25	15	2		T						NNVA
6	Press & Bending	Press & Bending Machine	-	45	2	O					VA		
7	Sending Press & Bending Result Parts to Hull Construction Workshop	Fork Lift	200	35	2		T						NNVA
8	Set Up above Jig	Over Head Crane	-	10	2	O					VA		
9	Sub-Assembly Welding	Mesin Las, Palu, sikat kawat	-	1800	6	O					VA		
10	Quality Check (Internal)	Senter, Meteran, Palu, UT	-	75	3			I			VA		
11	Transportasi Sub-Assembly to the Jig Assembly	Fork lift	300	50	2		T						NNVA
12	Set Up above Jig	Crane	-	70	2	O					VA		
13	Assembly Welding	Welding machine, hammer, wire brush	-	6480	6	O					VA		
14	Quality Check (Internal & External)	Flashlight, Meter, Hammer, UT	-	420	4			I			VA		
15	Transport the Assembly Resultstoabove Building Birth	Crane	60	100	2		T						NNVA
16	Set Up between the blocks to be erected	Crane	-	80	2	O					VA		
17	Erection Welding	Welding machine, hammer, wire brush	-	1080	6	O					VA		
18	Quality Check (Internal & External)	Flashlight, Meter, Hammer, X-Ray	-	300	4			I			VA		
19	Launching To do the finishing process	Blander	125	60	2		T						NNVA

Tabel 4. shows that the total time for the construction process of 2x1800HP Tug Boat ship construction is 11190 minutes. The total time in Operation activities has the highest number of 10055 minutes with a percentage of 89.86%. Then the total time for the inspection has the second highest number with 795 minutes or 7.10%. In the construction of the 2x1800HP Tug Boat, there is also a Necessary Non Value Added Activity with a total time of 340 minutes or a percentage value of 3.04%.

Table 5. Future State Process Activity Mapping

No.	Steps	Machine/Tools	Distance (m)	Time (minute)	Operator	Activity					Category		
						O	T	I	S	D	VA	NVA	NNVA
1	Receiving Material to Warehouse	Fork lift	150	25	2				S				NNVA
2	Delivery of Material from the Warehouse	Fork lift	200	35	2		T						NNVA
3	Set Up above Jig CNC	Over Head Crane	10	40	2	O					VA		
4	Cutting & Marking	CNC Machine	-	450	2	O					VA		
5	Delivery Part from CNC Cutting warehouse	Trolly	25	15	2		T						NNVA
6	Press & Bending	Press & Bending Machine	-	45	2	O					VA		
7	Sending Press & Bending Result Parts to Hull Construction Workshop	Fork Lift	200	30	2		T						NNVA
8	Set Up above Jig	Over Head Crane	-	10	2	O					VA		
9	Sub-Assembly Welding	Mesin Las, Palu, sikat kawat	-	1840	6	O					VA		
10	Quality Check (Internal)	Senter, Meteran, Palu, UT	-	75	3			I			VA		
11	Transportasi Sub-Assembly to the Jig Assembly	Fork lift	300	35	2		T						NNVA
12	Set Up above Jig	Crane	-	55	2	O					VA		
13	Assembly Welding	Welding machine, hammer, wire brush	-	6520	6	O					VA		
14	Quality Check (Internal & External)	Flashlight, Meter, Hammer, UT	-	360	4			I			VA		
15	Transport the Assembly Results to above Building Birth	Crane	60	80	2		T						NNVA
16	Set Up between the blocks to be erected	Crane	-	60	2	O					VA		
17	Erection Welding	Welding machine, hammer, wire brush	-	1095	6	O					VA		
18	Quality Check (Internal & External)	Flashlight, Meter, Hammer, X-Ray	-	280	4			I			VA		
19	Launching To do the finishing process	Blander	125	60	2		T						NNVA

From Table 5. it can be concluded that there are several improvements to activities to increase the Value Added so that the production process of the 2x1800HP Tug Boat construction will be more efficient. New Value Added Ratio is:

$$\textit{Value Added Ratio} = \frac{\textit{Added Value Time}}{\textit{Cycle Time}} \; x\ 100\%$$

$$\textit{Value Added Ratio} = \frac{9950}{11100} \; x\ 100\% = 89{,}64\ \%$$

4.3 Value Stream Analysis using Value Stream Mapping

Based on the results of the Value Stream Mapping Current State in the form of information flow and physical flow, it can be seen that the production of 2x1800HP Tug Boat construction has a Value Added Activity value of 88.07%. In the process of making the ship construction, there are several problems, including: 1. There are limited means of transportation for materials. The use of transportation is still divided between new buildings and repairs, so that for the delivery of a material there is still a queue for the use of transportation means. With the queue or waiting for the needs of these means of transportation, it will lead to the activity of Non Added Value Activity. 2. There is a mismatch in the allocation of labor in ship construction. So that it causes queues or waiting because the work on a part that takes a long time due to a shortage of labor. This causes activity delays for further processing. 3. There are still many process errors such as the installation of materials that do not match the proper installation location. So that it causes defects and even excessive processes that are used to correct the welding error of the material.

5. CONCLUSION

Based on the results of the analysis that has been carried out in the production process construction of the 2x1800HP Tug Boat ship construction, using a study Lean Manufacturing method, the following conclusions can be drawn:

a. The flow of the 2x1800HP Tug Boat construction production process starts from the flow of information which is the initial process of a ship building tender that enters the company, then from the flow of information it will be forwarded to the ship's physical production flow line. The physical flow of the 2x1800HP Tug Boat construction production is Input Transfer, Press & Bending, Sub Assembly, Quality Check by Internal QC, Assembly Process, External Quality Check, Erection, External Quality Check. The flow of the Tug Boat production process has a VAR of 88.07% before making repairs and 89.64% VAR after making improvements to the production process.
b. Based on the results of research with the Borda Count Method questionnaire, it was found that the highest waste was in the type of waste Defect (19.23%), Inappropriate Processing (16.15%), and Overproduction (14.62%). By using Lean Manufacturing analysis it is known that the largest waste in the production process is caused by human error or human error and work equipment.

6. REFERENCES

Arum, Lutfia. (2017). Production Process Improvement Using Lean Manufacturing Method At PT. ABC, Thesis, Sepuluh Nopember Institute of Technology, Surabaya.

Djaya, I., K. (2008). Steel Ship Construction Engineering. Directorate General of Primary and Secondary Education Management, Ministry of National Education.

Hardianza, Dicky, (2016). Implementation of Lean Manufacturing Using the Value Stream Mapping Method at PT. X, Thesis, Sepuluh Nopember Institute of Technology, Surabaya.

Gasperz, Vincent dan Fontana, Avanti. (2015). *Lean Six Sigma for Manufacturing and Services*. Bogor : Vinchirsto Publication.

Jucan, G. (2005). *Root Cause Analysis for IT Incidents Investigation.* Tersedia di Digilib.its.ac.id/public/ITS/ Undergraduate-11025-Paper.pdf

Ma'ruf, B. (2014). Aplikasi Manajemen dan Teknologi untuk Mendorong Daya Saing Industri Kapal dan Industri Pelayaran Nasional, Main Speaker, Proceedings of the XXI Technology Management National Seminar, MMT Post-graduate Program, ITS, Surabaya, July, MU-2.1-MU-2.23.

Michael L, dkk. (2005). The Lean Six Sigma Pocket Toolbool. New York : McGraw-Hill

Mulyanto, I.P. (2004), Optimizing Based Sensitivity for Shipyard Productivity on Indonesia, *Majalah Kapal*, 8(3), 1, 62 – 66.

Nyata, Dewa Sang (2017) Analysis of Delays in the PT.Jatim Taman Steel Project in Gresik Using Lean Six Sigma Framework. Masters thesis, Sepuluh Nopember Institute of Technology.

Prakoso, C., Yannes M.P. (2010). Development of Ergonomics-based Coal Tugboat Tugboat Tugboat Development. [Journal of Bachelor of Art and Design]. Faculty of Art and Design, ITB. Bogor. 1:1-7

Ririyani ,Vika. (2015). *Increasing Efficiency In Pt Varia Usaha Beton By Applying Lean Manufacturing*, Thesis, Sepuluh Nopember Institute of Technology, Surabaya.

MODIFICATION OF LEAN ASSESSMENT MATRIX (LAM) TOOL WITH DECISION MAKING TRIAL AND EVALUATION LABORATORY (DEMATEL) AND KEY PERFORMANCE INDICATOR (KPI)

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ABSTRACT

One of the tools to assist in implementing lean is the Lean Assessment Matrix (LAM). This tool helps to map waste by type and root of waste, determine the root of waste andrecommend actions to reduce or eliminate root waste. LAM consists of two matrices. LAM1 is used to get priority types of waste and the root causes of waste. Waste priority is carriedout after conducting an assessment that takes into account severity, occurrence, relation value of waste and impact value. In the original version of LAM 1, use the Waste relationship matrix (WRM) to get the value of the relationship of waste. The weakness of the WRM tool is the large number of questions used and the conversion of values that have no basis when measuring the value of the waste relations, so it is not easy for respondents toget the value of the waste relations practically in the company. Besides, other deficiencies inLAM 1 also occur in severity, which sees the impact of waste-based only on the magnitude of the impact or from the amount of cost loss that must be incurred by the company, even though not all impacts could be measured. Therefore, modification of the LAM 1 tool is needed to (1) make it easier for respondents to determine the value of the waste relationship by adopting the Decision Making Trial And Evaluation Laboratory (DEMATEL) and (2) measuring the impact of the waste that appears not only from one perspective by linking the impact of waste to the achievement of the related Key Performance Indicator (KPI). The result of the modification of the LAM tool is expected to help improve the determination of critical waste better in the company.

Keywords: Lean, Decision Making Trial and Evaluation Laboratory, Key Performance Indicator, Lean Assessment Matrix (LAM 1).

1. INTRODUCTION

Business competition in industrial development requires the company to continue to make improvements in its performance. The performance of a manufacturing company could be measured from the effectiveness and efficiency of the production system. An efficient and effective production system will produce quality and competitive products. However, some problems are often faced by the manufacturing industry, one of which is waste. The appearance of waste in the production process could affect the quality of the products. Therefore, we need one method application to eliminate waste that occurs using lean methods.

Lean is a concept approach, philosophy, or way of thinking that has been developed by Toyota with the term Toyota Production System (TPS), where the main objective is that the company could increase the production of goods or services at the minimum cost. One of the lean tools that could be used to eliminate waste is the Lean Assessment Matrix (LAM) tool that has been developed by Pangesti (2019). LAM is developed based on the logic of analysis in the House of Risk matrix introduced by Pujawan & Geraldin (2009) and integrated with the relationship of wastes in the study Rawabdeh (2005). LAM consists of two matrices, namely LAM1 and LAM 2. LAM 1 is used to get priority types of waste and the root causes of waste. Whereas in LAM 2 is used to provide corrective actions that could reduce or eliminate the root causes of selected waste from LAM 1.

The output of LAM 1 in the form of waste priority is determined from severity, occurrence, waste type weight, and impact value. In the LAM 1, Pangesti (2019) adopted Waste Relationship Matrix (WRM) developed by Rawabdeh (2005) to determine the waste relationship and the ranking of each type of waste as a basis for priority handling. However, the main problem in using the WRM tool is the large number of questions used and converting the value from the matrix calculation that has no basis. Therefore, it is not easy for respondents to get the relation of waste practically in the company.

Kobryń (2017) proposes the use of Decision Making Trial And Evaluation Laboratory (DEMATEL) to calculate weight values whose results are compared with calculations from the Analytic Hierarchy Process (AHP) tool. Based on the results of his research, it shows that the proposed DEMATEL approach to calculate weight that has high compatibility compared with AHP. The other studies using DEMATEL to find weights have also been conducted by several previous researchers such as Dalalah et al. (2011); Baykasoğlu et al. (2013); Patil & Kant (2014). However, this research have shortcomings in the calculation because it is not known the weight value obtained if it does not have a relationship and influence. Therefore, research by Kobryń (2017) states that his research could deal with the shortcomings of research. previous research in calculating weights better.

In order to determine critical waste, apart from being influenced by the linkages between wastes, it is also influenced by the magnitude of the impact due to the occurrence of waste or on LAM which is represented as severity. Based on several studies, severity could be measured based on qualitative, quantitative, and semi-quantitative. Generally, severity is always associated with a loss in terms of cost. Pangesti (2019) measures the impact of waste on the LAM matrix based only on the magnitude of the impact or cost losses that must be incurred by the company. Meanwhile, not all impacts could be measured through one perspective. On the other hand, the relationship between waste and the achievement of a company's Key Performance Indicator (KPI) has been discussed in several previous studies, one of which is Kolos (2018) research which focuses on determining KPIs that are effective in evaluating the results of lean change, especially minimizing total costs.

KPI is an element that must be considered for a company, where KPI is an important tool to measure the performance of a company that continuously wants to make continuous improvement. In research conducted by Dotoli et al. (2012, 2013), determining the priority of waste in operational activities in the warehouse and the focus of improvement is based onmeasuring the impact (severity) of waste occurring with KPI inaccessibility. Thus, the determination of critical waste is better because it is associated with the impact of waste on the achievement of company’s KPIs.

This modification of the LAM tool is expected to improve the determination of critical waste by (1) calculating the weight of the influence strength between wastes to make it easier for respondents to determine the value of the waste relation practically by adopting the DEMATEL adopted from Kobryń (2017) and (2) modify the calculation of the severity due to the emergence of waste by connecting the impact of waste to the achievement of the KPI associated by Dotoli et al. (2013). Therefore, the LAM tool is more objective and easy to apply to the company in prioritizing waste.

2. METHOD

The development of the first matrix LAM tool is carried out in the several stages. The first stage is to modify the first matrix framework of LAM and its severity by connecting the amount of waste impact with the KPI achievement. The KPIs could be adjusted to the company's KPI and then classified using a Balanced Scorecard (BSC) consist of financial, customer, internal business process, learning and growth perspectives. This to make it easier to analyze and compare the performance indicators based on the impact of the waste. The assessment given for the selected KPI uses a Likert scale of 1 to 5. As for the modification of the assessment severity is calculatedby adding up each waste that has an impact on the KPI. The next step is to modify the waste type weight assessment by integrating the DEMATEL tool. At this stage, questionnaire was distributed to the experts, which were then filled out based on the DEMATEL rating scale, namely 0 to 4, 0 for no effect and 4 for the effect between very high wastes. Then, the results of the data obtained from the questionnaire will be calculated using the DEMATEL to obtain the relationship of waste. The last step is to determine the priority of waste by considering the severity of the waste associated with the KPI, the waste type weight with DEMATEL tool, occurrence, and impact value.

3. RESULT &DISCUSSION

3.1 Modification of Framework and Severity Assessment in LAM 1

This research is to modify the framework of the first matrix of LAM and severity assessment by integrating KPI adopted from Dotoli et al. (2013). Modification of the framework iscarried out by adding a column as an additional analysis of KPI aspects which will be used to measure the severity or impact due to waste. The mechanism for selecting KPIs that is included in LAM 1 is carried out by grouping KPIs based on the BSC perspective which consists of financial, customer, internal process business, learning and growth perspectives. After performance indicators of LAM 1 has been selected by grouping them based on the BSC perspective, then it could be used to link which waste has an influence on KPI achievement by using a likert scale.

The research of Pangesti (2019), severity measurement is carried out by linking the impact of waste based on how big the impact is and also the extent of financial losses that must be incurred by the company. Meanwhile, not all impacts could be measured. Modification to the LAM 1 severity assessment is adopted the impact measurement method developed by Dotoli et al. (2013). The level of severity is calculated by adding up the number of KPIs selected to the impact of the waste. Severity assessment could be determined using equation 1.

$$Si = \sum_{j=1}^{k} P_{ij} \quad i = 1, \ldots, p \tag{1}$$

where :

Si : The summation of waste impacts on the chosen performance indicator

Pij : Impact value of key performance indicator j to waste i

Therefore, the difference between Pangesti's (2019) and LAM 1 matrix of this study could be shown in **Figure 1** below.

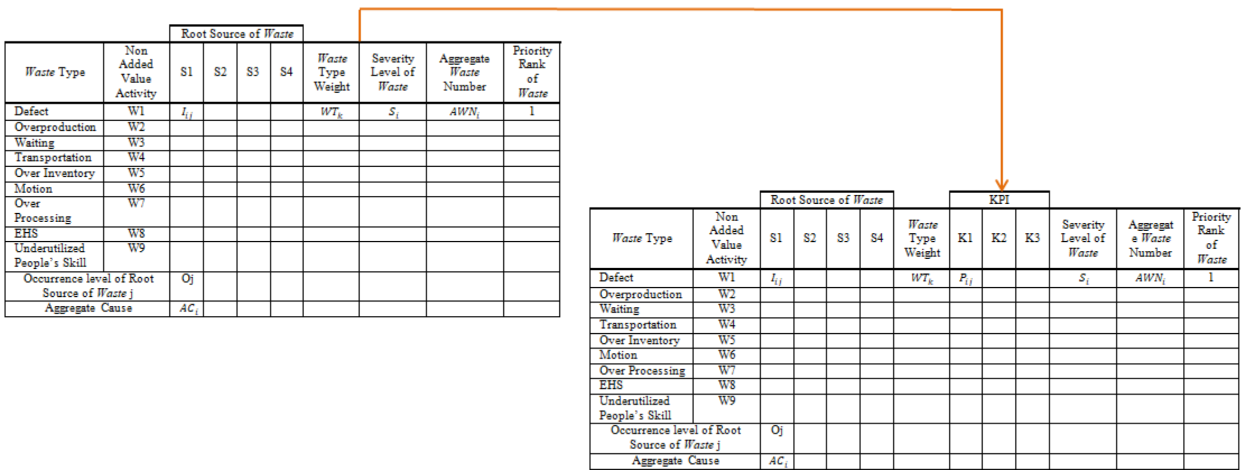

Figure 1. Modification of the LAM 1 Framework

3.2 Modification of The Waste Type Weight Assessment

In this study, a modification to measure the value of the waste relation uses the DEMATEL tool adopted from Kobryń (2017). The application of the DEMATEL tool in this research is not only done to identify the relationship between one type of waste but also to calculate waste type weight. The waste type weight is used to get waste priority. To find out the relationship of waste, a DEMATEL questionnaire was made and given to the expert. The expert will assess the level of how much impact one type of waste to another using a likert scale. The likert scale used is a 5 point. The results of the questionnaire that have been filled in by the expertsthen will be processed based on the DEMATEL stages in general.

1. Create a direct-relation matrix
   At this stage DEMATEL uses four levels of comparison scale, namely 0 (no effect), 1 (low effect), 2 (moderate effect), 3 (high effect), 4 (very high effect).
2. Normalize the direct relationship matrix
   Normalization of the Z matrix relationship directly could be obtained through the following equation:

$$Z = k \times X \tag{2}$$

$$k = \min\left[\frac{1}{\max i \sum_{j=1}^{n} |x_{ij}|}, \frac{1}{\max j \sum_{j=1}^{n} |x_{ij}|}\right], \text{ dimana } i, j = 1,2,3,\ldots,n \tag{3}$$

3. Derive the total relationship matrix
   The total T matrix relationship which is denoted as the identity matrix could be calculated through the following equation:

$$T = X(I - X)^{-}1 \tag{4}$$

4. Count the rows and columns of the matrix T
   The number of rows and columns are denoted separately as vector D and vector R. Then horizontal vector (D + R) called "prominence" is created by adding D to R which indicates the level of importance of the criteria:

$$(D_i + R_i) = \sum_{j=1}^{n} t_{ij} + \sum_{k=1}^{n} t_{ik} \tag{5}$$

$$(D_i - R_i) = \sum_{j=1}^{n} t_{ij} - \sum_{k=1}^{n} t_{ik} \tag{6}$$

5. Determine the threshold value
   The threshold value is obtained from the average of all values from the T matrix (total relation matrix). The determination of the threshold value is used to determine the relationship between criteria :

$$\alpha = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} [t_{ij}]}{N} \tag{7}$$

6. Create an impact-digraph
   Impact-digraph maps could be determined by plotting data sets (D + R, D-R), so they could provide information in the decision-making process.
7. Calculating the weight value
   Calculate the weight obtained by the following equation:

$$t_i^{average} = \frac{1}{2}(t_i^{+} + t_i^{-}) = \sum_{j=1}^{n} t_{i,j}, \tag{8}$$

$$w_i = \frac{t_i^{average}}{\sum_{i=1}^{n} t_i^{average}} \tag{9}$$

Dimana :

$t_i^{average}$ = The Average value of appropriate pair of indicators t_i^{+} and t_i^{-}

t_i^{+} = importance indicator

t_i^{-} = relation indicator

w_i = normalised weight

4. CONCLUSION

In determining the priority of critical waste in the first matrix of LAM, apart from considering the value of the waste relation, one must also consider the magnitude of the impact due to the resulting waste. This research proposes to modify the determination of critical waste in the first matrix of the LAM tool. The purposes of modifying this LAM tool are to be more objective because it measures the impact of waste associated with the KPI and makes expert easier to determine the relation of waste using the DEMATEL tool. The future work of this research is the application of modification of LAM tool in a case study.

5. ACKNOWLEDMENTS

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6. REFERENCES

Baykasoğlu, A., Kaplanoglu, V., Durmuşoglu, Z. D. U., & Şahin, C. (2013). Integrating fuzzy DEMATEL and fuzzy hierarchical TOPSIS methods for truck selection. Expert Systems with Applications, 40(3), 899–907. https://doi.org/10.1016/j.eswa.2012.05.046

Dalalah, D., Hayajneh, M., & Batieha, F. (2011). A fuzzy multi-criteria decision making model for supplier selection. Expert Systems with Applications, 38(7), 8384–8391. https://doi.org/10.1016/j.eswa.2011.01.031

Dotoli, M., Epicoco, N., Falagario, M., & Costantino, N. (2013). A lean warehousing integrated approach: A case study. IEEE International Conference on Emerging Technologies and Factory Automation, ETFA. https://doi.org/10.1109/ETFA.2013.6648030

Dotoli, M., Petruzzelli, G., & Turchiano, B. (2012). A Lean Warehousing Approach Using Unified Modelling Language and Value Stream Mapping: A Case Study. 9th International Conference of Modeling, Optimization and Simulation, June, 20(June 2012), 6–8.

Kobryń, A. (2017). DEMATEL as a weighting method in multi-criteria decision analysis. Multiple Criteria Decision Making, 12(April), 153–167. https://doi.org/10.22367/mcdm.2017.12.11.

Kolos, I. (2018). Formation Of The Key Performance Indicators System For Lean Management Of Enterprises. Technology Audit and Production Reserves, 5(4(43)), 15–19. https://doi.org/10.15587/2312-8372.2018.146342

Pangesti, A. T. (2019). Pengembangan Tool Untuk Penerapan Lean Dengan Integrasi Waste Relationship Matrix (WRM) Dan House Of Risk (HOR). Surabaya: Institut Teknologi Sepuluh Nopember.

Patil, S. K., & Kant, R. (2014). A hybrid approach based on fuzzy DEMATEL and FMCDM to predict success of knowledge management adoption in supply chain. Applied Soft Computing Journal, 18, 126–135. https://doi.org/10.1016/j.asoc.2014.01.027

Pujawan, I. N., & Geraldin, L. H. (2009). House of risk: A model for proactive supply chain risk management. Business Process Management Journal, 15(6), 953–967. https://doi.org/10.1108/14637150911003801

Rawabdeh, I. A. (2005). A model for the assessment of waste in job shop environments. International Journal of Operations and Production Management, 25(8), 800–822. https://doi.org/10.1108/01443570510608619.

TOPIC

Performance and Cost Management

PERFORMANCE MONITORING FOR AIRCRAFT ENGINE SHOP VISIT PROJECT

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ABSTRACT

One striking aspect of aircraft maintenance revealed through recent studies into industry practice (personal correspondence) is that only half of the overall maintenance workload within heavy maintenance comes about as planned efforts. This means, the proportion of unplanned maintenance activities arising out of inspections carried out during an aircraft lay-up can be as high as 50 percent of the total work involved in heavy maintenance. That maintenance type has significantly effect to the spare parts inventory management, resourcesplanning, and maintenance task execution. That problem can impact the further complication in scheduling and cascading effect to reach the general objectives from maintenance project,such as cost, time, quality, and safety. Engine Services Department in one company has toolsto manage engine maintenance project based on CPM and MRP technique. In the implementation, this tools focus on the cost integration in order to make fully-recorded cost and manage the cost-efficient. For the whole project management, this tools is limited to describe the initial planning gantt chart. If there is a shifting from the initial schedule due to the uncertainty task from inspection result, then the assign task should be done manually by planner, as a consequence the is shifted without knowing the original plan, so project manager do the record of the deviation in a different sheet and cannot analyze the difference automatically. The needs of project monitoring and the deviation calculation needs to be analyzed and developed to control how far the project phase development. This research hasbeen done using the earned value management and earned schedule method for the extension.This research shows that earned value, planned value, and actual cost can represent whether project is above schedule, on track, or behind schedule. Cost performance index stability in this project is in 40% project completion and schedule performance index stability reach in 70% project completion.

Keywords: Shop Visit, Earned Value, Earned Schedule, Project Monitoring

1. INTRODUCTION

Aircraft heavy maintenance consists of complex sets of interrelated activities that must be performed in a given period of time regarding the maintenance schedule. The timely delivery of aircraft regarding maintenance schedule is a critical issue that directly affects to revenue opportunityand survival of airline business (Pimapunsri & Weeranant, 2018). For aircraft engine maintenance, repair, and overhaul (MRO) companies, everything revolves around reducing turn around time (TAT). Generally speaking, substandard aircraft engine MRO TAT performance is caused by inefficient capacity utilization, complexity and unpredictability of demand, lack of data integration and cross-functional collaboration, and unavailability of spare parts (Secilmis, 2020). One striking aspect of aircraft maintenance revealed through recent studies into industry practice (personal correspondence) is that only one half of the overall maintenance workload within heavy maintenance comes about as planned efforts. This means, the proportion of unplanned maintenance activities arising out of inspections carried out during an aircraft lay-up can be as high as 50 percent of the total work involved in heavy maintenance (Samaranayake, 2012).

MRO processes are characterized by high variability, due to the uncertainty about the statusof the engine to be maintained. The activities to carry out are set according to the engine arrival conditions and the needed type of intervention. Management of such a variable process is, hence, one of the most important challenges that the systems have to face in supporting the management. To get work-in-progress (WIP) information from the shop floor (accurate and up- to-date information about the (physical) parts constituting engines and components, regarding both their localization, their identification data such as part number, serial number, quantity, job order, etc.) and their processing status is of great importance. The systematic availability of such information allows the enterprise to have an improved control on work order and process activities.

Aircraft engine services department in one of company in Indonesia use IT systems to manage engine maintenance project based on CPM and MRP. Unfortunately, the implementation of systems focus on cost system integration rather than duration, uncertainty task, and variable process. Consequently, project manager manage and monitor the project in a separate sheet. The aim of this project is to create suitable project monitoring tool to make this activity become easier, to analyze project monitoring performance in term of cost controlling, duration controlling in uncertainty project.

2. METHOD

This research propose earned value and earned schedule method to create suitable project monitoring, in order to create the extension tools for the existing system. Earned value uses some parameters to control project performance, such as planned value, budget at completion, earned value, actual cost, and percentage of completion (Haghighi, 2013). Figure 1 shows the earned valuegraphical representation.

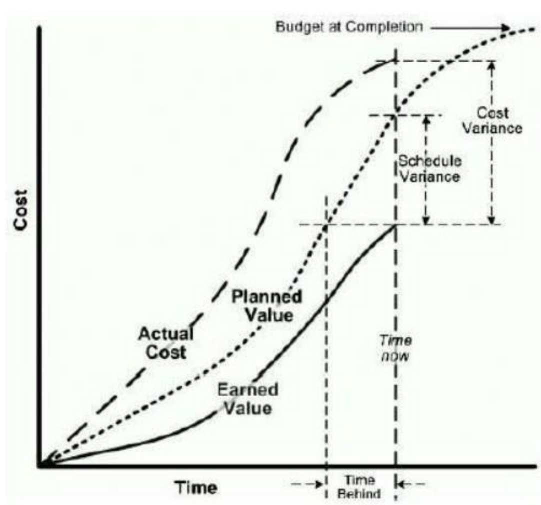


Figure 1. EVM Graphical Representation (Haghighi, 2013)

Although Earned Value Management represents a significant contribution to project management, from its earliest development and adoption limitations were apparent (Fleming, 1988). Experience and further research have shown that while EVM methods for cost are reliable (Fleming & Koppelman, 2003), schedule metrics are not as robust. Among the problemsare schedule metrics expressed monetary terms, the lack of reliable metrics for projects whose duration has exceeded thebaseline end date, and the unreliability of EVM schedule calculations inthe latter stages of a project(Bill Mowery, 2012).

The concept of Earned Schedule is relatively simple: derive a time based measurement of schedule performance by comparing a project's Earned Value today (Actual Time, AT) to the pointon the Performance Measurement Baseline (Planned Value curve, PV) where it should have been earned. The difference between AT and PV represents a true time-based Schedule Variance, or in Earned Schedule notation, SV (t) (Bill Mowery, 2012). Earned schedule is calculated by formula:

$$ES = t + \frac{EV - PV_t}{PV_{t+1} - PV_t}$$

Where t is the number of time increments where EV ≥ PV. PV_t is the value of PV at the last full performance period and PV_{t+1} is the value of PV at the end of partial performance period. The combination of earned method and earned schedule will be used in this research along with 5 aircraftengine maintenance study cases. Figure 2 shows the flowchart of research method.

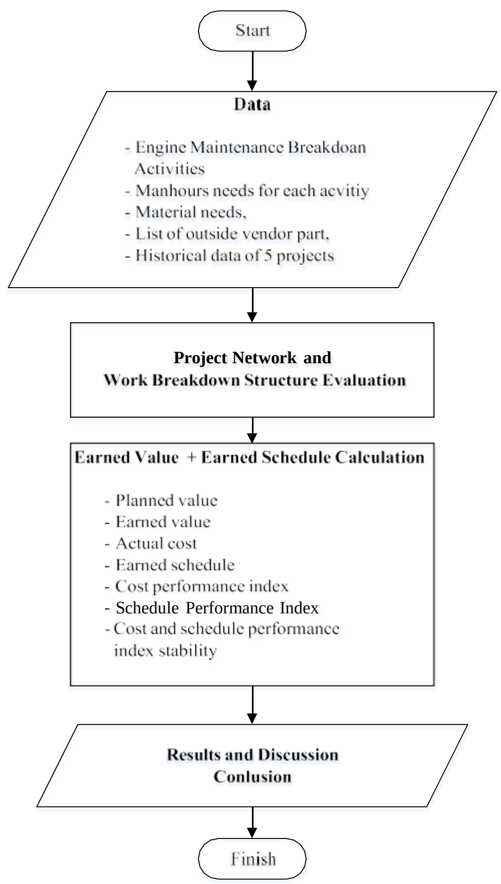


Figure 2. Method of Research Using Earned Value and Earned Schedule Method

3. RESULTS AND DISCUSSION

3.1 Earned Value Method

Earned value method calculate planned value, earned value, and actual cost in 5 engineproject and the result shown in Table 1.

Table 1. Cumulative Planned Value, Earned Value, Actual Cost in USD

Project	***Cumulative Planned Value* (PV), *Cumulative Earned Value* (EV), and *Cumulative Actual Cost* in USD**								
	Week 1			**Week 2**			**Week 3**		
	PV	**EV**	**AC**	**PV**	**EV**	**AC**	**PV**	**EV**	**AC**
APU A	16,250	37,564	24,322	43,308	74,023	52,242	97,425	91,130	64,235
APU B	16,250	29,039	46,410	30,562	74,760	134,458	203,422	87,812	161,892
APU C	16,250	39,994	39,126	38,475	195,201	302,088	163,091	248,442	368,179
APU D	16,250	31,301	37,795	36,759	281,940	279,304	77,777	287,445	286,981
APU E	13,250	39,564	37,979	44,730	211,103	185,844	101,691	258,449	210,563
Project	**Week 4**			**Week 5**			**Week 6**		
	PV	**EV**	**AC**	**PV**	**EV**	**AC**	**PV**	**EV**	**AC**
APU A	263,010	211,762	190,906	374,478	246,526	225,670	430,212	322,373	305,118
APU B	376,281	232,046	326,780	448,398	359,918	475,008	449,648	451,731	578,263
APU C	287,708	253,768	373,812	327,792	243,132	377,119	333,792	291,878	433,687
APU D	232,467	323,969	327,724	346,139	327,014	331,586	409,225	331,046	336,671
APU E	238,295	242,274	215,667	317,938	249,838	223,897	357,760	268,329	241,850

Earned value can show the actual status of a project compared to the planning schedule, whether the project was late, on schedule, or ahead of plan. Actual cost can show the status and value of the project cost, whether it is overbudget, underbudget, or in accordance with the budget. Table 1 shows, in the first week, the project budget had exceeded the cost budget for that week, butthe earned value also exceeded the planned value, this indicates that the actual costs absorbed were also added to the progress of project implementation which was carried out prematurely. As long as the actual costs do not exceed the total project budget as a whole, the monitoring process can continue. Things are different when EV <PV, but AC> PV, as in APU B in the fifth week. The PVvalue is 448,398 USD, the EV is 359,918 USD, and the AC is 475,008 USD. At that time, the projectprogress was still behind schedule (EV <PV), but the actual cost had exceeded the limit (AC> PV), so the engine owner needed to take initiatives that could prevent the project from exceeding the planned TAT. On the proposed monitoring dashboard in Figure 1Figure 3, a graph of the earned value is provided to facilitate reporting of a project consisting of planned value, earned value, and actual cost.

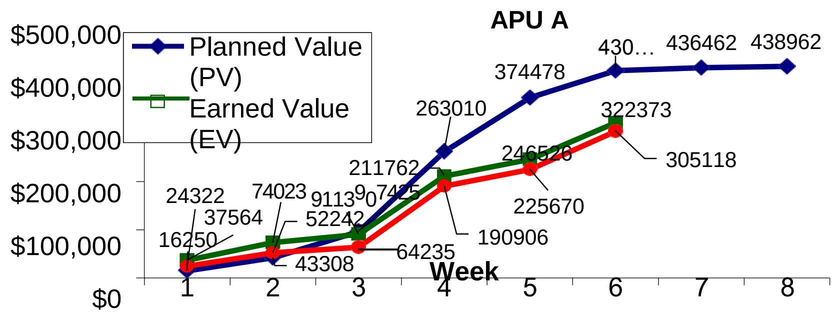


Figure 3. Proposed Monitoring Dashboard

3.2 Earned Schedule Method

Earned value method uses cost basis to measure project performance, while earned schedulemethod uses duration basis to measure project performance. Apart from cost, duration is also a crucial parameter in the APU maintenance project. Earned schedule is calculated based on the resultsof planned value and earned value. A slice of the planned value and earned value at one horizontalpoint indicates that during that period, the project progress that has been carried out is in accordancewith the actual duration. Table 2. shows the result of earned schedule calculation.

Table 2. Result of Earned Schedule Calculation of 5 Projects in 6 Weeks

No.	Project	***Earned Schedule* (week(s))**					
		Period (week)					
		1	**2**	**3**	**4**	**5**	**6**
1	APU A	1.79	2.57	2.88	3.69	3.90	4.53
2	APU B	1.89	2.26	2.33	3.17	3.91	6.42
3	APU C	2.01	3.26	3.68	3.73	3.64	4.10
4	APU D	1.73	4.44	4.48	4.80	4.83	4.87
5	APU E	1.84	3.80	4.25	4.05	4.14	4.38

In the first week, all APUs showed project performance according to schedule, even ahead of schedule. This is indicated by the earned schedule value that has passed value 1 in the first week. In the second week period, APU D provided significant progress, leading 2 weeks from the planned schedule. In the third week, the delay signal was shown by APU A and APU B, with values of 2.88 and 2.33. In the third week period, if according to schedule, then the earned schedule value should be 3. In the fifth week, all APU experienced delays because the value was less than 5, and on the sixth week, APU B had shown recovery results so that it had shown the earned schedule value 6.42,while other APUs were still experiencing delays.

3. 3 Cost Performance Index Stability

The Cost Performance Index (CPI) can show the quantitative value of project performance (Lipke, et al., 2009). Projects can be categorized as under budget or over budget fromthe CPI value. The CPI value can be calculated in each period, in this project it is calculated weekly. The status indicator is divided into 3, CPI <1 which indicates the project cost exceedsthe budgeted cost, CPI

= 0 which indicates the project cost is the same as the budget cost, CPI> 0 which indicates the projectcost is less than the budgeted cost.

Table 3. *Cost Performance Index of 5 Projects in 6 weeks*

No.	Proyek	*Cost Performance Index*					
		Period (week)					
		1	**2**	**3**	**4**	**5**	**6**
1	APU A	1.54	1.42	1.42	1.11	1.09	1.06
2	APU B	0.63	0.56	0.54	0.71	0.76	0.78
3	APU C	1.02	0.65	0.67	0.68	0.64	0.67
4	APU D	0.83	1.01	1.00	0.99	0.99	0.98
5	APU E	1.04	1.14	1.23	1.12	1.12	1.11

Table 3 shows the CPI value which can be used as an indicator to measure the actual costs absorbed by the project. In APU A and APU E, it appears that during the first to sixth week period,the actual cost of this project does not exceed the cost budget, which is indicated by a CPI > 1. In contrast, the CPI value in the APU B project from the first week appears to have been below 1 whichindicates the actual cost of the project exceeds the cost budget.

The stability of the CPI is an important indicator for a project because the index measuresa project's performance and is used to measure the difference in costs. When the indexis stable at the beginning of the project, a more precise forecast estimate can be made earlier in a project and the risk of project failure can be minimized. In this test, the CPI stability is calculatedusing the finalrange method, which is when the CPI difference value at the test point and the finalCPI value is less than 0.10.

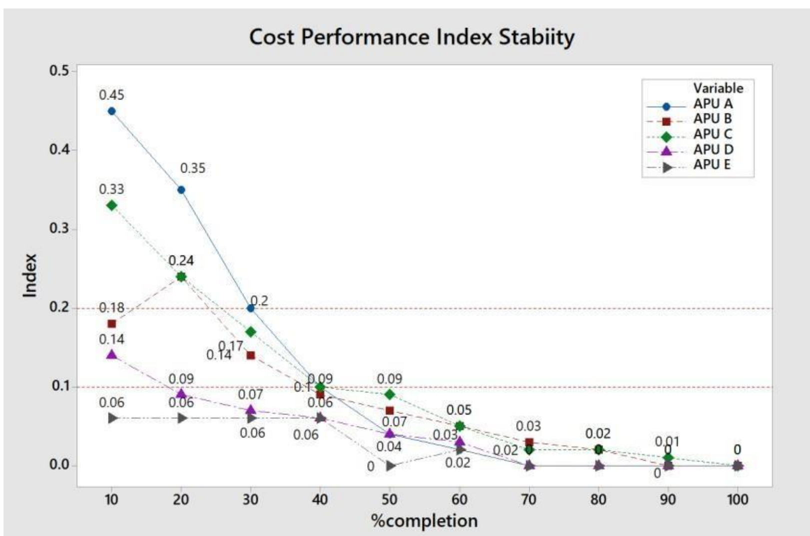


Figure 4. Cost Performance Index Stability APU Serial Number A, B, C, D, E

Figure 4 shows a graph of the results of the CPI stability measurement. In the figure it appearsthat the measurement of the cost performance index can be considered reach stablility and can be used as a reference when the project has been completed 20% for APU D and E and 40% for APU A, B, and C. When compared with the implementation of the gate system, this period is the period when the repair has been carried out and 50% of the cost of material procurement has been absorbed.

3.4 Schedule Performance Index Stability

Both earned value and earned schedule method produce schedule performance index. The difference is in calculation basis. Earned value use cost basis while earned schedule use duration basis. Schedule Performance Index is an indicator that can indicate the status of a projectschedule for a certain period without seeing any deviation in the value. The status indicator is divided into 3, SPI <1 which indicates the project is late from the initial plan, SPI = 0 which indicates the actual duration of the project is the same as the project duration plan, SPI> 0 which indicates the project iscarried out earlier than the initial plan.

Table 4. Schedule Performance Index Using Earned Value Method

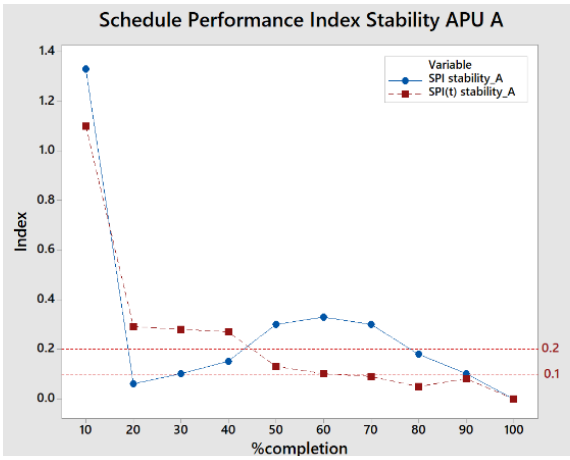
No.	Project	*Schedule Performance Index*					
		Period (week)					
		1	2	3	4	5	6
1	APU A	2.31	1.71	0.94	0.81	0.66	0.75
2	APU B	1.79	2.45	0.43	0.62	0.80	1.00
3	APU C	2.46	5.07	1.52	0.88	0.74	0.87
4	APU D	1.93	7.67	3.70	1.39	0.94	0.81
5	APU E	2.99	4.72	2.54	1.02	0.79	0.75

Table 4 shows the SPI value which can be used as an indicator measuring the project duration status. In the first and second weeks, the five projects were completed faster, marked with an SPI value> 1.The third week, the APU A and APU B projects began to signal that the project was delayed, marked by SPI values of 0.94 in APU A and 0.43 in APU B. In the fourth week, APU A, B, and C have SPI <1 indicating continuation of the delay signal for APU A andB as well as the start of the delay signal for APU C. In the fifth week, all projects experience delays but by the sixthweek, APU B can show the value of SPI = 1 which indicates the project is back on track while for other APUs it is still late from the initial duration plan.

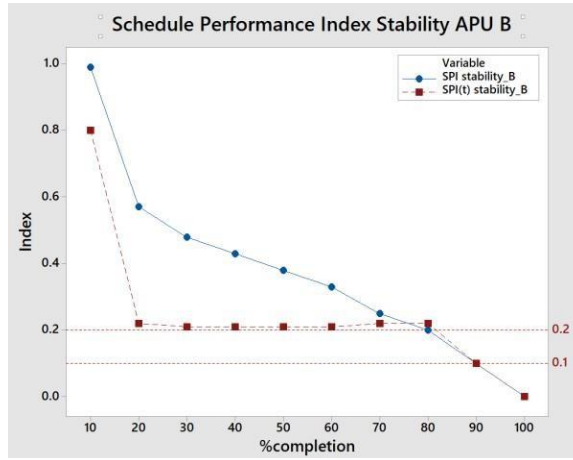
Table 5. Schedule Performance Index Using Earned Schedule Method

No.	Project	*Schedule Performance Index*					
		Period (week)					
		1	2	3	4	5	6
1	APU A	1.79	1.28	0.96	0.92	0.78	0.76
2	APU B	1.89	1.13	0.78	0.79	0.78	1.07
3	APU C	2.01	1.63	1.23	0.93	0.73	0.68
4	APU D	1.73	2.22	1.49	1.20	0.97	0.81
5	APU E	1.84	1.90	1.42	1.01	0.83	0.73

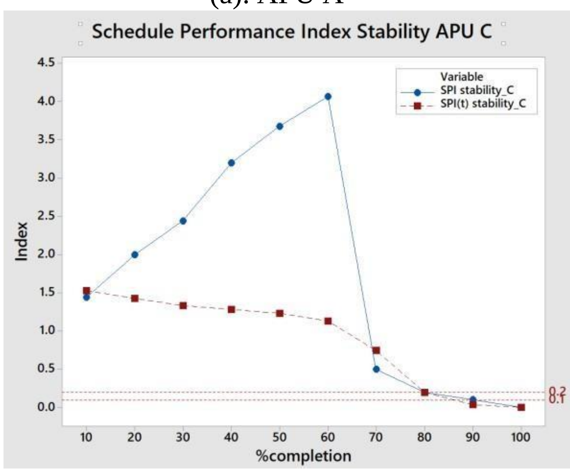
Table 5 shows the SPI value which can be used as an indicator measuring the project durationstatus. In the first and second weeks, the five projects completed faster, marked with an SPI value>1.The third week, the APU A and APU B projects began to signal that the project was delayed, marked by SPI values of 0.96 in APU A and 0.78 at APU B. In the fourth week, APU A, B, and C have SPI <1 indicating continuation of the delay signal for APU A and B as well as the start of thedelay signal for APU C. In the fifth week, all projects experience delays but by the sixth week, APUB can show the value of SPI = 1 which indicates the project is back on track while for other APUs it is still late from the initial duration plan.



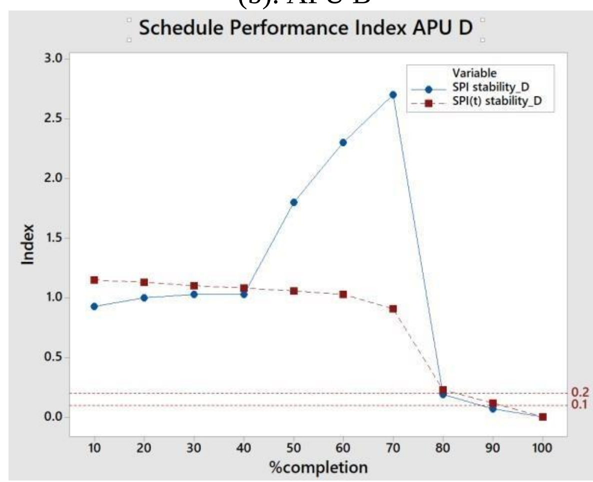
(a). APU A



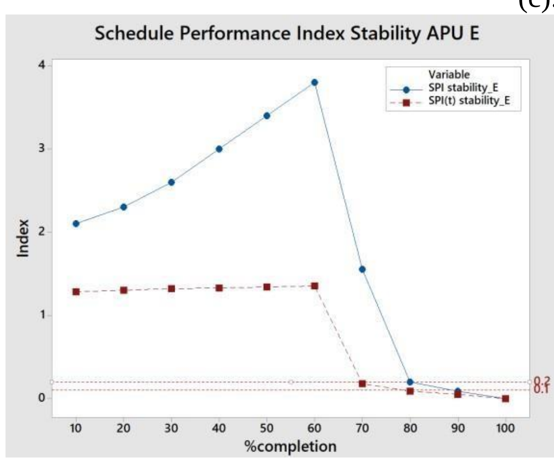
(b). APU B



(c). APU C



(c). APU D



(e). APU E

Figure 5. Schedule Performance Index Stability in APU A, B, C, D, E

The stability of SPI (t) and SPI at APU E shows a value that is far from stable. SPI and SPI (t) begin to stabilize when the project has reached 80% of work. However, the SPI curve shows a curve model that moves away from the stable figure when the project is running 10% to 60%, whilethe SPI (t) shows a value that tends to be close to stability. The calculation of the stability of the SPIcan be seen using two approaches, the range method and the final range method, with limits at 0.20

and 0.10. Figures above show that the stability of SPI and SPI (t) is achieved above 70% of projectcompletion. Compared to the gate system, 70% is the gate period 4-5, which means the stability ofthe SPI cannot be seen at the start of the project.

Several reasons can be put forward why the SPI was not stable in the beginning. The schedule performance index has improper performance on projects whose completion is far behindschedule. SPI will be worth 1 at the end of the project so this does not represent a realistic view of the delay, it only makes the stability of SPI a value of 0 at the end. SPI (t), a parameter generated by the earned schedule calculation, shows a position that is almost the same as the SPI for earned value, however the graph shows instability in the SPI that exceeds the movement in the SPI (t) graph.

During project execution and particularly in the middle of the project, plans can change due to additional work, problems with material supply, and changes in the decision of some activities. Although the APU project had typically the same work, the five projects faced several issues that made changes to the original plan. This adjustment causes workforce. These factors can cause project performance to be slower than planned. The stability that has just been achievedabove 70% for this reason does not make the results from the earned schedule broken, but it should be noted that the estimated schedule can still change quite significantly in the middle, however SPI (t) has amore stable performance than SPI.

4. CONCLUSION

The project management system currently in use can only show jobcard status features, material consumption, and manhours with a separate menu. Jobcard status can indicate jobcards that have not been worked, are being worked on, and have been worked on. The material consumption shows the status of the part that has been installed into the engine, and the actual manhours are obtained after the jobcard has been barcoded. The project manager needs toaggregate the information required for reporting himself and needs to get the actual cost values. Manual calculations cannot be obtained directly in real time and take time to calculate, while one project manager manages 4 to 5 projects at a time. The estimated completion of the project duration and costs if in the middle of the project there is a workscope upgrade, finding, or implementation of other work priorities cannot be determined directly by the project manager through existing tools. This can cause the project manager to have difficulty providing forecasts for the completion date as well as estimating total costs in the middle of the project. From the results, there are several benefits that can be stated from the results of project data processing using the earned value and earned schedule methods as follows:

1. Assist in realistic project planning
2. Able to measure the accuracy of cost and duration directly
3. Able to make project managers anticipate risks early
4. Can be used as iteration and review material for future projects

Adding methods to the existing system can increase the speed of reporting and make decision making easier. To support the benefits that have been described, calculation of the stability of the CPI and the stability of the SPI is carried out to determine the conditions of the calculation parameters when used in project monitoring.

5. REFERENCES

Acebes, F., Pajares, J., Galan, J. M. & Paredes, A. L., 2013. A new approach for project control under uncertainty. Going back to the basics. *International Journal of Project Management*, Volume 32, pp. 423-434.

Anbari, F. T., 2011. Advances in earned schedule and earned value management. *Scheduling, Quality Management, Earned Value Management,* 22 October.

Bill Mowery, M. P., 2012. Earned Schedule: From Emerging Practice to Practical Application. *Leading Edge Forum | CSC Papers.*

Buyse, P., Vandenbussche, T. & Vanhoucke, M., 2009. *Performance Analysis of Earned Value Management in The Construction Industry,* Belgium: Universiteit Gent.

Clayson, D., White III, E. & Jr, A. E. T., 2018. Cost Performance Index Stability: Insights from Environmental Remediation Projects. *Journal of Defense Analytics and Logistics,* 2(2019), pp. 94-109.

Colin, J. & Vanhoucke, M., 2015. A comparison of the performance of various project control methods using earned value management systems. *Expert Systems with Applications,* Volume42, pp. 3159-3175.

Haghighi, F. R., 2013. *Earned Value Management Syatem in Manufacturing Industry,* Kuala Lumpur: University Malaya.

Henderson, K., 2004. Further Developments in Earned Schedule. *The Measurable News,* pp. 1-8.

Kumanan, S., Raja, K. R. & Jose, G. J., 2006. Multi-project scheduling using an heuristic and a genetic algorithm. *International Journal of Advanced Manufacturing Technology,* pp. 360-366.

Lipke, W., 2012. Earned Schedule Contribution to Project Management. *PM World Journal,* pp. 1-19.

Lipke, W., Zwikael, O., Henderson, K. & Anbari, F., 2009. Prediction of project outcome: the application of statistical methods to earned value management and earned schedule performance indexes. *International Journal of Project Management,* 27(4), pp. 400-47.

Miller, R. & Judgev, K., 2012. Critical Success Factors in Projects: Pinto, Slevin, and Prescott-The Elucidation of Project Success. *International Journal of Managing Projects in Business,* 5(4),pp. 757-775.

Negi, S., 2021. *Crucial Benefit of Earned Value Management.* [Online] Available at: https://www.saviom.com/blog/crucial-benefits-of-earned-value-management/ [Accessed 8 February 2021].

Pimapunsri, K. & Weeranant, D., 2018. Solving Complexity and Resource-Constrained Project Scheduling Problem in Heavy Maintenance. *International Journal of Applied Engineering Research,* 13(11), pp. 8998-9004.

Samaranayake, P., 2012. Aircraft Maintenance Planning and Scheduling: an Integrated Framework. *Journal of Quality in Maintenance Engineering,* 18(4), pp. 432-453.

Secilmis, K., 2020. *Reducing TurnAround Times: The Most Critical and Challenging KPI for Aircraft Engine MRO Companies.* [Online] Available at: https://icrontech.com/https://icrontech.com/blog_item/reducing-turnaround- times-the-most-critical-and-challenging-kpi-for-aircraft-engine-mro-companies/ [Accessed 20 October 2020].

Spalek, S., 2019. *Data Analytics in Project Management.* Florida: CRC Press.

Sveinsson, O. G., 2010. *Implementation of The Earned Value and Earned Schedule Methods for Project Cost and Schedule Control in The Icelandic Construction Industry,* Reykjavik: University of Iceland.

Urgiles, P., Gil, J. C. & Sebastian, M. A., 2019. Analysis of the Earned Value Management and Earned Schedule Techniques in Complex Hydroelectric Power Production Projects: Cost andTime Forecast. *Hindawi Complexity,* Volume 2019, pp. 1-12.

COST VOLUME PROFIT ANALYSIS OFBOEING B777 MAINTENANCE REVENUE AND COST

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ABSTRACT

Power by the Hours (PBTH) is one of a business contract bases applied by aircraft owners/airline with Aircraft Maintenance, Repair and Overhaul (MRO) company. Maintenance, Repair and Overhaul (MRO) company received payments for their services based on the flight hours of all fleets operated by the airline. The decrease of income for maintenance services within the last 4 years is not equal with actual costs of maintenance incurred. Some influenced factors are, actual flight hours do not achieve target, Aircraft gets older, the requirement of spare parts and other materials get higher. Those factors are the weakness within PBTH contracts. In this research, it was found that the maintenance costs of the B777 aircraft increased according to the age of the aircraft. The decline in achieving flight hours in 2020 does not have a significant effect on aircraft maintenance costs. From the results of the sensitivity analysis, maintenance costs will increase in the years 2021- 2025, one of which is due to maintenance with intervals of 3 years or 15,000 flight hours. The increase in maintenance costs is greater than the income from flight hours, so from the results of the CVP analysis it is necessary to evaluate the value of the PBTH Rate by providing the minimum flight hours that must be achieved.

Keywords: Maintenance Cost, PBTH, Cost Volume Profit, Sensitivity Analysis

1. INTRODUCTION

The COVID-19 pandemic is having an enormous impact on the aviation industry, affecting passenger capacity and gross passenger operating revenues of airlines. The change in the behaviour of passengers following the COVID-19 crisis, travel restrictions and the ensuing economic crisis have resulted in a dramatic drop in demand for airline services. According to International Air Transport Association (IATA), passenger air transport measured as revenue passenger kilometre was down 90% year-on-year in April 2020 and still down 75% in August.The collapse in economic activity and trade affected freight, which was almost 30% lower year- on-year in April and still about 12% lower in August 2020. IATA also estimates the revenue of asia pacific passenger airlines in 2020 drop by 113 billion USD compare with 2019.

Maintenance is one of the most important things in aviation. The decrease of income for maintenance services within MRO within the last 4 years is not equal with actual costs of maintenance incurred by the MRO. Some influenced factors are, actual flight hours do not achieve planned target, Aircraft gets older (maturity factor), so does the requirement of spare parts and other materials get higher.

One of the biggest Airlines and MRO in Indonesia using Power by the hours (PBTH) contract agreement to running their business. PBTH income based on the number of hours of flight earned each month is multiplied by the PBTH rate (PBTH rate) that has been agreed upon. The weakness of the current calculation is that it does not use a sensitivity analysis for every change in its parameters, so the risk of reducing the number of flights cannot be fixed costs incurred. In addition, there is no minimum lower limit for PBTH rates in PBTH contracts and there has not been a tariff evaluation since 2017. By conducting a sensitivity analysis, what might occur from these changes can be known and anticipated in advance. Furthermore, in this study an approach will be used with the Cost Volume Profit Analysis method. Cost Volume Profit Analysis(CVP) is a tool to help understanding the relationship between cost, volume, and profit with a focus on the interactions between product price, volume of activity, variable costs per unit, total fixed costs, and the mix of fixed costs.

2. METODOLOGY

This research purpose is to know actual revenue and cost achievement, so we propose direct maintenance cost calculation for line maintenance that consist of manhours and material cost from routine and nonroutine tasks. Boeing show a curve that compares the cost of maintaining aircraft to the age of the aircraft, which is called the maturity curve as shown atFigure 1.

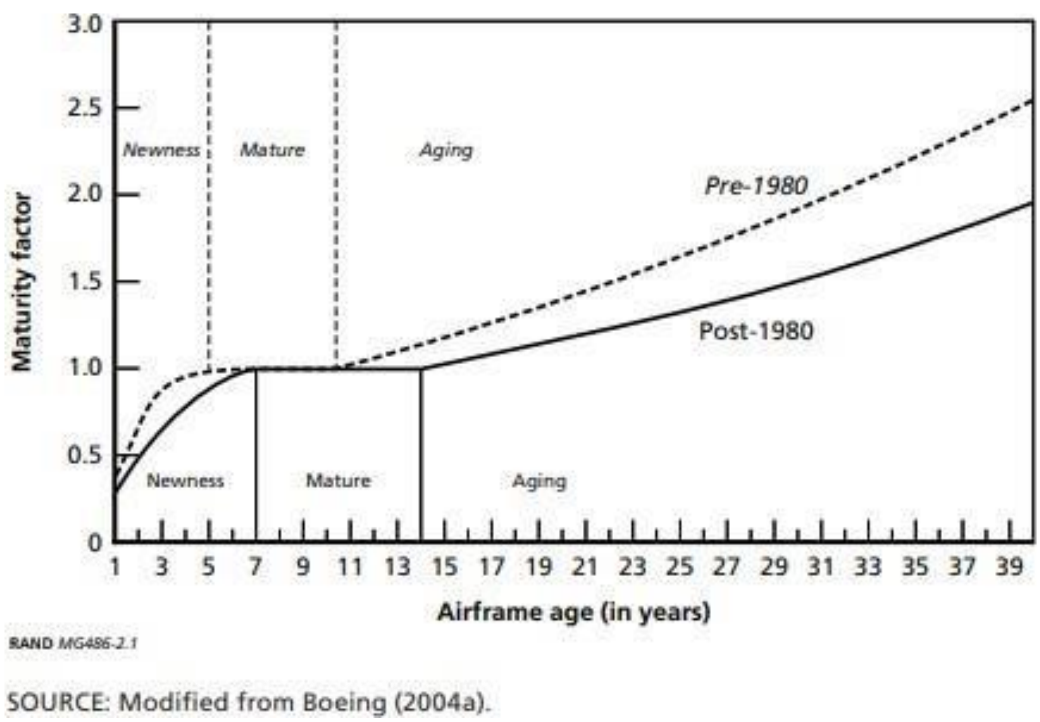

Figure 1. Boeing Maturity Curve

The mathematical model of direct maintenance cost in this research is develop from MassoudUrdu (2015) and and adjusted to the existing situation at MRO observed. While the considered constraints are constructed based on the Basic Operation Manual of MRO observed for Boeing 777-300 Aircraft. Figure 2 shows the flowchart of research method.

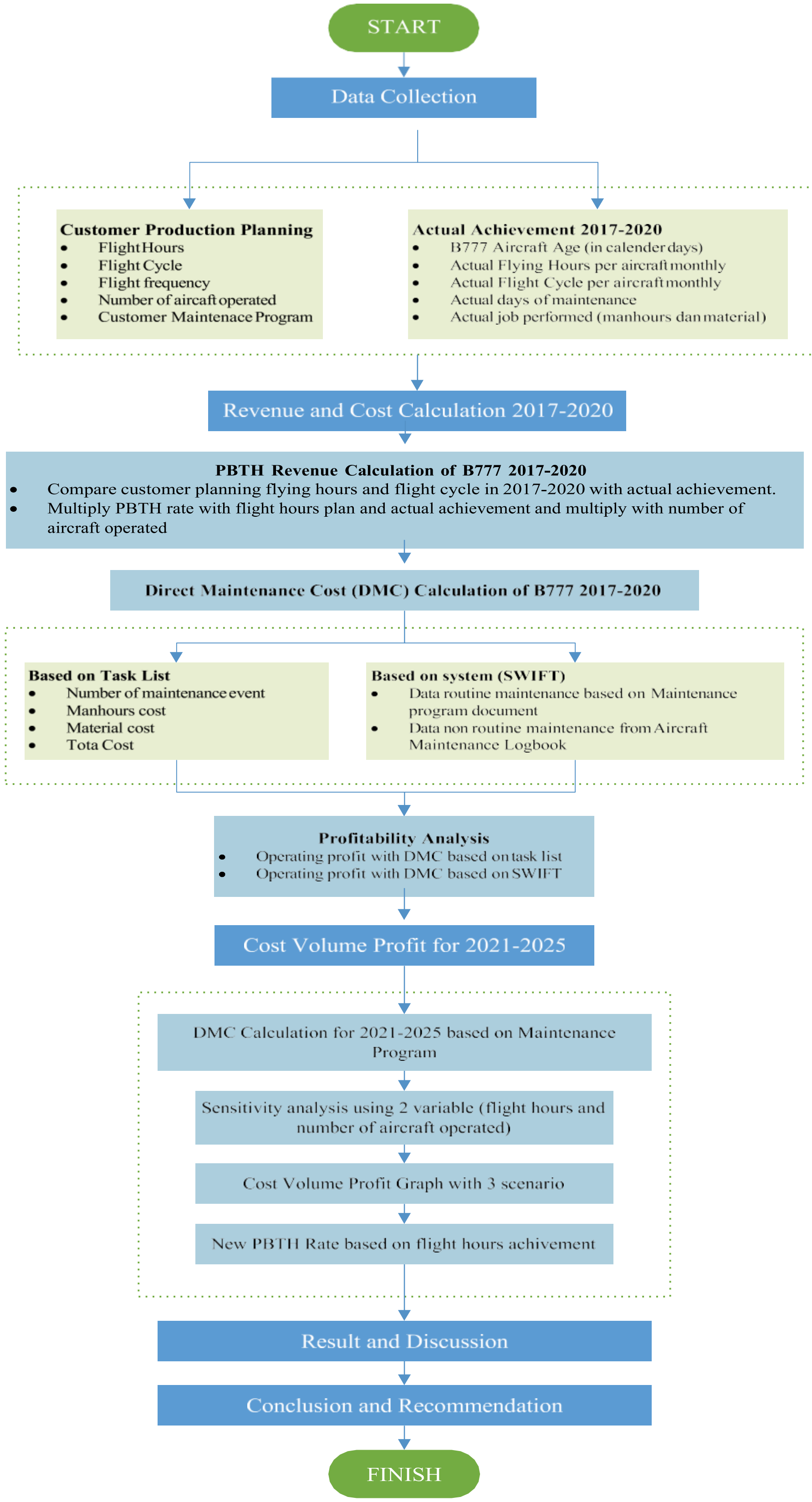

Figure 2. Research flowchart

PBTH revenue is calculated for each registration by calculating the actual number of flight hours achieved in each month multiplied by the PBTH tariff value for its fleet. The objective function of mathematics model is to maximize operating profit.

$$max \sum_{a}^{k} R - \sum_{a}^{k} M \quad (1)$$

where,

R = PBTH revenue for aircraft registration a until k

M = Direct maintenance cost for aircraft registration a until k

The airbus method calculates the direct maintenance cost (DMC) as sum of manhours and material cost. Wu et al (2004).

$$\mathbf{DMC = MMH \times LR + MC} \quad (2)$$

where,

MMH = maintenance man hours on aircraft and off

aircraft LR = labor rate

MC = material costs

Revenue and direct maintenance cost are paramaters of cost volume profit that will be analyze in this research. According to Gautier Et al (2011) the CVP analysis shows the relationship between sales prices, production volume, costs, expenses and income, target profit. According to Drury (2000), the CVP analysis determines performance, measurement, control, stock evaluating, costs that need to be planned for production or service, the creating sales prices etc. In this research we use CVP graphic method. This method is very useful, because it highlights relations between the cost-volume-profit in a wider aspect of business activities (manufacturing and service). In this case it enables managers, greater perspective to planning and making decisions for the future. The steps included in the graphical method are three: the profit area, the loss zone, the equilibrium zone. Based on three areas, managerial accountants should, to planning production quantity, sales price, target profit, risk threshold.

3. RESULT AND DISCUSSION

3.1 PBTH Revenue

PBTH revenue is calculated by multiplying the achievement of flight hours by the number of aircraft and PBTH rate.

Table 1. PBTH Revenue 2017-2020

Flight Hours	Flight Hours Achievement/Year				Revenue Achievement/Year			
	2017	2018	2019	2020	2017	2018	2019	2020
PK-AAA	3,840	3,588	3,614	774	382,925	357,795	360,388	77,183
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
PK-JJJ	4,475	4,300	3,688	1,007	446,247	428,796	367,767	100,418
TOTAL	42,408	42,131	37,846	12,120	4,228,926	4,201,303	3,774,003	1,208,606

Table 1 show PBTH revenue calculation for 10 aircraft registration in 4 years 2017-2020. The achievement of flight hours has decreased since 2017 and in 2020 the decline has reached 12,120 hours per year due to COVID-19. This achievement has an effect on revenue generation periode 2017-2020.

Table 2. PBTH Revenue Budget and Actual 2017-2020

Description	2017	2018	2019	2020
Rate PBTH	99.72	99.72	99.72	99.72
Planning FH (10 A/C)	38,903	38,903	38,903	38,903
Budget Revenue	3,879,407.16	3,879,407.16	3,879,407.16	3,879,407.16
Actual FH	42,408	42,131	37,846	12,120
Actual revenue	4,228,925.76	4,201,303.32	3,774,003.12	1,208,606.40
GAP	349,518.60	321,896.16	(105,404.04)	(2,670,800.76)
Ach %	109.01%	108.30%	97.28%	31.15%

Table 2 shows that the reduction in PBTH income is proportional to the decrease in flight hours. If we compare with customer production plan in 2017, there were excess profit in 2017 and 2018 but there were losses in 2019 and 2020.

3.2 Direct Maintenance Cost

The following is an example of lubrication work in the elevator power control areaaccording to the Maintenance Program with document number 10000004179 which has an interval of 5000 FH note 500 DY (which was reached first), estimated work of 0.5 manhours (30 minutes by 1 person) and material requirements of USD 720.

Table 3. Flight Hours PK-AAA

Year	Aircraft Age	Flight Hours (accumulatif)
2017	1629	17762
2018	1989	21350
2019	2349	24964
2020	2709	25738

Step 1: Determine number of *event maintenance* (n)

- Constrain number of event maintenance (n) or number of tasks are whose interval reach first in between $\{fh_t, fc_t, days_t\}$ compare with actual achievement. $\{fh_p, fc_p, days_p\}$.
- Table 3 shows actual achievement of aircraft aging and flight hours in 2017-2020 at PK- AAA. Cumulative achievement in 2020 is 25738 hours.
- Comparing the achievement of flight hours and actual aircraft age with tasklist intervals. For example, elevator work has a maintenance interval every 500 days, while PK-AAA hasreached the age of 1629 in 2017, so elevator maintenance until 2017 must be done 3 times. When viewed from the flight hours parameters, the required interval is every 5000 flight hours

while the actual achievement is 17.7762 hours, so that the maintenance is done 3 times. Furthermore, the highest value is selected from the aspects of age and flight hours to determine the number of maintenance events, in this case the same, namely 3. If until 2016 it has been done 2 times, then in 2017 it is enough to do 1 time.

Table 4. Total Maintenance Event Calculation

	A	b	c = a/b	d	e	f = d/e	g max (c/f)	h g-(Y-1)
Year	Aircraft age (day)	Interval days	Frequency (day)	Actual Flight Hours (accumulation)	Interval Flight Hours	Frequency (FH)	Nilai max	Total Event
2016								2
2017	1629	500	3	17762	5000	3	3	1
2018	1989	500	3	21350	5000	4	4	1
2019	2349	500	4	24964	5000	4	4	0
2020	2709	500	5	25738	5000	5	5	1

- In conclusion, for this elevator work, there was a total of 1 event in 2017, 1 time in 2018, no 2019, and 1 time in 2020.

Step 2: Calculate Manhours and Material Cost:

- Manhours Cost (example for 2017)
  = number of maintenance event x manhours required per task x manhours rate (3)
  $= 1 \ x \ 0.5 \ x \ 50$
  $= 25$
- Material cost (example for 2017)
  = number of maintenance event x material cost per task (4)
  $= 1 \ x \ 720$
  $= 720$
- Perform the same calculation steps for 2018-2020

Step 3: Calculate Direct Maintenance Cost:

Aircraft maintenance costs are the sum of the cost of manhours and materials. Table 5 show direct maintenance cost at registration AAA in 2017, 2018 and 2020 have the same value.

Table 5. Total Direct Maintenance Cost PK-AAA

Year	Manhours Cost	Material Cost	Total Cost
2017	25	720	745
2018	25	720	745
2019	0	0	0
2020	25	720	745

If the calculation of the number of maintenance events for several other tasks results in a decimal fraction number, it will be bred upwards. This is intended to anticipate premature deployments that may occur in maintenance scheduling due to aircraft rotation, irregularities, limited maintenance slots and others. With the same data processing for all tasks, the results of maintenance costs for manhours and materials for all B777 registrations are shown in table 6. The average manhours costs in 2020 have decreased since 2019 amounting to 4,608 USD while for materials in 2020 it has increased when compared to 2019 to 258,606 USD.

Table 6. Summary manhours and material cost for all registration

A/C Reg	Manhours				Material			
	2017	2018	2019	2020	2017	2018	2019	2020
AAA	27,395	25,852	29,852	20,951	209,838	172,456	204,822	118,633
BBB	28,543	26,172	30,740	21,093	210,491	178,434	213,715	115,716
….	….	….	….	….	….	….	….	….
….	….	….	….	….	….	….	….	….
….	….	….	….	….	….	….	….	….
JJJ	18,687	20,568	23,968	18,547	98,091	109,482	108,941	96,290
Total	28,073	27,827	27,608	23,000	202,028	180,395	198,927	121,611

By adding the cost of manhours and materials, you will get a total maintenance cost of B777. During 2017-2020 there were no significant changes in terms of total costs. Table 7 shows that the 2017 B777 maintenance cost of 6.7 million USD is the largest cost for the last 4 years.

Table 7. Direct Maintenance Cost (Manhours and Material)

A/C Reg	Total Direct Maintenance Cost B777			
	2017	2018	2019	2020
AAA	237,233.21	198,308.72	234,674.01	139,584.31
BBB	239,033.14	204,605.41	244,454.62	136,808.84
….	….	….	….	….
….	….	….	….	….
….	….	….	….	….
JJJ	116,777.93	130,049.18	132,909.64	114,836.33
Total	2,301,014.60	2,082,215.00	2,265,357.69	1,446,108.80

Maintenance costs for 2018-2020 have almost the same value, this means that achieving low flight hours in 2020 does not significantly reduce maintenance costs. In terms of aircraft maturity, AAA maintenance costs are greater than other registrations and PK-JJJ costs are the smallest costs.

3.3 Sensitivity Analysis

Since we know that based on the aircraft operation data, not all aircraft operated during this pandemic at 2020 for example PK-AAA only operates for 3 months from January to March, while PK-HHH and PK-JJJ will continue to operate during 2020. This will be one of the parameters in conducting a sensitivity analysis of the incurred maintenance costs. Sensitivity is carried out to determine the estimated maintenance costs for the year 2021-2025 for the entire B777 fleet. The following are the initial parameters used in the sensitivity calculation:

- Number of aircraft in each simulation year,
- The age of the aircraft in each simulation year,
- Cumulative flight hours in each simulation year,
- Flight cycle in each simulation year with an estimated increase of the same as in 2020,
- Estimated material price escalation of 15% from the previous year,
- Manhours rate will not change until 2025, which is 50 USD per hour.

Sensitivity in 2021-2025 will simulate by changing the number of aircraft to be operated from a total of 10 existing aircraft, as well as the achievement of aircraft flight hours with an estimated increase of between 700-4000 flight hours each year. For simulations, the average value of all registrations is used to facilitate calculation.

Table 8. Direct Maintenance Cost (Manhours and Material) 2021

		2021							
		Flight Hours							
Number of Aircraft Operated	$ 2,420,236	$ 700	$ 1,000	$ 1,500	$ 2,000	$ 2,500	$ 3,000	$ 3,500	$ 4,000
	2	$ 446,167	$ 449,025	$ 485,664	$ 490,842	$ 525,626	$ 531,951	$ 808,047	$ 813,104
	3	$ 669,250	$ 673,537	$ 728,497	$ 736,262	$ 788,439	$ 797,927	$ 1,212,070	$ 1,219,656
	4	$ 892,334	$ 898,049	$ 971,329	$ 981,683	$ 1,051,253	$ 1,063,902	$ 1,616,094	$ 1,626,208
	5	$ 1,115,417	$ 1,122,562	$ 1,214,161	$ 1,227,104	$ 1,314,066	$ 1,329,878	$ 2,020,117	$ 2,032,759
	6	$ 1,338,501	$ 1,347,074	$ 1,456,993	$ 1,472,525	$ 1,576,879	$ 1,595,853	$ 2,424,140	$ 2,439,311
	7	$ 1,561,584	$ 1,571,587	$ 1,699,826	$ 1,717,945	$ 1,839,692	$ 1,861,829	$ 2,828,164	$ 2,845,863
	8	$ 1,784,668	$ 1,796,099	$ 1,942,658	$ 1,963,366	$ 2,102,505	$ 2,127,804	$ 3,232,187	$ 3,252,415
	9	$ 2,007,751	$ 2,020,611	$ 2,185,490	$ 2,208,787	$ 2,365,318	$ 2,393,780	$ 3,636,210	$ 3,658,967
	10	$ 2,230,835	$ 2,245,124	$ 2,428,322	$ 2,454,208	$ 2,628,132	$ 2,659,755	$ 4,040,234	$ 4,065,519

Table 8 shows sensitivity analysis in 2021. Direct maintenance cost will be increase if number of aircraft operated increase of if flight hours achievement increase. In Januari 2021, number of aircraft operate only 7 unit and flight hours is 200 per month. If we assume that achievement in Januari will be same for all of month in 2021 so the maintenance cost will be 1,5- 1,7 million USD. The effect of the increase in the number of aircraft operated on maintenance costs is greater than the effect of the addition of flight hours.

The next table is sensitivity analysis in 2025 which higher maintenance cost than 2021.The maintenance cost will be 2,1 million USD for 7 aicraft operated with 200 hours per month. It means that maintenance cost increases 30% from maintenance cost in 2021. Table 9 show direct maintenance cost in 2025.

Table 9. Direct Maintenance Cost (Manhours and Material) 2025

		2025							
		Flight Hours							
Number of Aircraft Operated	$ 2,060,128	$ 700	$ 1,000	$ 1,500	$ 2,000	$ 2,500	$ 3,000	$ 3,500	$ 4,000
	2	$ 361,498	$ 407,860	$ 414,185	$ 450,344	$ 455,461	$ 490,827	$ 495,904	$ 604,664
	3	$ 542,247	$ 611,790	$ 621,277	$ 675,516	$ 683,191	$ 736,240	$ 743,856	$ 906,996
	4	$ 722,996	$ 815,720	$ 828,370	$ 900,688	$ 910,922	$ 981,654	$ 991,808	$ 1,209,329
	5	$ 903,745	$ 1,019,650	$ 1,035,462	$ 1,125,860	$ 1,138,652	$ 1,227,067	$ 1,239,760	$ 1,511,661
	6	$ 1,084,494	$ 1,223,580	$ 1,242,554	$ 1,351,032	$ 1,366,383	$ 1,472,481	$ 1,487,712	$ 1,813,993
	7	$ 1,265,243	$ 1,427,510	$ 1,449,647	$ 1,576,204	$ 1,594,113	$ 1,717,894	$ 1,735,664	$ 2,116,325
	8	$ 1,445,992	$ 1,631,440	$ 1,656,739	$ 1,801,376	$ 1,821,844	$ 1,963,308	$ 1,983,616	$ 2,418,657
	9	$ 1,626,741	$ 1,835,370	$ 1,863,832	$ 2,026,548	$ 2,049,574	$ 2,208,721	$ 2,231,568	$ 2,720,989
	10	$ 1,807,490	$ 2,039,300	$ 2,070,924	$ 2,251,720	$ 2,277,305	$ 2,454,134	$ 2,479,520	$ 3,023,321

3.4 Cost Volume Profit

The next step is to determine the price break that will be used as a reference in determining the price in the form of PBTH rate to customers who accommodate fixed costs and variable costs. In the cost volume profit, there must be three elements to be evaluated, cost, volume of products or services sold and profit. In this research, the costs used are direct maintenance costs, the volume of products or services used is the number of aircraft operated and the achievement of flight hours. The analysis is carried out by comparing income with costs incurred in 2021-2025 for the achievement of certain flight hours. Some of the options used include:

- flight hours options, namely 1000, 2000, 3000 and 3500
- 9 options for the number of registrations, namely 2 to 10 aircraft to be operated.

Table 10. Revenue and Cost Comparison (FH = 2000)

Flight Hours 2000						
A/C operated	Revenue	Cost 2021	Cost 2022	Cost 2023	Cost 2024	Cost 2025
2 Reg	398,880	456,339	695,368	780,745	598,873	612,304
3 Reg	598,320	684,509	1,043,051	1,171,118	898,309	918,456
4 Reg	797,760	912,679	1,390,735	1,561,491	1,197,745	1,224,608
5 Reg	997,200	1,140,849	1,738,419	1,951,864	1,497,182	1,530,760
6 Reg	1,196,640	1,369,018	2,086,103	2,342,236	1,796,618	1,836,912
7 Reg	1,396,080	1,597,188	2,433,787	2,732,609	2,096,054	2,143,064
8 Reg	1,595,520	1,825,358	2,781,471	3,122,982	2,395,491	2,449,215
9 Reg	1,794,960	2,053,527	3,129,154	3,513,354	2,694,927	2,755,367
10 Reg	1,994,400	2,281,697	3,476,838	3,903,727	2,994,363	3,061,519

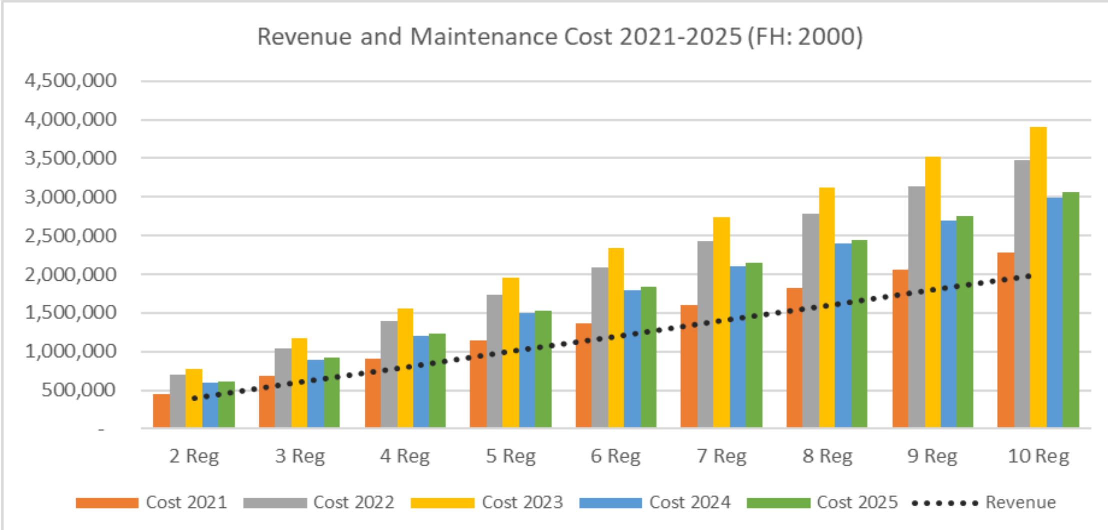

Figure 3. Cost Volume Profit Graph (Flight hours = 2000)

4. CONCLUSION

Revenue from aircraft maintenance services according to the PBTH 2017 contract is calculated based on the multiplication result of the number of aircraft operated times the PBTH Rate times the achievement of flight hours. The achievement of B777 flight hours in 2017-2020 has decreased so that it has an impact on income achievement. Estimated income in 2021-2025 using a moderate scenario, which is only 7 out of 10 aircraft are operated, and the assumption of achieving flight hours per year 2000 flight hous uses the January 2021 achievement approach, thenthe revenue for 2021-2025 is USD 1,396,080.

Aircraft age, flight hours and flight cycle are parameters that determine aircraft maintenance costs. During the Covid-19 pandemic that occurred in 2020, the total flight hours of all B777 registrations reached 12,120 flight hours, a decrease of 32% from 2019 of 37,846 hours. The decrease in the achievement of flying hours did not have a significant impact on reducing aircraft maintenance costs, this was because there were 307 out of 560 tasks that had calendar intervals.

From the results of sensitivity analysis and Cost-Volume-Profit at revenue, costs, and flight hours during 2021-2025 with flight hours less than or equal to 2000 hours per aircraft, MROwill experience losses in 5 years. The minimum value is obtained if the operator only uses 2 of the10 B777 aircraft.

Cost volume profit analysis states that the 2017 PBTH budget is no longer relevant to use because it causes losses to MRO. This is due to the low aircraft utilization in 2020 so that the amount of revenue that is smaller than the budget is not proportional to the maintenance costs tobe carried out. So that to avoid losses, proposals for a new PBTH rate scheme are made as shown at Table 12, it can be used until 2025.

Table 12. PBTH Rate Range

Scenario	Flight Hours	PBTH Rate
Optimist	>4000	99.72
Moderate	2000-4000	157.18
Pesimist	<2000	263.95

This research also give recommendation for some stakeholder. Operators need to optimize flight hours and the number of aircraft operated to obtain the most efficient maintenance costs. Evaluate the effectiveness of the maintenance program that is being run to get effective results from the maintenance scheduling side. For MRO, it is necessary to evaluate the 2017 PBTH contract which accommodates the achievement of current flight hours. It is necessary to make a price range according to aircraft utilization. In addition, the discipline of data input to the SAP system regarding the use of manhours and old materials needs to be done. For further research, it can be done for other types of aircraft with a wider age range. Research on the relevance of using PBTH contracts to airlines and MRO businesses during the Covid-19 pandemic.

5. REFERENCES

Ackert, S. 2010. Basics of Aircraft Maintenance Programs for Financiers. Evaluation & insights of commercial aircraft maintenance programs.

Aprizal, Muhammad. 2017. “GMF Aeroasia C-Check PBTH Cost Analysis Study Case: Garuda Indonesia Fleet’, INA.

Barringer, H. Paul. 2003. “Predict Future Failures from Your Maintenance Records”, International Maintenance Conference, Florida.

Correira, Vitor M. 2012. “The Aircraft Maintenance Program and its importance on Continuing Airworthiness Management”, Instituto Superior Técnico.

Dixon, Matthew. 2006. “The Maintenance Costs of Aging Aircraft Insights from Commercial Aviation”,

Flouris, Triant., Dennis Lock. 2008. Aviation Project Management, USA: Ashgate Publishing. Glautier, M., & Underdown, B. (2001). Accounting Theory and Practice. Harlow England:

Pearson Education Limited.

Hilton, R. W. (2002). Management Accounting Creating Value in a Dynamic: Business Environment. . Irwin: McGraw Hill

Kachaner, Nicolas., 2009. “Variabilization” from Boston Consulting Group: https://www.bcgperspectives.com/content/articles/innovation_growth_strategy_variabilizatio n/

Kinnison, Harry A. 2004. Aviation Maintenance Mangement, USA: McGraw-Hill.

Lulaj, Enkeleda. Iseni, Etem. 2018. “Role of Analysis CVP (Cost-Volume-Profit) as Important Indicator for Planning and Making Decisions in the Business Environment. European Journal of Economicsand Business Studies Vol 4 No 2.

Mora, Minda. 2012. Literature Review on Aircraft Maintenance Program. Jurnal Penelitian Perhubungan Udara Vol. 38 No. 4 Desember 2012. INA

Pintelon, L.M., L.F Gelders. 1992. “Maintenance management decision making”, European Journal of Operational Research 58 (1992), North-Holland.

Samaranayake, Premaratne. 2006. Current Practices and Problem Areas in Aircraft Maintenance Planning and Scheduling -Interfaced/Integrated System Perspective. The University of Western Sydney, Australia

Saltoglu, Remzi., Nazmia Humaira, Gokhan Inalhan. 2016. “Scheduled Maintenance and Downtime Cost in Aircraft Mainteanance Management”, International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering.

Silalahi, Jordan. 2006. Analisa Biaya Perawatan Pesawat Boeing 737-200 Pada Strategic Business Unit Merpati Maintenance Facility Surabaya. Institut Teknologi Sepuluh Nopember.

Tanudjaja, Vixky. 2014. Analisis Cost-Volume-Profit (CVP) terhadap Strategi Maksimalisasi Laba pada Grand Maximum Café & Resto di Jalan Putri Merak Jingga No.2D Medan. Universitas Sumatera Utara.

Urdu. Massoud. 2015. "Aircraft maintenance cost modelling considering the influence of design parameters", Delft University of Technology. Netherlands.

Woodward, David G. 1997. "Life cycle costing theory, information acquisition and application", Internattonal Journal of Project Management, UK.

Wyman, Oliver. 2018. Global Fleet & MRO Market Forecast Summary 2018-2028. Oliver Wyman, USA.

FINANCIAL FEASIBILITY STUDY ON INVESTMENT IN PEKANBARU - PADANG TOLL ROAD, BANGKINANG - PANGKALAN SECTION

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ABSTRACT

Toll road infrastructure development can be used as a measure of a country's economic progress, including in Indonesia. One of them is the construction of the Trans Sumatra Toll Road (JTTS), the Government is targeting that this cross-Sumatra will be connected in 2024. It is a challenge for the Government as an investor to realize this target. Investments in toll road development are closely related to risks and uncertainties. So that beforedeciding to develop an investment project, an in-depth feasibility study is needed to determine whether the investment is in the feasible category or not. The Pekanbaru - PadangToll Road Project, the Bangkinang - Pangkalan Section which is currently being implemented has the potential to not be completed according to the contract time, it is interesting to review its investment feasibility. Financial feasibility review parameters include cash flow, NPV, IRR and Payback Period. Investments will always be associated with uncertainty and risk. To find out what variables and how much influence they have on the achievement of investment targets, it is seen through the sensitivity analysis withchanges in the NPV value due to the influence of the input variables. With reference to the main risk in investment project research that has been done before, through sensitivity analysis approach with Monte Carlo modeling, to find out what variables dominate the effect of changes in the level of investment feasibility on toll roads. The results of the research on project conditions that could not possibly be completed according to the time of the initial contract due to land acquisition constraints, resulting in delays in starting construction, with the Cost of Capital analysis carried out, the NVP value was Rp. (-2,515) trillion < 0, IRR value of 6.271% >MARR of 8.06% and Payback Period more than 40 years. This illustrates that the investment is not feasible financially. And through the sensitivity analysis, it was found that 3 (three) main risk variables that had the mostinfluence on changes in the investment feasibility level were changes in construction costs, changes in inflation (changes in toll rates) and uncertainty in projected traffic volumes during the concession period. For further research, it is necessary to develop a feasibility study from an economic analysis.

Keywords: *investment, financial feasibility, cost of capital, Monte Carlo, sensitivity analysis.*

1. INTRODUCTION

The development of toll road infrastructure in a country can be used as a benchmark to measure the progress of a country's economy, both macro and micro. In several developing countries, the implementation of toll road investment projects often faces obstacles so that it affects to investment targets, one of which is in Indonesia, Vietnam and India. Toll road infrastructure development is categorized as a high-risk project, it needs to prove the extent to which the risk variable affects the feasibility of an investment project, including toll roads.Investment is closely related to the components of capital, income and uncertainty, because the benefits incurred by investors at this time will be beneficial in the future, especially investments such as toll roads that absorb high capital and risk (Haming, et.al. 2010). These uncertainties include technical implementation constraints, prolonged land acquisition constraints, uncertain resource price fluctuations which affect price adjustments, force majeure and others.

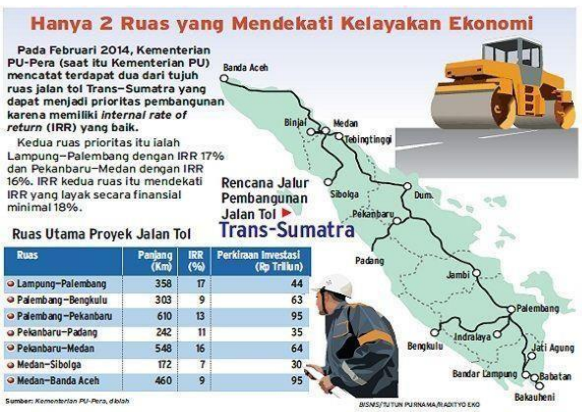

Figure 1. Trans- Sumatera Toll Road Plan (Bisnis.com, 2014)

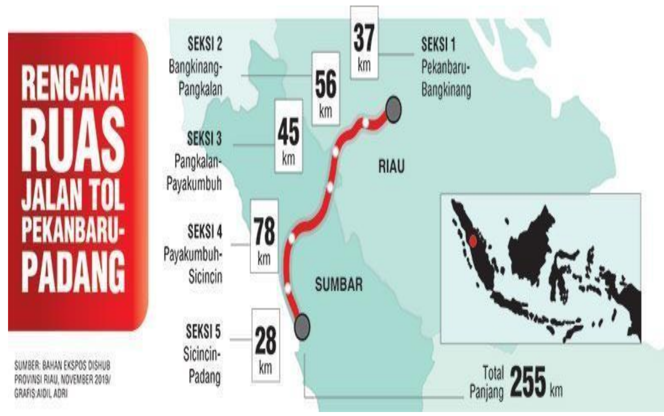

Figure 2. Section Pekanbaru – Padang Toll Road (RiauPos.co, 2019)

From the data above, it is informed that in February 2014, the PUPR Ministry noted that from the results of the investment evaluation, 2 (two) of the 7 (seven) trans Sumatra toll roads had a good Internal Rate of Return (IRR). According to the report of the National Legal Development Agency (BPHN), toll road construction projects are categorized as high-risk projects. From the data it is recorded that until the end of 2019 only one-fifth (1/5) of the total cross-Sumatra tollroad construction package has been realized. In this study, a study was conducted on the feasibilityof investing in one of the Trans Sumatra Toll Road (JTTS) packages, namely the Pekanbaru - Padang Toll Road Package for the Bangkinang - Pangkalan section of 54.2 km which is currently still under construction. The feasibility study is reviewed economically and financially, with data parameters optimizing the adequacy of actual data.

The results of this study are expected to provide a realistic picture of the level financial feasibility in the research object, by considering changes in uncertainty variables that have an impact on changes in the value of the financial feasibility parameters that are reviewed to determine the sensitivity level of risk variables to changes in the feasibility level with the NPV at Risk parameter.

2. METHOD

In this study the research method was carried out by conducting a feasibility study of investment both economically and financially with the stages of the research as shown in the following Research Flow Figure 2 :

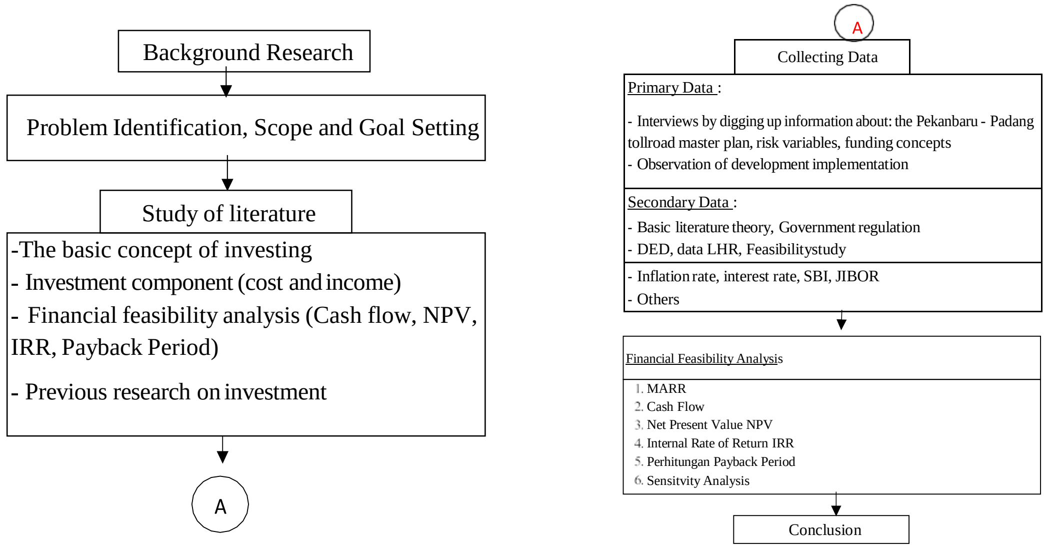

Figure 3. Research Flow Chart

Finansial Feasibility Analysis

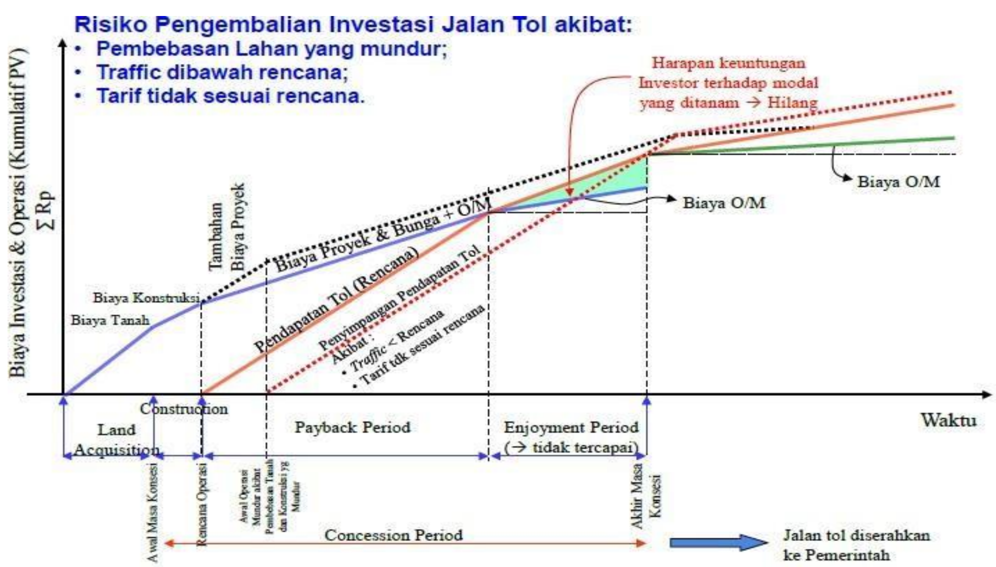

Figure 4. Toll Road Investment Return Scheme (Jasa Marga 2014)

The costs to be calculated are predictive costs, namely the estimated costs that will be incurred if the activity is carried out: Investment Costs, Operational Costs, Maintenance Cost. According to Husnan Suswarsono (2000) financial analysis is an analysis that compares costs and benefits to determine whether a business will be profitable during the life of the business. Evaluation criteria in financial analysis are generally cash flow, net present value (NPV), benefit cost ratio (BCR), internal rate of return (IRR) and payback period (PP).

2.1 Cash Flow Planning

According to the Financial Accounting Standard Statement (PSAK) No. 2, what is meant by cash flow is the inflow and outflow of cash or cash equivalents.

2.2 Minimum Atractive Rate of Return (MARR)

MARR is the minimum rate of return desired in an investment so that it is attractive, often referred to as the hurdle rate, which is the financial feasibility limit value of a project (Degarmo, 2006). several things that need to be considered in determining the using of MARR: Cost of Capital, Cost of Opportunity, Investment Risk.

2.3 Net Present Value (NPV)

Net Present Value (NPV) can be explained as the difference between the present value of cash inflows and the present value of cash outflows (Fabozzi, 2002). The Net Present Values of a project provide a measure of the net present value of an investment proposal in terms of its present value for money. NPV is expressed by the following formula:

$$NPV=\sum_{t=1}^{n} \frac{FCFt}{(1+k)^t} - I_o$$

FCFt: Annual free cash flow in the period t; k: Discount rate, as the rate of return (Cost of capital) ; I_o : Initial cash disbursements; n : project age.

2.4 Internal Rate of Return (IRR)

Mathematically, IRR is a discount rate that offsets the present value of cash inflows with the present value of cash outflows. This IRR is used to determine whether an investment is feasible to run or not, in this case the return on investment must be higher than the minimum acceptable rate of return or the minimum attractive rate of return.

$$I_o = \sum_{t=1}^{n} \frac{FCF_t}{(1+IRR)^1}$$

FCFt : Annual free cash flow in the period t; I_o : initial investment; n : investment age ; IRR : Internal Rate of Return.

2.5 Payback Period (PP)

Payback Period of an investment describes the time needed to get back the funds that have been invested in a project. Calculation methods for getting the payback period: Payback Period without interest and Discounted Payback Period.

2.6 Sensitivity Analysis

Sensitivity analysis by making simulations with the Monte Carlo concept to analyze how changes in the NPV at Risk value due to changes in risk variables while maintaining other variables remain.

3. RESULT AND DISCUSSION

3.1 Financial Feasibility

The feasibility of developing this toll road is determined based on the value of 3 (three) criteria, namely NPV, IRR and Profitability Index. In this study the analysis was carried out using the following planning data:

Table 1. Financial Analysis Planning Data

NO.	INVESTMENT PARAMETERS	PLANNING	INFORMATION
I.	**Technical Aspects**		
1	Length of the tollroad	54.2 km	
2	Time Schedule		
	- land acquisition	2018 - 2020	
	- Construction schedul	3 Mei 2019 - 1 Mei 2021	
	- Operation start	Tahun 2021	
	- Consession Period	40 tahun (2019 - 2059)	
II.	**Financial Aspects**		
	- Construction Cost (Rp Juta)	8,043,104	Dalam juta rupiah
	- Design	20,000	Dalam juta rupiah
	- Supervision	261,383	Dalam juta rupiah
	- Escalation	217,164	Dalam juta rupiah
	- Overhead	12,137	Dalam juta rupiah
	Construction Cost	**8,553,787**	
	- IDC	723,879	
	- Financial Cost	51,708	
	Financial Cost	**775,588**	
	Total Investment Cost	**9,329,375**	
	- Interest rate/ year - loan	8.9%	
	- Struktur Permodalan		
	Equity 70%	6,530,563	
	Loan incl IDC 30%	2,798,813	
	- SBI rate	5.75%	
	- Safe Rate +Risk	7.70%	
	- MARR	8.06%	
III.	**Operational Aspects**		
1	Initial Toll Rates (Rp . /km)	Th 2022	
	Golongan I	1,000	/km
	Golongan II	1,500	/km
	Golongan III	2,000	/km
	Golongan IV	2,500	/km
	Golongan V	3,000	/km
2	Tariff adjustments/year	12% / 2 years	
	Other income (billboards, user fees, tenants)	1.5% x toll incomes	
3	Traffic Volume per day (vehicle / day)	secondary data	
IV.	**Project Feasibility**		
1	Consession Period	40 years	
2	Income tax	25.00%	

Table 2. LHR data during the concession period

No	Year	EXISTING ROAD WITHOUT PROJECT vehicle/year					EXISTING WITH PROJECT vehicle/year					SWITCHING TO TOLL ROADS vehicle/year				
		Gol. I	*Gol. II*	*Gol III*	*Gol IV*	*Gol V*	*Gol. I*	*Gol. II*	*Gol III*	*Gol IV*	*Gol V*	*Gol. I*	*Gol. II*	*Gol III*	*Gol IV*	*Gol V*
1	2020	1,160,700	226,300	48,058	28,592	19,467	464,280	90,520	19,223	11,437	7,787	696,420	135,780	28,835	17,155	11,680
2	2021	1,246,475	242,725	51,708	31,025	21,292	498,590	97,090	20,683	12,410	8,517	747,885	145,635	31,025	18,615	12,775
3	2022	1,331,642	259,150	55,358	32,850	21,900	532,657	103,660	22,143	13,140	8,760	798,985	155,490	33,215	19,710	13,140
4	2023	1,417,417	276,183	59,008	35,283	23,725	566,967	110,473	23,603	14,113	9,490	850,450	165,710	35,405	21,170	14,235
5	2024	1,503,192	292,608	62,050	37,108	24,942	601,277	117,043	24,820	14,843	9,977	901,915	175,565	37,230	22,265	14,965
6	2025	1,588,358	309,642	65,700	39,542	26,158	635,343	123,857	26,280	15,817	10,463	953,015	185,785	39,420	23,725	15,695
7	2026	1,714,283	333,975	71,175	42,583	28,592	685,713	133,590	28,470	17,033	11,437	1,028,570	200,385	42,705	25,550	17,155

No	Year	EXISTING ROAD WITHOUT PROJECT vehicle/year					EXISTING WITH PROJECT vehicle/year					SWITCHING TO TOLL ROADS vehicle/year				
		Gol. I	*Gol. II*	*Gol III*	*Gol IV*	*Gol V*	*Gol. I*	*Gol. II*	*Gol III*	*Gol IV*	*Gol V*	*Gol. I*	*Gol. II*	*Gol III*	*Gol IV*	*Gol V*
8	2027	1,840,208	358,308	76,042	45,625	30,417	736,083	143,323	30,417	18,250	12,167	1,104,125	214,985	45,625	27,375	18,250
9	2028	1,965,525	382,642	81,517	48,667	32,850	786,210	153,057	32,607	19,467	13,140	1,179,315	229,585	48,910	29,200	19,710
10	2029	2,091,450	406,975	86,992	52,317	34,675	836,580	162,790	34,797	20,927	13,870	1,254,870	244,185	52,195	31,390	20,805
11	2030	2,216,767	431,917	91,858	55,358	36,500	886,707	172,767	36,743	22,143	14,600	1,330,060	259,150	55,115	33,215	21,900
12	2031	2,371,892	461,725	98,550	59,008	39,542	948,757	184,690	39,420	23,603	15,817	1,423,135	277,035	59,130	35,405	23,725
13	2032	2,527,017	492,142	104,633	62,658	41,975	1,010,807	196,857	41,853	25,063	16,790	1,516,210	295,285	62,780	37,595	25,185
14	2033	2,682,142	522,558	111,325	66,917	44,408	1,072,857	209,023	44,530	26,767	17,763	1,609,285	313,535	66,795	40,150	26,645
15	2034	2,837,875	552,367	117,408	70,567	46,842	1,135,150	220,947	46,963	28,227	18,737	1,702,725	331,420	70,445	42,340	28,105
16	2035	2,993,000	582,783	124,100	74,217	49,883	1,197,200	233,113	49,640	29,687	19,953	1,795,800	349,670	74,460	44,530	29,930
17	2036	3,125,617	608,942	129,575	77,867	51,708	1,250,247	243,577	51,830	31,147	20,683	1,875,370	365,365	77,745	46,720	31,025
18	2037	3,258,233	634,492	135,050	80,908	54,142	1,303,293	253,797	54,020	32,363	21,657	1,954,940	380,695	81,030	48,545	32,485
19	2038	3,390,850	660,042	140,525	84,558	55,967	1,356,340	264,017	56,210	33,823	22,387	2,034,510	396,025	84,315	50,735	33,580
20	2039	3,523,467	686,200	146,000	87,600	58,400	1,409,387	274,480	58,400	35,040	23,360	2,114,080	411,720	87,600	52,560	35,040
21	2040	3,656,083	711,750	151,475	91,250	60,833	1,462,433	284,700	60,590	36,500	24,333	2,193,650	427,050	90,885	54,750	36,500
22	2041	3,859,875	751,900	159,992	96,117	63,875	1,543,950	300,760	63,997	38,447	25,550	2,315,925	451,140	95,995	57,670	38,325
23	2042	4,064,275	791,442	168,508	100,983	67,525	1,625,710	316,577	67,403	40,393	27,010	2,438,565	474,865	101,105	60,590	40,515
24	2043	4,268,675	831,592	177,025	106,458	70,567	1,707,470	332,637	70,810	42,583	28,227	2,561,205	498,955	106,215	63,875	42,340
25	2044	4,473,075	871,133	185,542	111,325	74,217	1,789,230	348,453	74,217	44,530	29,687	2,683,845	522,680	111,325	66,795	44,530
26	2045	4,677,475	910,675	194,058	116,192	77,867	1,870,990	364,270	77,623	46,477	31,147	2,806,485	546,405	116,435	69,715	46,720
27	2046	4,888,567	952,042	202,575	121,667	80,908	1,955,427	380,817	81,030	48,667	32,363	2,933,140	571,225	121,545	73,000	48,545
28	2047	5,099,658	993,408	211,700	127,142	84,558	2,039,863	397,363	84,680	50,857	33,823	3,059,795	596,045	127,020	76,285	50,735
29	2048	5,310,750	1,034,167	220,217	132,008	88,208	2,124,300	413,667	88,087	52,803	35,283	3,186,450	620,500	132,130	79,205	52,925
30	2049	5,522,450	1,075,533	228,733	137,483	91,858	2,208,980	430,213	91,493	54,993	36,743	3,313,470	645,320	137,240	82,490	55,115
31	2050	5,733,542	1,116,292	237,858	142,350	94,900	2,293,417	446,517	95,143	56,940	37,960	3,440,125	669,775	142,715	85,410	56,940
32	2051	5,926,992	1,154,008	245,767	147,217	98,550	2,370,797	461,603	98,307	58,887	39,420	3,556,195	692,405	147,460	88,330	59,130
33	2052	6,127,133	1,192,942	254,283	152,692	101,592	2,450,853	477,177	101,713	61,077	40,637	3,676,280	715,765	152,570	91,615	60,955
34	2053	6,351,608	1,233,700	262,800	157,558	105,242	2,540,643	493,480	105,120	63,023	42,097	3,810,965	740,220	157,680	94,535	63,145
35	2054	6,547,492	1,275,067	271,317	163,033	108,892	2,618,997	510,027	108,527	65,213	43,557	3,928,495	765,040	162,790	97,820	65,335
36	2055	6,768,317	1,318,258	280,442	168,508	112,542	2,707,327	527,303	112,177	67,403	45,017	4,060,990	790,955	168,265	101,105	67,525
37	2056	6,996,442	1,362,667	290,175	173,983	116,192	2,798,577	545,067	116,070	69,593	46,477	4,197,865	817,600	174,105	104,390	69,715
38	2057	7,232,475	1,408,292	299,908	180,067	119,842	2,892,990	563,317	119,963	72,027	47,937	4,339,485	844,975	179,945	108,040	71,905
39	2058	7,476,417	1,455,742	310,250	186,150	124,100	2,990,567	582,297	124,100	74,460	49,640	4,485,850	873,445	186,150	111,690	74,460
40	2059	7,728,875	1,505,017	320,592	192,233	128,358	3,091,550	602,007	128,237	76,893	51,343	4,637,325	903,010	192,355	115,340	77,015
41	2060	7,989,242	1,556,117	331,542	198,925	132,617	3,195,697	622,447	132,617	79,570	53,047	4,793,545	933,670	198,925	119,355	79,570

Discounted Cash Flow

MARRLoan	BI rate =	8.90%
MARRequity	Safe rate + Risk =	7.70%
MARRinv =		**8.06%**

Table 3. NPV and IRR calculations (Financial)

In million rupiah

No	Year	Loan	Construction Cost	Revenue	Operation Expences	NOI	Terminal Value	Loan Installment	Gross Profit	PPH 25%	Net Cash Flow	Disc factor	Present Value
		1	2	3	4	5 = 3+4	6	7	8	9	10 = 8+9	11	
1	2019		(119,264)	-	-	-			(119,264)	-	(119,264)	1.000	(119,264)
2	2020		(113,289)	-	-	-		-	(113,289)		(113,289)	0.925	(104,839)
3	2021	2,798,813	(855,152)	-	-	-		-	1,943,660		1,943,660	0.856	1,664,525
4	2022		(7,677,143)	89,099	(6,939)	82,160		(249,094)	(7,844,077)		(7,844,077)	0.793	(6,216,515)
5	2023		(619,319)	96,451	(7,829)	88,622		(249,094)	(779,791)		(779,791)	0.733	(571,898)
6	2024			112,182	(8,233)	103,949		(249,094)	(145,145)	-	(145,145)	0.679	(98,509)
7	2025			120,443	(10,723)	109,720		(249,094)	(139,374)	-	(139,374)	0.628	(87,537)
8	2026			142,992	(46,914)	96,077		(249,094)	(153,017)	-	(153,017)	0.581	(88,937)
9	2027			155,399	(52,606)	102,793		(249,094)	(146,302)	-	(146,302)	0.538	(78,692)
10	2028			182,674	(129,948)	52,727		(249,094)	(196,368)	-	(196,368)	0.498	(97,743)
11	2029			197,484	(46,465)	151,019		(317,530)	(166,511)	-	(166,511)	0.461	(76,700)
12	2030			230,240	(47,101)	183,140		(317,530)	(134,390)	-	(134,390)	0.426	(57,287)
13	2031			249,419	(102,393)	147,026		(317,530)	(170,504)	-	(170,504)	0.394	(67,260)

In million rupiah

No	Year	Loan	Construction Cost	Revenue	Operation Expences	NOI	Terminal Value	Loan Installment	Gross Profit	PPH 25%	Net Cash Flow	Disc factor	Present Value
		1	2	3	4	5 = 3+4	6	7	8	9	10 = 8+9	11	
14	2032			292,241	(51,676)	240,565		(317,530)	(76,965)	-	(76,965)	0.365	(28,096)
15	2033			314,755	(144,646)	170,108		(317,530)	(147,422)	-	(147,422)	0.338	(49,803)
16	2034			366,246	(57,733)	308,513		(317,530)	(9,017)	-	(9,017)	0.313	(2,819)
17	2035			391,098	(75,769)	315,330		(317,530)	(2,200)	-	(2,200)	0.289	(637)
18	2036			450,316	(104,085)	346,230		(317,530)	28,700	(7,175)	21,525	0.268	5,763
19	2037			475,007	(68,742)	406,265		(317,530)	88,735	(22,184)	66,551	0.248	16,489
20	2038			545,000	(162,520)	382,480		(317,530)	64,949	(16,237)	48,712	0.229	11,169
21	2039			573,091	(86,704)	486,388		(317,530)	168,858	(42,214)	126,643	0.212	26,871
22	2040			655,838	(77,367)	578,471		(317,530)	260,941	(65,235)	195,706	0.196	38,427
23	2041			700,579	(125,789)	574,790		(317,530)	257,260	(64,315)	192,945	0.182	35,059
24	2042			812,507	(86,824)	725,683		(317,530)	408,153	(102,038)	306,115	0.168	51,474
25	2043			864,598	(202,577)	662,020		(317,530)	344,490	(86,123)	258,368	0.156	40,205
26	2044			998,105	(92,721)	905,384		(317,530)	587,854	(146,964)	440,891	0.144	63,490
27	2045			1,055,918	(99,401)	956,518		(317,530)	638,987	(159,747)	479,241	0.133	63,865
28	2046			1,216,953	(149,429)	1,067,524		(317,530)	749,994	(187,498)	562,495	0.123	69,369
29	2047			1,285,482	(123,232)	1,162,249		-	1,162,249	(290,562)	871,687	0.114	99,481
30	2048			1,474,878	(215,251)	1,259,627		-	1,259,627	(314,907)	944,720	0.106	99,774
31	2049			1,552,410	(126,097)	1,426,312		-	1,426,312	(356,578)	1,069,734	0.098	104,551
32	2050			1,776,111	(124,197)	1,651,913		-	1,651,913	(412,978)	1,238,935	0.090	112,056
33	2051			1,857,864	(194,990)	1,662,874		-	1,662,874	(415,718)	1,247,155	0.084	104,386
34	2052			2,120,015	(138,944)	1,981,072		-	1,981,072	(495,268)	1,485,804	0.077	115,085
35	2053			2,219,486	(254,522)	1,964,965		-	1,964,965	(491,241)	1,473,723	0.072	105,635
36	2054			2,527,795	(150,629)	2,377,166		-	2,377,166	(594,291)	1,782,874	0.066	118,262
37	2055			2,642,833	(178,651)	2,464,182		-	2,464,182	(616,046)	1,848,137	0.061	113,448
38	2056			3,013,629	(221,065)	2,792,564		-	2,792,564	(698,141)	2,094,423	0.057	118,976
39	2057			3,150,943	(177,425)	2,973,518		-	2,973,518	(743,379)	2,230,138	0.053	117,237
40	2058			3,594,988	(299,604)	3,295,384		-	3,295,384	(823,846)	2,471,538	0.049	120,236
41	2059			3,756,908	(211,397)	3,545,510	50,219,693	-	53,765,203	(13,441,301)	40,323,903	0.045	1,815,365
												Total	(2,515,336)

The results of the Financial Feasibility Analysis are as follows:

- Net Present Value NPV = Rp. (2.515) trillion < 0 "not feasible"
- IRR = 6.271% < 8.06% "not feasible"
- Payback Period =more than 40 years Financially "not feasible"

3.2 Sensitivity Analysis

The results of the sensitivity analysis of risk variables to NPV changes can be seen in the Figure below:

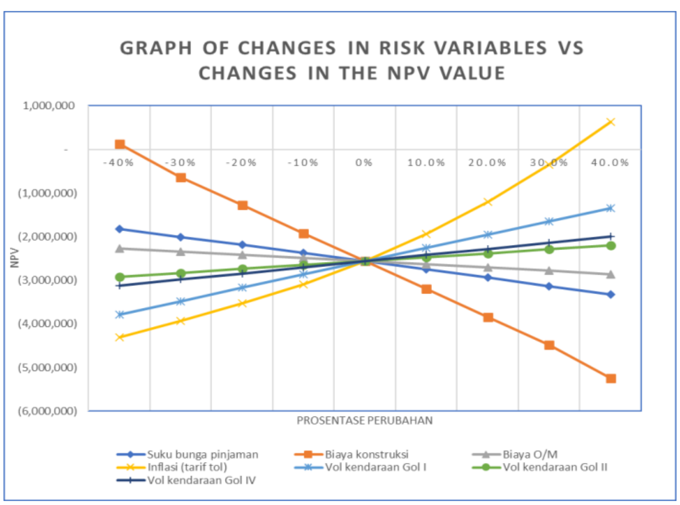

Figure 5. Graph of sensitivity analysis

Discussion

In general, the construction of the Toll Road in the Bangkinang - Pangkalan Section is not financially feasible, this is indicated by the NPV value of Rp (-2,515) trillion <0 and the IRR value of 6,271% <minimum attractive rate of return (MARR) of 8.06% at an interest rate of 8.9% and at an average traffic growth of 4.95% / year. This shows that the traffic volume that is estimated to pass through the toll road with the condition that there will be a toll rate increase every 2 years of 12% is not sufficient to cover the investment and operating costs of the toll road during the 40 years concession period.

Furthermore, by looking at the sensitivity analysis chart the determination of the dominant variable influencing changes in the investment feasibility level is selected from the equations of the line with the steepest shape, so that 3 main variables that influence can be seen, namely: 1) Construction costs, 2) Volume of light vehicles (Gol 1) , 3) Inflation (changes in toll rates).

4. CONCLUSION

Based on the analysis and discussion that has been carried out, several conclusions can be drawn in the feasibility study for the construction of the Pekanbaru - Padang Bangkinang - Pangkalan toll road as follows:

- Financially, the construction of the Pekanbaru - Padang Bangkinang - Pangkalan Toll Road is not feasible, broadly speaking, the possibility of this inadequacy is due to the level of benefits (profits) on revenue during toll road operation during the concession period that has not been able to cover the total investment and O / M costs of the toll road.
- it was found that 3 (three) main risk variables that had the most influence on changes in the investment feasibility level were delays in land acquisition which resulted in delayed project completion, changes in SBI rates and uncertainty in projected traffic volumes during the concession.
- For further research, it is necessary to develop a feasibility study from an economic aspect, considering that one of the objectives of the Indonesian Government's program in the construction of the Trans Sumatra Toll Road is to accelerate the increase in economic growth in cities in Sumatra, including in Riau Province - West Sumatra Province.

5. AKNOWLEDGEMENTS

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6. REFERENCES

F. A. Nadia (2016), “Risk and Policy in Indonesian Toll Road Development: from the Perception of Public and Private Sector Study Case of Pandaan – Malang & Manado Bitung,” *M. Eng. Thesis, Institute of Social Studies*, Netherlands.

Bordat, C. et al (2004), “An Analysis of Cost Overruns and Time Delays of INDOT Projects”,

Joint Transportation Research Programme, Indiana Department of Transportation. Anh Nguyen1, Abu Mollik, Ph.D. dan Ying-Yi Chih, Ph.D. (2018), “Managing Critical Risks

Affecting the Financial Viability of Public–Private Partnership Projects: Case Study of Toll Road Projects in Vietnam”, *Journal of Construction Engineering and Management.*

Andreas Wibowo, (2005), "Estimating General Threshold Traffic Levels of Typical Build, Operate, and Transfer Toll Road Projects in Indonesia", *Construction Management and Economics*, Vol 23, Hal 621–630

James Odeck dan Morten Weldea (2017), "The accuracy of toll road traffic forecasts: An econometric evaluation*"*, Transportation Research Part A: Policy and Practice, Elsevier, Vol. 101(C), Hal 73-85.

MortenWelde (2011), "Demand and operating cost forecasting accuracy for toll road projects",

Transport Policy, Elsevier, Vol. 18, Hal 765-771

RidwanAnas, Ofyar Z.Tamin dan Sony S.Wibowo (2015), "Applying Input-output Model to Estimate the Broader Economic Benefits of Cipularang Tollroad Investment to Bandung District", *Procedia Engineering*, Vol 125, Hal 489-497.

James Odeck (2019), "Estimating and predicting the operational costs of road tolls: An econometric assessment using panel data", Transportation Research Part A: Policy and Practice, Vol. 130, Hal 466-478

.Erik W. Larson dan Clifford f. Gray (2018), *Project Management, The Managerial Process 7th Edition*.

Arthur J Keown, John D Martin, J. Willian Petty, David F. Scott Jr (2005), *Financial Management Principals and Applications Tenth Edition*.

Mike A Miles, Laurence M Netherton, Adrienne Schmitz (2015), *Real Estate Development Principles and Process 5th Edition*

Peterson, Pamela, Frank J. Fabozzi, New York: Jhon Wiley & Sons (2002), *Capital budgeting: Theory and practice.*

Sunito, F.S. (2007), "Percepatan Pembangunan Jalan Tol, Kendala dan Langkah-Langkah Perbaikannya", *Economic Jurnal Review*, Jakarta.

Fitriani, et.al. (2006), "Kajian Penerapan Model NPV-at-Risk Sebagai Alat Untuk Melakukan Evaluasi Investasi Pada Proyek Infrastruktur Jalan Tol : Studi Kasus Pembangunan Jalan Tol Cisumdawu*", Tesis tentang Rekayasa Struktur*, ITB, Bandung.

RISK ANALYSIS SAFETY MECHANICAL ELECTICAL ON ROBOT PALETIZING MACHINES AT PT X .

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ABSTRACT

The lingkages between workers and industrial machines in the workplace area is acommon problem in the industrial world. The operational process of machines is not only until the machine starts, but how to make workers feel safe in operating the machine. The application of safety is needed not only in workers but also in machines. It is a Machine Safety concept. PT. X is a multinational company headquartered in Europe. PT X produces food, drinks, cleaners, and also body care. The basic problem that occurs at PT X, which causes the importance of holding a Machine Safety System is theImplementation of "Zero Accident" as the target and objectives of PT.X which will be reported to management everyyear.
ISO 12100: 2010 and ISO 13849-1: 2006 is one of the references for implementing a safety system on a machine. ISO 12100 is the basis for risk assessment on machines, usingthe STI methodology in determining the value of risk where the severity, probability, frequency and number of operators are factors that need to be assessed. ISO 13849-1 and Bowtie tools are used in risk reduction, so it can be seen the part level performance value that must be used as well as the preventive and curative actions that will be carried out at that risk.
The results of this study obtained 1 medium hazard and 5 hazard highs in the robot palletizing machine. By using ISO 13849-1 and bowtie diagrams for risk reduction, 5 medium hazards and 1 high hazard in the palletizing robot machine. The installation of a safety control system and the use of PPE are the most widely used preventive measures to prevent work accidents, while the installation of an emergency stop is a curative effort that is mostly done when a work accident occurs.

Keywords: Risk Assement, Safety Machinery, Machine Industry.

INTRODUCTION

In the industrial process, production is divided into 3 stages, namely processing, assembling and transporting materials. In the modern industrial era, machines are the main component in the production process to replace human labor. This is in line with the high technological development in the industrial machine world.

Research on machine safety has been carried out by many previous researchers, either using ISO 12100: 2010 or using ISO 13849-1. A study related to industrial robots was also carried out by Hippertta et al. (2019), This study aims to propose a method of calculating the level of security involved in the process with robots. Machine safety is not only carried out for industrial robotic machines, as research conducted by Giuliani (2014). In this study ISO 13849-1 was used to determine the PLr value in determining machine pressure. The results show that the machine uses a safety part with a PLr C value. Other research that supports the use of safety parts on a palletizer was carried out by Stohl, et al. (2016). This article focuses on the use of safety relays on each safety device installed on a palletizing machine. Research conducted by Anwar.HA (2019), this research uses a palletizing robot as an object and the variables used are mechanical hazards, electrical hazards, chemical hazards, heat hazards.

The basic problem that occurred in PT X that led to the importance of a machine safety system was the application of "Zero Accident" as the target and objective of PT.X which would be reported to management every year. From this goal, PT.X made improvements related to occupational safety and health both in terms of employee knowledge, work environment and security on machines at PT.X.

The selection of tools ISO 12100: 2010 and ISO 13849-1: 2006 in this study is the basis of safety machinery. ISO 12100 is the basis for risk assessment on machines, while ISO 13849-1 is a standard that describes a good safety control system in terms of circuits and electrical parts.

Materials and Methods

This study aims to identify the risks in the robot palletizing machines in the PT X in order to obtain the risk level and the correct application of safety levels in each industrial machine to reduce the level of risk.

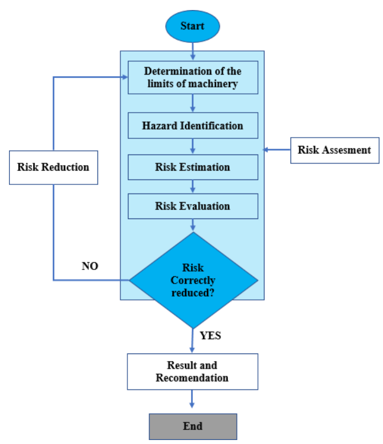

Figure 1. A The methodology used for this thesis (Researcher, 2020)

Problem identification is done by observation and field survey. The results of field observations and surveys are in the form of problem topics that will be raised as research themes. The theme is then described in the formulation of the problem.

This paper was conducted because of an issue at PT.X which is closely related to machine safety, including:

a. Change of old employees to new employees.
b. Changes to the production facility of PT X.
c. Market Globalization.
d. PT X employee awareness about safety in the operation of industrial machines.

Survey and field observations were carried out by researchers assisted by competent parties in the field of "Safety Machinery" in order to obtain valid data required for this thesis research. This research stage was carried out in March 2020.

The problems that will be discussed in this research are formulated into several problems to be resolved with specific objectives by determining the problem boundaries. The objectives are adjusted to what you want to achieve in the research, while the problem boundaries are so that the discussion in this study is not too broad (more focus on the object of the research). The data needed to carry out this research are:

a. Machine Name Plate
b. Number of Operators on the machine
c. The number of accidents in a year from these machines.
d. Engine speed and working hours data.
e. PT X employee data data

From the results of the survey and PT X's request, 2 types of machines are interconnected in the good ice cream finish area so that the risk level of the machine can be assessed including:

Table 1. Machine data in PT X

Pg#	Manufacturing	Type Machine	Serial Number	Location	Speed Machine	Score before assesment
24	PT.DEF	Paletizing Box	NA	PT.X	60 bpm	26

Hazard identification, which is a list of all relevant accident scenarios with their potential causes and effects, in response to the question "What are the possible risks?".

Table 2. The hazard variable generally occurs in a machine

No	Hazard	Hazard Information
1	Mechanical Hazards	Crushing, entangling, puncturing, shearing, pulling or trapping, friction or abrasion, cutting or breaking, discharge of high pressure fluids, etc.
2	Electrical Hazards	Contact by a person with live parts, or parts with incorrect wiring, primarily the result of insulation failure, etc.
3	Heat Hazard	Burns due to fire, explosion, radiation from heat sources, etc.
4	Noise Hazard	Hearing loss, tinnitus, etc.
5	Object Vibration Hazard	Serious damage to the entire body, in particular to the hands, arms and lower back.
6	The dangers posed by neglect of ergonomic principles in machine design	Unhealthy postures, human error, etc.

Source : ISO 12100:2010

After finding and analyzing the hazards on the machine, the next step is to estimate the severity of a hazard. Risk evaluation functions to determine every hazard found whether it is necessary to carry out risk reduction steps on the machine. The level of risk must be at a tolerable level where the level of risk is acceptable to someone.

Table 3. Risk Level Identification

LEVEL OF RISK	SCORE
HIGH	12 and Higher
MEDIUM	7 - 11
LOW	1 - 6

Source : Safety Technology and Inovation (2007)

Table 4. Risk Level Identification

RISK FACTOR	DESCRIPTION	POINTS PER CATEGORY
Severity	The most severe injury that can be reasonably conceived. **Scale 1-10**	1 = Minor - (Requiring no more than first aid) Bruising, cuts and abrasions. 3 = Serious - (Normally reversible) Loss of consciousness, burns, breakage etc. 6 = Major - (Normally irreversible) Permanent disability, loss of sight, amputation, etc. 10 = Fatal
Frequency	The frequency of exposure to hazard. **Scale 1-4**	1 = Seldom - Weekly or less 2 = Occasional - Daily 4 = Frequent - Several times per day
Probability	The probability or likelihood that an injury will occur. **Scale 1-6**	1 = Unlikely - Remote 2 = Possible - Not likely to occur 4 = Probable - May occur 6 = Certain - Near certain to occur
Adjustments	Consideration of additional factors. **Scale 0 +**	▶More than one person exposed = Multiply SEVERITY by number of people exposed ▶>15 min. in danger zone = add 1 point ▶Unskilled/untrained operator = add 2 points

Source : Safety Technology and Inovation (2007)

In this paper, the risk assessment uses the STI methodology, where the value of the Severity X number of operators is added to the value of the probability and frequency to produce a risk value in a hazards.

$$\text{Risk} = (\text{S x People Exposed}) + \text{F} + \text{P} + \text{other Factor}$$

Where:

S = Severity
People Exposed = People who are directly involved with
Risk F = Frequency (Level of Frequency)
P = Probability (Probability of Avoiding Hazard)
Other Factor = Other factors that influence the occurrence of danger

Regulation of the Minister of Manpower No. 5 Article 7 paragraph 3 (2018), the control of the work environment as referred to in paragraphs 1 and 2 shall be carried out according to the hierarchy of control covering efforts:

a. Elimination.
b. Substitution
c. Technical engineering
d. Administration,
e. Use of personal protective equipment

Synthesis

The theoretical basis of risk management in industrial machines is taken from several theoretical sources. Kristiansen (2005), generally explains that risk is a measure of the chance of various consequences. Giving a risk category for personnel or human accidents where accidents are often related to humans, can be grouped into risk of death and risk of disability. The risk of course cannot be separated from hazard. Cooling (1990), hazard is an activity, object, component that is considered to cause damage or disruption of processes / activities in it, and work accidents.

This paper will use risk management as a reference, Clough and Sears, (1994), define risk management as a comprehensive approach to dealing with all events that cause loss. in risk management consists of risk assessment and risk reduction. ISO 31010, (2009), states that risk assessment is the entire process of risk identification, risk analysis and risk evaluation. the use of different methods can be adapted to the context in which the risk assessment will be carried out. Risk assessment provides an understanding of the hazards, risks, causes and impacts involved in risk. ISO 31010, (2009), states that risk / hazard identification is the process of finding, recognizing and recording risks. Identify any risks that may occur that can affect the achievement of a system. ISO 31010, (2009), states that Risk Estimation is about developing an understanding of risk. It provides input for risk assessment and decisions about whether risks need to be addressed and about the most appropriate treatment strategies and methods. ISO 31010, (2009), risk evaluation uses the understanding of risk obtained during risk analysis to make decisions about future actions. ISO 31010, (2009), states that risk treatment / reduction involves selecting and agreeing on one or more relevant options to change the likelihood of occurrence, risk effects, or both, and implementing these options. ISO12100-1 (2010), states that the safety concept in a machine considers the ability of a machine to perform its desired function during its life cycle where risks have been sufficiently reduced.

Table 5. Hierarchy of Safeguards

	Protective Measure	Examples
Most Effective	Elimination or Substitution	• Elimination human interaction in the process • Eliminate pinch points (increase clearance) • Automate material handling (robots, conveyors, etc.)
	Engineering Controls (Guards / Safeguarding Technology / Protective Devices)	• Barrier guards • Interlocks • Presence sensing devices (light curtains, safety mats, area scanners, etc.) • Two hand control and two hand trip devices
	Awareness Means	• Lights, beacons, and strobes • Computer warnings • Signs and labels • Beepers, horns, and sirens
	Training and Procedures (Administrative Controls)	• Safe work procedures • Safety equipment inspections • Training • Lockout / Tagout / Tryout
Least Effective	Personal Protective Equipment (PPE)	• Safety glasses and face shields • Ear plugs • Gloves • Protective footwear • Respirators

Source : ISO 12100 (2010)

ISO 13849-1 (2006), General principles of design to determine the level of performance (PLr) required for the safety functions to be performed by the part concerned with the control system safety (SRP / CS) under consideration.

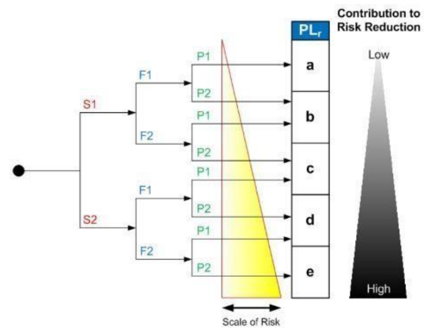

Figure 2. Risk Estimation Process to Determine the Required Performance Level (PLr) (ISO 13849-1,2006)

Burgess, et al (2014), bow-tie analysis can be studied further to examine the effectiveness of controls or barriers by including barrier decay mechanisms and an assessment of the likely effectiveness of control measures.

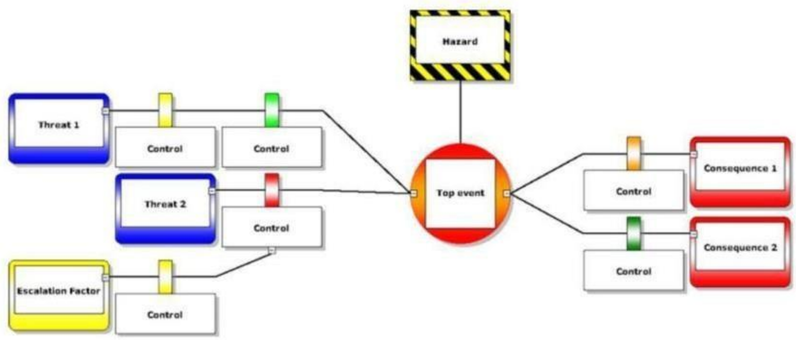

Figure 3. Bowtie Representation (Gifford, et.al., 2003)

Results and Discussion

After determining the part level performance and carrying out risk response steps that can be carried out at each hazard source, the next step is to re-assess the risk after risk reduction has been carried out. This aims to determine the value of the risk contained in each hazard whether it is reduced or not.

From table 4. It can be seen that the risk value of each hazard is reduced, the reduction in the risk value of each hazard depends on every action taken in an effort to reduce the risk. This is important because risk reduction measures greatly affect the final value of the hazards that exist in robot paletizing machines.

Table 4. Risk Comparison of the Risk Level Value before and after reducing the Risk in the Robot Paletizing

No	Hazard	Description of Hazard	Before Risk Reduction		Performa Level Part	After Risk Reduction	
			Risk Score	Risk Level		Risk Score	Risk Level
1	Hazard 1 Conveyor Palletize	Roller conveyor palletize dapat menyebabkan bahaya terjepit dan terjatuh.	14	HIGH	C	10	MEDIUM
2	Hazard 2 Pallet Base	Pallet base dapat menyebabkan tertusuk dan terjepit.	8	MEDIUM	B	6	MEDIUM
3	Hazard 3 Pallet Lifter	Pergerakan lifter naik dan turun dapat menyebabkan terjepit.	15	HIGH	C	8	MEDIUM
4	Hazard 4 Robot Arm and Gripper	Pergerakan robot dapat menyebabkan terpukul yang sangat keras	26	HIGH	D	13	HIGH
5	Hazard 5 Falling Object	Benda jatuh dari vacum carton dapat menyebabkan tertimpa.	15	HIGH	C	8	MEDIUM
6	Hazard 6 Conveyor Supply and Return	Conveyor supply dan conveyor return dapat menyebakan bahaya terjeptit dan terperankap.	12	HIGH	B	9	MEDIUM

In the risk assessment of the palletizing robot machine, there is a change in the risk value and risk level with the highest and lowest values for each hazard, namely:

1.The highest risk score decreased from 26 to 13
2.The lowest risk value is reduced from 8 to 6
3.Changes in risk level at 5 sources of danger

There is a level of risk in each hazard that does not change, but the value of the risk remains changing. This explains that the "severity" value for this hazard is quite high. The severity value can be changed by eliminating or replacing the hazard source, but because this research was conducted on machines that are already in operation, it cannot be done for all hazards.

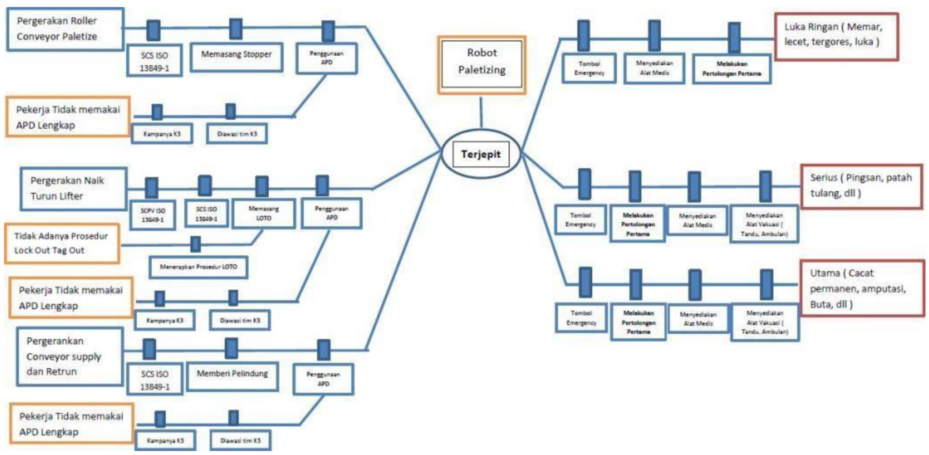

Figure 4. Bowtie Diagram 1 Robot Paletizing Machine (Clamped Worker)

From the results of the bowtie diagram analysis above, it is concluded that, from the prevention variable the cause of each risk event activity has generally similar mitigation, namely making a separate function for the safety control system at the PLd performance level according to ISO 13849-1 and installing an emergency stop in the danger area.

Conclusions

The conclusion of the value of each hazard before risk reduction and after risk reduction is quite significant. Based on the results of the above calculations, it is found that:

1. The Saverity value has the greatest influence on the risk value of a hazard. However, not all severity values can be reduced, this is because this research was conducted on machines thatare already in operation, so not all hazards can be eliminated or the source of the hazard is replaced. Eliminating or replacing the source of the hazard can be done if the assessment is carried out during the initial design of the machine.
2. Frequency, probability and person incharge are factors that can be implemented to reduce risk. By referring to ISO-12100 and ISO 13849-1, the reduction of frequency and probability values can be done.
3. Changes in risk levels occurred in 5 sources of danger in the palletizing robot machine.
4. The installation of a safety control system and the use of PPE are the most widely used preventive measures to prevent work accidents, while the installation of an emergency stop is a curative effort that is mostly done when a work accident occurs.

Based on the risk assessment and risk reduction data above, it is found that the risk value can be reduced by taking risk reduction actions based on ISO 13849-1 and bowtie diagrams, so that in its operation it can prevent and reduce the number of work accidents at PT. X. PT.X's own target in implementing “Zero Accident” can be fulfilled.

Acknowledgment

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References

Burgess, Et. (2014), *Bow-Tie Analysis of A Fatal Underground Coal Mine Collision*, Ergonomics Australia, 10:2.

Clough, R. H. (1994), *Construction Contracting, 6th Edition*, John Wiley, New York.

Cooling, D.A. (1990), *Industrial Safety Management and Technology*, *Prentice Hall*, New Jersey.

Gifford, M.J., Gilbert, S.M., (2003),*The Use of Bow-tie Analysis in OME Safety Cases.Atkins Defence Systems*, Barnes, I. Ministry of Defense.

ISO 12100, (2010), *Safety of machinery General principles for design - Risk assessment and risk reduction.*

ISO 13849-1, ISO 13849-2, (2016), *Safety of machinery - Safety-related parts of control systems.*

ISO 31010, (2009), *Risk management Risk assessment techniques.*

Kristiansen, S. (2005), *Maritime Transportation Safety Management and Risk Analysis*, *Elsevier Butterworth Heinemann*. London.

Peraturan Menteri Ketenagakerjaan Republik Indonesia no 5, (2018) Keselamatan dan Kesehatan kerja Lingkungan Kerja,Jakarta.

Hippertta, M.P, (2019). Towards safety level definition based on the HRN approach for industrial robots in collaborative activities. *Pontifical Catholic University of Parana.*

Giuliani, et al, (2014). SOI-based, High Reliable Pressure Sensor with Floating Concept for High Temperature Applications. *Technical University of Berlin*, Germany.

Stohl, et al, (2016). Comparing the Functional Safety Ensured by Safety Relays and CIP Safety Communication in Palletizing Machines. *Brno University of Technology*, Brno.

Anwar, H.A, (2019). *Penilaian Risiko Pekerjaan Pengoperasian Dan Maintenance Robot Di Pt X Jakarta*. Universitas Esa Unggul. Jakarta.

DESIGN OF KEY RISK FACTORS IN SUPERVISORY PLANNING OF HETEROGENOUS FINANCIAL CONGLOMERATION IN INDONESIA

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ABSTRACT

The reorganization of heterogeneous financial conglomerates supervision function to lead entity supervisor affected the supervisor's workload and increase the risk of delayed on detection of significant risk exposure possessed by financial conglomerates (FC) due to additional responsibility to supervisor to perform both sectoral and financial conglomerates supervision. Limitations and risk identified could be mitigated by implementing supervisory plan which adopted risk based audit concept. Therefore, this qualitative research with a study case approach was carried out to recommend key risk factors to determine supervision priorities in the supervisory planning process. The researcher performed content analysis on data used in this study, which are primary data from interview and observation, also secondary data such as standard operating procedures, regulations and internal documents. The techniques used in this study includebenchmarks to 3 (three) supervisory authorities, validation process of Risk & Control Self-Assessment (RCSA) documents, and determination of key risk indicators. Based on the assessment, it recommended 3 (three) categories of key risk factors, as follows: business complexity based on business diversification and FC's structure, the significance of FC's member to its respective industry, and the FC's integrated risk rating. The application of new key risk factors could be categorized to 3 (three) groups ofsupervision priority. The result of this research may help supervisors to supervise optimally based on FC's risk exposure.

Keywords: Financial Conglomerates; Key Risk Factors; Risk-based Supervisory Plan

1. INTRODUCTION

Financial Service Sector (FSS) in Indonesia that compromise to Banking industry, Non-Bank Financial Institution (NBFI) industry, and Capital Market industry, shows positive growth until the end of 2019. Among the financial service sector, there are groups of financial institutions under common ownership or control, known as financial conglomeration (OJK,2014). The asset of heterogeneous financial conglomerates (FC) in Indonesia is amounted to Rp7.407 trillion indicating a significant contribution (62,63%) to FSS.

Integrated supervision of FCs performed to addressed the FCs risk exposure due to its significant contribution to FSS, product and technology innovation, interconnectedness on member of FCs, and complexities of intragroup transactions (OJK, 2014). FCs supervision in Indonesia follows a risk-based integrated supervision cycle and requires the integrated supervisors to assess the risk profile and soundness of FCs (known as integrated risk rating) as well as update the understanding of the FCs every semester. FCs supervision was performed by integrated supervisors who coordinated with sectoral supervisors who focuses on financial institutions (lead entity[1] or member of FCs) supervision as a single entity. Each sectoral supervision function has its own supervisory methodologies and cycle that has to be followed. However, at the end of 2018 there is reorganization of FCs supervision function to lead entity supervisors. The reorganization affected the supervisor's workload and increase the risk ofdelayed on detection of significant risk exposure possessed by FCs due to additional responsibility to supervisors to perform both sectoral supervision and FCs supervision.

The current implementation of FCs supervision includes supervision of integrated governance, integrated risk management, and integrated capital minimum requirement in accordance with regulations issued by OJK. This supervision is in line with the concept of internal audit, which The Institute of Internal Audit (2016) states that the internal audit activity adds value to the organization and its stakeholders when it considers strategies, objectives, and risks; strives to offer ways to enhance governance, risk management, and control processes; and objectively provides relevant assurance.

In practice, a risk-based audit approach can be used in internal audit to focuses audit activities on the highest risk or significant risk faced by a business (Griffiths, 2005). In risk- based audit planning, in order to focus the audit on significant risks, the auditor will conduct a risk assessment of the key risk factors of each potential audit area so that the auditor can determine audit priorities and develop an audit engagement plan (Griffiths, 2005).

Adopting a risk-based audit concept, limitations and risks faced by integrated supervisors (currently lead entity supervisors) can be mitigated by implementing a risk-based supervision plan in determining the priority of FCs supervision. Therefore, through this research, the researcher will propose key risk factors for the heterogeneous FCs portfolio as the object of FCs supervision to determine the optimal supervision priority for integrated supervisors according to the risk exposure of each FCs.

2. METHOD

This research is a case study approach to propose key risk factors that should be considered in the risk-based supervision planning process to determine the priority of heterogeneous FCs supervision in order to mitigate the risks and limitations faced by integrated supervisors. The research method used is qualitative to explore and understand problems in the implementation of the supervisory of FCs, where the researcher acts as a key instrument that collects data (i.e. document inspection, observation, and interview) from Institution X.

The data collected in this study are primary data in the form of interviews and observations and secondary data such as of Law of the Republic of Indonesia Number 21 of 2011, guidelines for FCs supervision at Institution X, minutes of Integrated Supervision Committee meetings, organizational structure of Lead Entity Supervisors, data recapitulation of heterogeneous FCs in Indonesia, report of self-assessment on integrated risk profile and integrated good corporate governance submitted by FCs, integrated risk rating of FCs assessedby Lead Entity Supervisors (Integrated Supervisors), and prudential supervisory standards for FCs regulated by three foreign supervisory authorities: Australian Prudential Regulation Authority (APRA) in Australia, Monetary Authority of Singapore (MAS) in Singapore, dan Financial Supervisory Service (FSS) in South Korea.

[1] Lead entity (Entitas Utama) is the parent company of FCs or appointed financial institutions by the controlling shareholder of FCs (OJK, 2014)

The researcher performed content analysis of the interviews, observations, and documentation related to the implementation of FCs supervision at Institution X then compared them with the risk-based audit planning phase in the Practice Guide: Developing a Risk-based Internal Audit Plan published by IIA. To design key risk factors in this study, the researcher uses risk management techniques, including 1) benchmarking key risk factors in determining FCs as the object of supervision at the three foreign supervisory authorities, with the consideration that APRA, MAS, and FSS are the authorities that have a FC's prudential supervision function in their respective countries; 2) the RCSA and KRI applications of FCs, through content analysis of the interview result about assessment process of FC's integrated risk rating by the Lead Entity Supervisor, also the reliability and depth of the analysis in Lead Entity Supervisor's assessment compared to the self-assessment FC's risk profile reported by the FC's Lead Entity, to propose keys risk factors that represent the risk exposure of a FC. Based on the literature related to risks that may arise from financial groups, each characteristic on key risk factors is formulated into supervisory priority scale. The priority parameter setting is adjusted based on the availability of supervisory data so that it could be applied in Institution X.

3. RESULTS AND DISCUSSION

Comprehensive risk-based planning can align and focus limited resources in the assignment of supervisory activities on significant risk exposures to generate sufficient assurance that financial conglomerate issues are detected early and supervisors can take appropriate and timely supervisory action. Therefore, the researcher compared the supervision activities of financial conglomerates at Institution X and the risk-based audit planning based on the Practice Guide: Developing a Risk-based Internal Audit Plan (IIA, 2020), with the summarized results as follows:

1. Understand the organization component
   The strategic objectives and organization-wide risk identified related to FC supervision due to reorganization have not been mitigate with changes in FC's standard operating procedure and strategic planning process of FC supervision. However, Institution X has administered all FC portfolio (audit universe) and updated regularly.
2. Internal audit's risk assessment
   Integrated risk rating as assessment result on FC's condition by integrated supervisors is not used to determine which financial conglomerates is priority in the strategic supervision plan.
3. Additional planning consideration
   aspects of additional requests from management of additional supervisory areas or processes are irrelevant because all FC are supervised with the same methodology, scope, frequency and timing of assignment of supervisory activities.
4. Estimating resources
   Component of the appropriateness of the allocation of resources is fulfilled even if it is noted that it is necessary to increase the supervisory capability of the lead entity supervisor as integrated supervisor related to the supervision of FC. For example, the banking-led entity supervisor has only had the expertise in Bank supervision. However, as integrated supervisor, the banking-led supervisor need to understand the business nature of other members of FC, regulation of governance, risk management and capital requirement that apply to each business activities in FC, as well as general knowledge on supervisorysectoral indicators of the members of the FC to identify and assess risk exposures of FC asa group which are not detected in sectoral supervision such as double gearing, contagion

risk, conflict of interest, exposure, and intra-group transactions.

For the component of coordination with other providers of assurance and consulting services, the FC supervisory methodology has accommodated this through coordination and communication forums with sectoral supervisors who are members of FC to obtain sectoral supervisory results as part of the process of understanding financial conglomerates and assessing the condition of FC (integrated risk rating). However, the FC's supervisionplanning has not met the adequacy of resources aspect, considering that the composition of the lead entity supervisory team was not recalculated despite of the additional supervisory tasks and functions to supervise financial conglomerates.

5. Drafting the internal audit plan and communicating to finalize the plan
This component cannot be assessed because currently the FC supervision methodology and cycle applies to all auditable units (in this case 46 FC) regardless FC's significance or risk exposure to financial service sectors, so there is no strategic supervision planning of a financial conglomerate. However, each Lead Entity Supervisor is required to propose integrated supervisory engagement plan (in the concept of internal audit it is called an audit engagement plan) yearly which goes through approval process according to the delegation of authority as required by standard operating procedure, then communicated or reported to the Integrated Supervision Committee.

Given the limited time and resources as well as the risk of not achieving the objective of strengthening supervision at Institution X, it is necessary to determine the key risk factor for the FC portfolio and its exposure to the financial services sector in planning the FC supervision. The proposed key risk factor is then used to provide recommendations for supervisory areas that need to be prioritized and needed adjustment in supervisory method so that integrated supervision and sectoral supervision can be implemented optimally.

This study uses risk management application techniques in the form of benchmarks, the validation process of RCSA documents and the determination of KRI reported by financial conglomerates to Institution X. Based on the benchmarks, the criteria for the supervision of financial conglomerates in the three authorities (APRA, MAS, and FSS) are in line with the definition of financial conglomerates by the Joint Forum and the Council of EU: there are heterogeneous criteria and certain levels of materiality. The determination of materiality is emphasized on qualitative aspects, not quantitative criteria, so it depends on supervisory judgment (except for FSS Korea).

The self-assessment document on the implementation of integrated governance and integrated risk management reported by the FC is the result of the RCSA internal working group between the Lead Entity and the representatives of the FC's member that have been mutually agreed upon. Based on observations and interviews with the Integrated Supervisor of Banking- led FC, the self-assessment reports submitted to Institution X will be further analyzed in the context of performing the supervisor's duties. This report is not used as a single reference by the Integrated Supervisor in conducting an integrated risk rating assessment, because in practice not all FC submit comprehensive reports and analyzes, there are also judgment aspects in self- assessment and there is different maturity level of understanding related to the implementation ofrisk management between supervisory sectors. Integrated Supervisor also considers information obtained from Sectoral Supervisors (Supervisors of FC's member) related to strategic issues, supervisory concerns, business conditions, as well as risk profile assessments and/or soundness rating conducted for each financial service institution of a member of FC (including governance, risk management, and business performance). Each risk to a member of a financial conglomerate, depending on its significance, has influence on the FC's integrated risk rating. In addition, Integrated Supervisors identify risk exposures that are not detected in sectoral supervision, including information on wider-group intragroup transaction (for financial conglomerates that are part of wider-group with various non-financial service business segments).

Assessment of integrated risk rating by the Integrated Supervisor must go through a gradual review in the supervisory work unit and then reported to the Integrated Supervision Committee periodically. The analysis and capability of the Integrated Supervisor on the results ofthe integrated risk rating's assessment are also evaluated through periodic peer reviews which will provide recommendations to improve the quality of the supervisory process performed bythe Integrated Supervisors.

IIA (2020) states that the risk-factor approach is an approach that can be used to determine audit priorities by identifying common risk factors in all auditable units that can affect the achievement of organizational goals. The FC's integrated risk rating based on the assessment of the Integrated Supervisor represents the risks profile and performance of the FC and its supervision quality reviewed periodically, therefore integrated risk rating of FC is proposed as one of key risk factors. However, the integrated risk rating of each FC has not fully illustrated the financial conglomerate's exposure to the strategic objective of Institution X, which is a stable and competitive financial services sector. Therefore, referring to benchmark result, and analysis on implementation RCSA and KRI related to the risk assessment of FC, the researcher divides the proposed key risk factors in prioritizing auditable units (portfolios of FC) into 3 (three) categories, as follows: business complexity, FC's significance, and FC's condition (integrated risk rating). For each key risk factor, the researcher assigns three level of priority: (1) red for the first priority; (2) yellow for the second priority; and (3) green for the third priority (not urgent).

1. FC's business complexity
   This category is a combination between the composition of the types of FC's activities and the structure of FC considering the heterogeneous FC portfolio in Indonesia which could be seen in Table 1.

Table 1. Priorities formula of FC's business complexity

Structures / Financial service business	Vertikal	Horizontal/ Mixed	Horizontal/ Mixed and non-regulated business segment > 1
> 3 type of business	2	1	1
3 type of business	2	2	1
2 type of business	3	2	2

2. The significance of FC
   Based on benchmarks, determination of the materiality of a FC as supervisory objects differs between those three authorities. For this reason, the researcher assesses the FC's significance based on the number of member of FC which are categorized as "systemic" fortheir respective industries as can be seen in Table 2.

Table 2. Priorities formula of the significance of FC

Systemic Entities	Priorities
> 1 member	1
1 member	2
0 member	3

3. Integrated risk rating of FC
   Integrated risk rating is the result of the Integrated Supervisor's comprehensive assessment of the integrated risk profile (10 FC's risk components), integrated good corporate governance, and integrated financial performance (earning and capital). Integrated Supervisors must assess the integrated risk rating using a 1 (good) to 5 (bad) scale and have to prioritize supervision on FC's that has worse condition/rating. The assessment of the rating can be divided into 3 (three) groups to determine the urgency of the supervisory action as described in Table 3.

Table 3. Priorities formula of the integrated risk rating of FC

Rating	Supervisory Action	Priority
Bad or Very Bad	Very urgent	1
Fair	Urgent	2
Very Good or Good	Less urgent	3

Based on the identification and design of the proposed key risk factors, the researcher applies these indicators to the entire portfolio of heterogeneous FCs, then using a conservative approach, the final determination in level of prioritize of each FC is the highest priority between three key risk factor's result. For example, K005 is a FC with a mixed structure that consisting of 13 members, that has activities in banking, multifinance, and insurance. In addition, K005's ultimate shareholder also owns dozens of companies engaged in the automotive, heavy equipment, agribusiness, information technology and property (non-regulated business segments)so that K005 are classified as complex FC with quite high business synergy between financial service entities and non-regulated entities as in wider-group (FC's business complexity: priority 1). In addition, there are 3 members of K005 that have a significant influence on their respective industry (The significance of FC: priority 1). Therefore, although the condition of the KK is classified as good (FC's integrated risk rating: priority 3), K005 needs to be the top priority (priority 1) on the FC supervision in Institution X.

The results of the research showed that there are 16 heterogeneous FCs that need to be a top priority (as shown in Table 4), 14 heterogeneous FCs that are priority category 2, and 16 heterogeneous FCs that are priority category 3 in supervision planning of financial conglomerates. In the portfolio of FC that are classified as top priority, several banking-led FCs (for example K003, K005, K012, K015, K016) are known to the public as conglomerates that have business segments in the financial services sector and the non-financial service sector with ahigh market share so that they are suitable/predicted to be categorized as top priority in supervisory plan. However, on the application of the proposed key risk factors, the researcher found that there were heterogeneous FCs that became anomalies and were not previously predicted to be the top priority, such as K035 and K041. Both FCs have assets below Rp10 trillion and have a good integrated risk rating, but are included in the top priority because of the horizontal structure of its FC with various business activities and are part of a larger conglomerate group.

Table 4. Assessment Result: Portfolio of FC Category 1

Kode	Business Complexity	Significance	IRR	Priority Category
K001	1	1	3	1
K003	1	1	3	1
K005	1	1	3	1
K007	2	1	3	1
K008	1	2	2	1
K009	1	2	3	1
K012	1	2	2	1
K015	1	2	3	1
K016	1	2	3	1
K020	3	3	1	1
K031	1	3	2	1
K035	1	3	3	1
K041	1	3	3	1
K042	2	3	1	1
K044	1	3	3	1
K045	1	3	2	1

Before determining the supervision priority, there are 46 FCs that must be supervised using the same methodology and process. By dividing the portfolios of FCs into 3 priority categories, supervisory activities can be focused on portfolios in priority 1 which require intense supervision and coordination between integrated supervisors (lead entity supervisors) and sectoral supervisors (supervisors of member of FC). Prioritization of supervision can be used as a reference for supervisors to simplify business processes, supervisory documentation/products, as well as business process periodization for the portfolio of financial conglomerates that areclassified as priority 2 and priority 3. For example, for FC with priority 3 with low complexity, less significance to industry, and has good integrated risk rating, the integrated supervisor will berequired to perform a simple business process and reports on updating documentation of 'know your financial conglomerate' and integrated risk rating, but the supervisor has to maintaincoordination and communication between all sectoral supervisor to monitor any significant risk and issues on FC's members and the impact to FC.

By simplification in supervision process and documentation for priority 2 and priority 3, there will be time savings for integrated supervisors that can be allocated to increase the risk- based supervision, or to ensure the quality assurance of FC's supervision performed periodically.For example, by setting priorities and simplify business processes, the integrated supervisor teamthat supervises 2 FCs with different supervisory priorities can broaden the scope of supervision for FC that categorized as 1st priority that become integrated supervisor's concern such as joint examination on joint financing agreement between FC's member (intragroup transactions) with sectoral supervisor. Additional time savings could also be allocated to the implementation of periodic peer reviews to assess the quality of FC supervision and obtain recommendations for the necessary improvements on supervisory actions that have been implemented in order to improve the quality of supervision of FC as well as FC's member.

4. CONCLUSION

Based on the analysis that has been discussed, the conclusion that can be drawn are as follows:

1. The researcher identify that there is a gap between the FC supervisory process and the risk-based audit planning concept, such as the strategic objectives and risks identified at the institution level related to the FC supervision have not been mitigated, the assessment results of integrated risk rating of FC and their exposure to the financial services sector are not used as a consideration to prioritize FC supervision; all FC portfolio are supervised withthe same methodology, scope, frequency and supervisory activities; and resource allocation is not based on an evaluation of the nature and complexity of the assignment, as well as time constraints.
2. The researcher proposes 3 (three) categories of key risk factors to determine the priority of supervision, which are the complexity of the business based on business diversification and the structure of the FC, the significance of FC's members to their respective industries, and the integrated risk rating which is the composite rating results of assessment in governance, risk profile (composite of 10 types of KK risk), and financial performance (earning and capital).
3. The application of new key risk factors to 46 heterogeneous FC in Indonesia resulted in 3 (three) priority groups of supervision, i.e. 16 heterogeneous FC as 1st priority, 14 heterogeneous FC as 2nd priority, and 16 heterogeneous FC as 3rd priority (less urgent). This priority setting is expected to help integrated supervisory activities to focus on FC that require more intense supervision and to mitigate the risk of delays in detection of FC problems that have significant exposure to the financial services sector.

Recommendation to implement the designed key risk factors in supervisory planning of heterogeneous FC in Indonesia are as follows:

1. Adjustment or changes to the standard operating procedure or internal regulations in Institution X with the time schedule as presented in Table 5.

Table 5. Recommendation of Changes in Internal Regulation of FC Supervision

Recommendation	Duration	1	2	3	4	5	6	7	8	9
Approval of Integrated Supervision Committee pertains to implementation of *key risk factors* in strategic supervisory planning of heterogeneous FC and new priority setting for FC supervision	3 months									
Adjustment on the BoC Regulation on Integrated Risk-Based Supervision of Financial Conglomerates	6 months									
Establishment on the BoC Circular Letter on Strategic Supervisory Planning of Financial Conglomerates	6 months									
Socialization of new regulation and circular letter on strategic supervisory planning to respective department	1 month									
Research on changes in internal regulation for supervision methodology and product/ documentation of FC's supervision	3 months									
Adjustment on the BoC Regulation and Circular Letter on Integrated Risk-Based Supervision of Financial Conglomerates (as the effect of changes in supervisory methodology)	6 months									
Socialization of BoC Regulation and Circular Letter on Integrated Risk-Based Supervision of Financial Conglomerates (as the effect of changes in supervisory methodology)	1 month									

2. Creating competency framework for Integrated Supervisor that consider diversity of FC's structures in Indonesia (e.g. vertical, horizontal, mixed), composition of FC's member and interrelationship with non-regulated entities on wider-group. The integrated supervisor(lead entity supervisor) required to have basic knowledge and competency pertain to other financial institutions which are member of FC under their supervision, competency on aggregating risk profile of all FC's member to integrated risk rating, and identify group- wide risk that not covered in individual or sectoral risk profile. Drafting the competency framework for integrated supervisor could be discussed and communicated through coordination meeting between supervisory department and human resource department in Institution X.

In conducting this research, the significance factors proposed as key risk factors refer to the determination of the "systemic" status of financial institution as a member of a financial conglomerate. Therefore, further research could be developed to quantifies the significanceaspect of a financial conglomerates to financial services sector to update the proposed key risk factor design. Quantitative research can also be carried out to determine the weight of the assessment in determining the priority of supervision in this study.

5. REFERENCES

Committee of Sponsoring Organizations of the Treadway Commission (COSO). (2017). *Executive Summary: Enterprise Risk Management – Integrating with Strategy and Performance*. https://www.coso.org/Documents/2017-COSO-ERM-Integrating-with-Strategy-and-Performance- Executive-Summary.pdf

Griffiths, Phil. (2005). *Risk-Based Auditing*. England: Gower Publishing Limited

International Monetary Fund (IMF). (2020). *Republic of Korea: Financial Sector Assessment Program-Technical Note-Financial Conglomerates Supervisions*. https://www.imf.org/en/Publications/CR/Issues/2020/09/18/Republic-of-Korea-Financial-Sector-Assessment-Program-Technical-Note-Financial-Conglomerates-49747

Lam, James. (2017). *Implementing Enterprise Risk Management: From Methods to Applications*. New Jersey: John Wiley & Sons, Inc

Lumpkin, Stephen A. 2011. *Risk in Financial Group Structure*. OECD Journal: Financial Market Trend 105, 106. Vol. 2010/2

Official Journal of the European Union: EU Directive 2011/89/EU dated 16 November 2011. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:326:0113:0141:EN:PDF

Otoritas Jasa Keuangan. 2019. *Laporan Tahunan 2018: Memacu Pertumbuhan*. Retrieved from https://ojk.go.id/id/data-dan-statistik/laporan tahunan/Documents/Laporan%20Tahunan%20OJK%202018.pdf

Peraturan Otoritas Jasa Keuangan Nomor 17/POJK.03/2014 tanggal 18 November 2014 tentang Penerapan Manajemen Risiko Terintegrasi Bagi Konglomerasi Keuangan [OJK Regulation No 17/POJK.03/2014 Dated 18 November 2014 on the Application of Integrated Risk Management for Financial Conglomerates] (Indonesia)

Peraturan Otoritas Jasa Keuangan Nomor 18/POJK.03/2014 tentang Penerapan Tata Kelola Terintegrasi Bagi Konglomerasi Keuangan [OJK Regulation No 18/POJK.03/2014 on the Implementation of Integrated Corporate Governance for Financial Conglomerates] (Indonesia)

Peraturan Otoritas Jasa Keuangan Nomor 26/POJK.03/2015 tentang Kewajiban Penyediaan Modal Minumum Terintegrasi Bagi Konglomerasi Keuangan [OJK Regulation No 26/POJK.03/2015 on the Minimum Capital Requirement for Financial Conglomerates] (Indonesia)

The Institute of Internal Auditors (IIA). (2016). *Standar Internasional Praktik Profesional Audit Internal*. https://na.theiia.org/translations/PublicDocuments/IPPF-Standards-2017-Indonesian.pdf

The Institute of Internal Auditors (IIA). (2020). *Practice Guide: Developing a Risk-based Audit Plan*

The Joint Forum. (2012). Principles for the Supervision of Financial Conglomerates.

Sukirno. 2014. *Konglomerasi Perbankan, Apa Saja Dampak Positif & Negatifnya?*. https://finansial.bisnis.com/read/20140414/90/219286/konglomerasi-perbankan-apa-saja-dampak- positif-negatifnya

Van den Berghe, Lugart A.A. Oosenbrug, A. Verweire, K. 1995. *Financial Conglomerates: New Rules for New Players?*. Erasmus Finance & Insurance Centre

TOPIC

Decision Support System in Business

SELECTION OF GYRO STABILIZED ANTENNA DEVICES IN THE MARITIME TELECOMMUNICATION PROJECT USING THE DELPHI, DEMATEL AND ANP METHOD

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ABSTRACT

Gyro antenna is an important component in maritime satellite communication. The processof gyro antenna procurement is very important in a maritime satellite telecommunications company because it takes the largest portion of the budget in the investment of maritime satellite telecommunications networks. The decision choose gyro antenna components must be supported by objective and beneficial considerations in achieving technical, cost, and quality. The opinions from experts in the maritime satellite telecommunications company as a gyro antenna user will be analyst to get the best gyro antenna results for the project. Determination of the criteria elements using expert opinions obtained using the Delphi technique. After the criteria and sub criteria element has been determined, the DEMATEL method is used to identify the relationship between the criteria, sub criteria and the strength of the weight of the relationship between the criteria. The best method of selecting a gyro antenna based on criteria that have been obtained previously, will be analysed using the Analytic Network Process (ANP) method. The final result from Delphi, DEMATEL and ANP method of selecting gyro antenna get Sailor gyro antenna for the first alternative choice, KNS gyro antenna for second choice and Seatel gyro antenna for the last choice.

Keywords: Gyro Stabilized Antenna, Delphi, DEMATEL, Analytic Network Process

1. INTRODUCTION

Satellite communication are vital infrastructure for national security purposes, national telecommunications infrastructure, broadcasting and regional observation services for Indonesia. Indonesia has been using satellite technology since 1976 for domestic communication purposes. Communication satellites are very useful with the condition of Indonesia as a maritime archipelago, Damanik (2017). According Domínguez (2015), The maritime very small aperture transmitter (VSAT) satellite telecommunication system on vessels can be illustrated in Figure 1 with components consisting of:

a. Stabilized gyro antenna with built in radio frequency (RF) signal receiver and device to capture and transmit signals to and from satellites.
b. Satellite modem connected to the VSAT stabilized gyro antenna.
c. The IP Router is equipped with an eight port switch and a GPS input connected to the ship's LAN.
d. WIFI access point, as an access medium for the ship's LAN network.

The stabilized gyro antenna is a central device in the configuration system for maritime telecommunications equipment on board. The stabilized gyro antenna equipment provides a 60-70% share of investment in maritime telecommunication equipment on ships.

Figure 1. Maritime satellite communication configuration

Decision making for choosing gyro antenna devices is not easy. This process is basically considered a multi-criteria decision-making problem that is influenced by different tangible and intangible criteria. The criteria are including total cost ownership, reliability of equipment, ease of installation, time to provide spare parts, pricing equipment, after sales services, and others where these criteria have a relationship to influence each other. All of these criteria can affect the project objectives. For that, the satellite telecommunication maritime service providers need a decision-making model that can help them to solve these problems.

2. METHOD

This research method is carried out using quantitative approach with the Delphi, DEMATEL and ANP technique methods. The survey was conducted on experts using the Delphi technique, building a network of relationships between criteria, sub criteria using DEMATEL and selecting the best selection solution using ANP. The research flow chart is summarized in Figure 2.

The data collected in this study are the opinions of five experts who meet the following requirements:

1. Work in maritime telecommunication company.
2. Experience in the field of maritime telecommunications work for a minimum of 10 years.

The five experts were selected to represent all stakeholders in determining the assessment of gyro antenna components in maritime telecommunications, namely: director position, Senior Manager Procurement, Senior Manager Service Delivery, Senior Manager Operation & Maintenance, Senior Engineer Maritime Telecommunication.

The Delphi method, according Kalanaki (2013), the stages of implementing the Delphi technique in step 1.1 are carried out with three rounds for each questionnaire, including:

1. In the first round, questionnaire questions were distributed to experts like a brainstorming where all the answers are collected and will be listed again as the second round of questions.
2. The second round, the results of the answers in the first round are listed and used as the second round questions. the result of the answer in the second round is in the list and if there is a result that no one chooses, then the answer is omitted in the third round question
3. The third round, the results of the answers in the second round are listed and used as the third round questions. The answers collected are analyzed again, if there are less than three votes for the results during these three rounds, it will be omitted from the final answer results.

Step 1.2 Focus Group Discussion (FGD) is carried out from these experts to verify the final selected criteria, sub-criteria and it will be used in the DEMATEL and ANP stages.

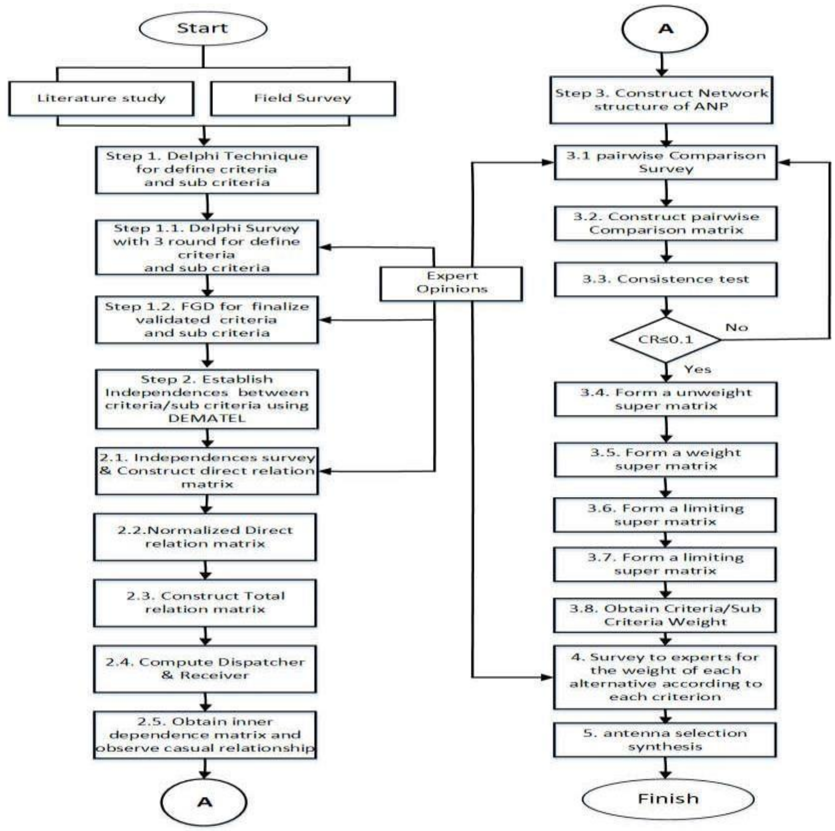

Figure 2. The proposed research flowchart

According to Büyüközkan (2016), DEMATEL able to complement the Analytic Network Process (ANP) method because DEMATEL can determine the interdependence relationship between criteria from several factors more objectively, even though DEMATEL cannot determine the weight of the criteria. The combination of the two methods, the Analytic Network Process (ANP) and DEMATEL, is very helpful for solving decision-making problems with criteria having dependence and feedback more accurately. Büyüközkan (2016) explain that the Decision-making trial and evaluation laboratory (DEMATEL) method has five main stages, including the following:

Stage 2.1: Conducting a survey of the relationship between the criteria and sub criteria then creating a direct relationship matrix

Stage 2.2: Normalization of the relationship matrix directly

Stage 2.3: Obtaining the total relationship matrix

Stage 2.4: Calculating the vector D (dispatcher) and the vector R (receiver)

Stage 2.5: Obtain an impact-digraph map and analyze the relationship between criteria

According to Varma (2012), the threshold value is obtained from the average of all values from the T matrix (Total Relation Matrix). The threshold value determines the relationship between the criteria / sub-criteria, If the cell value in the T matrix is higher than the threshold value, then the two sub criteria are related, for this decision. The results of the DEMATEL method are used to determine the relationship between criteria / sub-criteria in the Analytic Networking Process (ANP) method with Super Decision software.

According to Büyüközkan (2016) and Kheybari (2020), how to make decisions using the

Analytic Network Process (ANP) can be simplified into the following steps:

Stage 3.1: Building the model, transforming the problem into a network structure as shown in Figure 3, making a pairwise comparative survey

Stage 3.2: Determine the relative weights of each criterion and create a pairwise comparison matrix.

Stage 3.3: Calculate the Eigenvalues and Eigenvectors from the comparison matrix from step 2

Stage 3.4: Check consistency test: Consistency index (C.I) and consistency ratio (C.R) are used to estimate the consistency of pairwise comparisons

Stage 3.5: Creating a super-matrix

Stage 3.6: Creating a super-matrix weight

Stage 3.7: Creating super-matrix limiting

Stage 3.8: Obtain criteria and sub criteria weight

Step 4 survey the experts to get their views about the weight of each alternative according to each criteria/sub criteria.

Step 5 synthesis the results of the gyro antenna selection ranking, it is obtained in from multiply criteria and sub criteria weight (obtained in stage 3 the ANP process) with the weight of each alternative according to each criteria/sub criteria (obtained in stage 4).

3. RESULT AND DISCUSSION

Delphi Technique uses 3 rounds, the first round accommodates all the answers to all the criteria and sub-criteria written by and this final answer is verified by a team of experts through a Focus Group Discussion (FGD) of these experts. the final results of the criteria and sub criteria are obtained:

- Cost criteria with sub criteria, namely: 1. Antenna Price (A1), 2. Repair unit costs (A2), 3. Operational costs (A3), 4. Maintenance costs (A4).
- Technical criteria with sub criteria, namely: 5. System capacity (B1), 6. Reliability antenna (B2), 7. Ability to develop to future technologies (B3).
- Operational Criteria with Sub-criteria, namely: 8. Ease of configuration (C1), 9. Ease of operation (C2), 10. Ease of performance monitoring (C3), 11. There is a device security system feature (C4).
- Criteria for vendors with sub-criteria, namely: 12. Quality of service support (D1), 13. Speed of procurement (D2), 14. Speed of spare parts provisioning (D3), 15. Provision of technical support and after sales (D4), 16. Ease of operation coordination (D5).

Table 1. INFLUENCE MATRIX

		BIAYA				TEKNIS			OPERASI				VENDOR				
		A1	A2	A3	A4	B1	B2	B3	C1	C2	C3	C4	D1	D2	D3	D4	D5
BIAYA	A1	0,14	0,14	0,12	0,11	0,19	0,20	0,19	0,15	0,14	0,16	0,18	0,18	0,15	0,14	0,15	0,13
	A2	0,13	0,04	0,06	0,06	0,08	0,08	0,07	0,07	0,06	0,07	0,07	0,08	0,06	0,07	0,07	0,06
	A3	0,12	0,07	0,04	0,07	0,08	0,09	0,07	0,07	0,07	0,08	0,08	0,09	0,08	0,07	0,07	0,06
	A4	0,08	0,05	0,07	0,03	0,07	0,07	0,08	0,07	0,06	0,06	0,08	0,08	0,05	0,06	0,05	0,05
TEKNIS	B1	0,15	0,09	0,08	0,08	0,08	0,12	0,13	0,11	0,10	0,12	0,14	0,13	0,09	0,08	0,09	0,07
	B2	0,20	0,12	0,12	0,11	0,16	0,11	0,17	0,14	0,13	0,16	0,17	0,17	0,15	0,12	0,12	0,12
	B3	0,15	0,08	0,08	0,09	0,13	0,15	0,07	0,11	0,10	0,10	0,13	0,12	0,09	0,07	0,07	0,07
OPERASI	C1	0,12	0,07	0,07	0,07	0,11	0,11	0,11	0,06	0,12	0,12	0,11	0,09	0,08	0,07	0,07	0,06
	C2	0,14	0,08	0,10	0,08	0,12	0,13	0,12	0,13	0,06	0,14	0,13	0,11	0,10	0,09	0,09	0,07
	C3	0,13	0,07	0,08	0,07	0,11	0,12	0,10	0,12	0,11	0,06	0,11	0,09	0,07	0,07	0,07	0,07
	C4	0,15	0,07	0,07	0,09	0,13	0,13	0,13	0,11	0,10	0,11	0,07	0,10	0,08	0,07	0,07	0,06
VENDOR	D1	0,15	0,08	0,08	0,08	0,13	0,13	0,12	0,10	0,09	0,10	0,10	0,07	0,10	0,07	0,07	0,06
	D2	0,11	0,06	0,06	0,05	0,09	0,10	0,08	0,06	0,06	0,07	0,07	0,09	0,05	0,08	0,10	0,07
	D3	0,11	0,06	0,06	0,07	0,09	0,09	0,07	0,07	0,06	0,07	0,07	0,08	0,09	0,04	0,10	0,08
	D4	0,13	0,07	0,08	0,06	0,10	0,10	0,08	0,08	0,07	0,08	0,08	0,08	0,11	0,11	0,05	0,09
	D5	0,09	0,05	0,05	0,05	0,06	0,08	0,06	0,06	0,05	0,06	0,06	0,06	0,07	0,08	0,08	0,03

The results of the DEMATEL method in this study can be seen in Table 1. The threshold value is determined by the average value of the Total Influenced Matrix column value, which is 0.093. Matrix column values that are equal to or greater than the threshold value are coloured green, while smaller values are not coloured. A value below 0.093 means that the two criteria / sub-criteria are not related.

The pairwise comparison value can be determined between criteria/sub criteria and between alternatives. The pairwise comparison value was obtained by using an expert questionnaire. Value of pairwise comparison will be processed by ANP using Super decision software. The weighting of each sub criterion for gyro antenna selection is obtained in table 2.

Table 2. Weight sub criteria results from ANP process

Code	Weight	Sub Criteria
A1	27,04%	Antenna pricing
A2	3,67%	Repair cost
A3	0,84%	Operation Cost
A4	0,00%	Maintenance Cost
B1	7,15%	System capacity
B2	31,83%	Reliability antenna
B3	3,82%	Ability to develop to future technologies
C1	4,48%	Ease of configuration
C2	3,49%	Ease of operation
C3	1,47%	Ease of performance monitoring
C4	5,08%	There is a device security system feature
D1	2,42%	Quality of service support
D2	4,34%	Speed of procurement
D3	1,41%	Speed of spare parts provisioning
D4	2,79%	Provision of technical support and after sales
D5	0,17%	Ease of operation coordination

In this process, the measurement of the weight of each alternative according to each criterion is also carried out using a survey measuring the opinions of experts regarding alternative options according to each criterion. the results from that survey are obtained in table 3 below.

Table 3. Weight of each alternative according to each criteria

Code	Sub Criteria	Antenna Alternative		
		Sailor	KNS	Seatel
A1	Antenna pricing	3,23	2,30	1,17
A2	Repair cost	2,83	1,77	0,70
A3	Operation Cost	2,77	1,77	0,70
A4	Maintenance Cost	2,91	2,01	0,96
B1	System capacity	2,71	1,68	0,66
B2	*Reliability* antenna	3,34	2,30	1,21
B3	Ability to develop to future technologies	2,91	1,96	0,96
C1	Ease of configuration	2,91	1,96	0,92
C2	Ease of operation	2,65	1,63	0,69
C3	Ease of performance monitoring	2,65	1,63	0,62
C4	There is a device security system feature	2,96	1,92	0,88
D1	Quality of service support	3,01	1,87	0,88
D2	Speed of procurement	2,96	1,92	0,88
D3	Speed of spare parts provisioning	2,65	1,63	0,59
D4	Provision of technical support and after sales	2,65	1,63	0,59
D5	Ease of operation coordination	3,02	1,96	0,88
Total		46,17	29,95	13,28

From table 2 and table 3, the results of the gyro antenna selection ranking are obtained in table 4. It is obtained by multiplication between the values in table 2 and table 3. The weight of the alternative choice of gyro antenna with the highest value will be selected as the best choice.

Table 4. Gyro antenna selection ranking with DEMATEL + ANP

Code	Sub Criteria	Weight	Sailor		KNS		Seatel	
			Value	Total	Value	Total	Value	Total
A1	Antenna pricing	27,04%	3,23	0,87	2,30	0,62	1,17	0,32
A2	Repair cost	3,67%	2,83	0,10	1,77	0,07	0,70	0,03
A3	Operation Cost	0,84%	2,77	0,02	1,77	0,01	0,70	0,01
A4	Maintenance Cost	0,00%	2,91	-	2,01	-	0,96	-
B1	System capacity	7,15%	2,71	0,19	1,68	0,12	0,66	0,05
B2	*Reliability* antenna	31,83%	3,34	1,06	2,30	0,73	1,21	0,38
B3	Ability to develop to future tech	3,82%	2,91	0,11	1,96	0,08	0,96	0,04
C1	Ease of configuration	4,48%	2,91	0,13	1,96	0,09	0,92	0,04
C2	Ease of operation	3,49%	2,65	0,09	1,63	0,06	0,69	0,02
C3	Ease of performance monitoring	1,47%	2,65	0,04	1,63	0,02	0,62	0,01
C4	There is a device security system feature	5,08%	2,96	0,15	1,92	0,10	0,88	0,04
D1	Quality of service support	2,42%	3,01	0,07	1,87	0,05	0,88	0,02
D2	Speed of procurement	4,34%	2,96	0,13	1,92	0,08	0,88	0,04
D3	Speed of spare parts provisioning	1,41%	2,65	0,04	1,63	0,02	0,59	0,01
D4	Provision of technical support and after sales	2,79%	2,65	0,07	1,63	0,05	0,59	0,02
D5	Ease of operation coordination	0,17%	3,02	0,01	1,96	0,00	0,88	0,00
	Total		3,10		2,10		1,02	

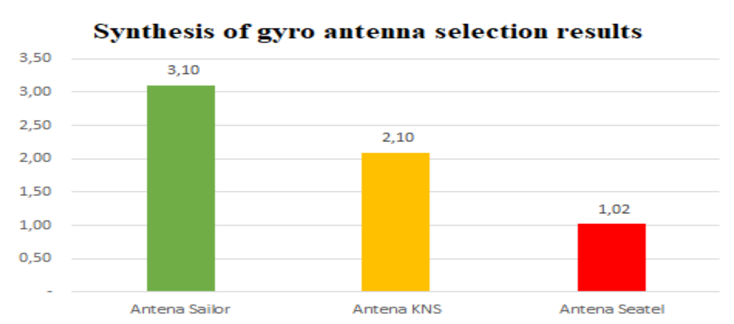

Figure 4. Synthesis of gyro selection decisions for DEMATEL + ANP

The gyro antenna rating is based on questionnaires and data processing with ANP + DEMATEL, the gyro antenna ranking graph can be seen in figure 4. The sailor antenna is ranked first with a value of 3.1 then the KNS antenna is ranked second with a value of 2.1 and finally the Seattle antenna is ranked third with a value of 1.02.

3.1 SENSITIVITY ANALYST

The sensitivity test of the gyro antenna selection results is a simulation by changing the value Weight of each alternative according to each criteria as in table 3 with minimum value 0 until maximum value 9. this simulation describes how far these changing can affect for the results of the gyro antenna selection. The sensitivity test was carried out on the five sub-criteria which had the highest weight using the DEMATEL + ANP data processing method.

Tabel 5. Sensitivity analyst of sailor antenna assessment to changes in alternative weight towards sub criteria

Sub Criteria Value	Rating Weight of Sailor Antenna with Change of Sub Criteria					Antenna Rating Weight		Gyro Antenna Selection
	B2	A1	B1	C4	C1	KNS	Seatel	
0	2,04	2,23	2,91	2,95	2,97	2,10	1,02	The best choice is KNS gyro antenna because the B2 value < KNS weight
1	2,35	2,50	2,98	3,00	3,01	2,10	1,02	The choice of Sailor gyro antenna is due to the weight value of the Sailor antenna with changes in all sub criteria above 2.10
2	2,67	2,77	3,05	3,05	3,06	2,10	1,02	
3	2,99	3,04	3,12	3,10	3,10	2,10	1,02	
4	3,31	3,31	3,19	3,15	3,15	2,10	1,02	
5	3,63	3,58	3,26	3,20	3,19	2,10	1,02	
6	3,95	3,85	3,33	3,25	3,24	2,10	1,02	
7	4,26	4,12	3,41	3,31	3,28	2,10	1,02	
8	4,58	4,39	3,48	3,36	3,33	2,10	1,02	
9	4,90	4,66	3,55	3,41	3,37	2,10	1,02	

From table 5, The weight of the Sailor antenna assessment with the change in the B2 sub-criteria reliability antenna below the value of 0.2 causes a change in the choice of the gyro antenna from Sailor to KNS, values above 0.2 will cause the choice of the gyro antenna shifting from KNS to Sailor. For the other sub criteria, it has no effect because when the value is 0, the weight of the Sailor antenna rating is still above the KNS weight, which is 2.10. Figure 5 can clearly show the change in sensitivity.

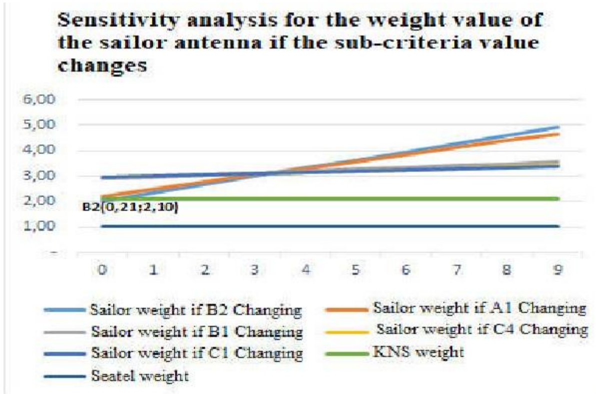

Figure 5. Analysis of the sensitivity of the weight value of the Sailor antenna if changing the alternative weight values against the sub-criteria changes from a value of 0 to a maximum of 9

3.2 THE ADVANTAGES OF DEMATEL IN THIS DECISION MAKING RESEARCH

The comparison of two methods in this study, DEMATEL + ANP method and ANP method show that the using of the DEMATEL method provides the advantage. The number of pairwise comparison questions can be reduced significantly if this study use DEMATEL+ANP method. According Kadoic (2018), integration between ANP and DEMATEL method can reduce the complexity of the ANP network structure based on the value of the strength of the relationship between DEMATEL criteria / sub criteria. In this study, when using only the ANP method, the pairwise comparison survey has 400 questions. This is happening because each sub-criterion has 25 pairwise comparison questions and then multiplied by 16 according to the number of sub- criteria. Integration between DEMATEL and ANP method can reduce the number of pairwise comparison questions to be 82 questions because it compares only related sub-criteria according to the DEMATEL relationship map.

Tabel 6. Weight comparison of sub criteria processed by DEMATEL + ANP with ANP

Code	Sub criteria Weight from:		Sub Criteria
	DEMATEL+ANP	ANP	
A1	27,04%	13,25%	Antenna pricing
A2	3,67%	12,25%	Repair cost
A3	0,84%	3,09%	Operation Cost
A4	0,00%	1,91%	Maintenance Cost
B1	7,15%	7,47%	System capacity
B2	31,83%	30,02%	Reliability antenna
B3	3,82%	4,37%	Ability to develop to future technologies
C1	4,48%	5,53%	Ease of configuration
C2	3,49%	2,71%	Ease of operation
C3	1,47%	1,55%	Ease of performance monitoring
C4	5,08%	5,86%	There is a device security system feature
D1	2,42%	0,59%	Quality of service support
D2	4,34%	4,46%	Speed of procurement
D3	1,41%	4,46%	Speed of spare parts provisioning

D4	2,79%	1,84%	Provision of technical support and after sales
D5	0,17%	0,63%	Ease of operation coordination

Table 6 shows comparison the result of selecting antenna gyro use the DEMATEL+ANP method with only ANP method. The DEMATEL + ANP method produce weight of the sub- criteria focused on the two highest sub-criteria, namely B2 reliability antenna and A1 antenna pricing. In the ANP method, the distribution of sub-criteria weights is more spread out to all the sub-criteria. Synthesis results obtained the same ranking results using either the DEMATEL + ANP method or only the ANP. The sailor antenna is the first choice, then the KNS antenna is the second and last, the Seatel antenna is the third. the difference in weight results for selecting the gyro antenna, DEMATEL + ANP method is 0.7 higher using only ANP method.

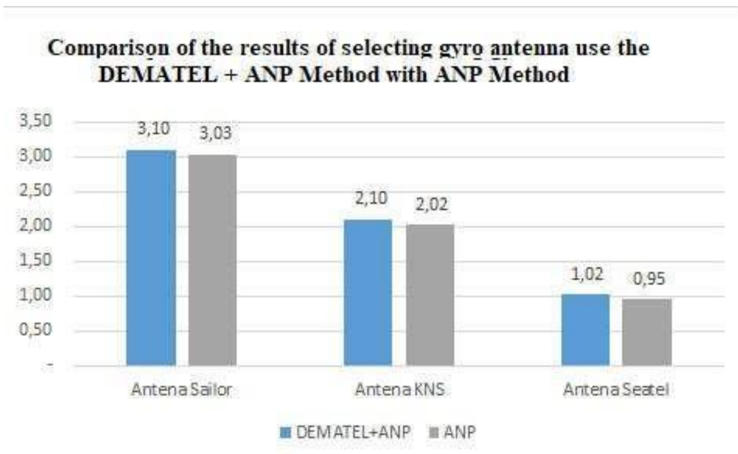

Figure 6. Comparison of DEMATEL + ANP gyro antenna selection and with ANP only

4. CONCLUSIONS

Based on the results of the research and analysis and interpretation of the data carried out, it can be concluded that:

1. Based on the results of determining the criteria / sub-criteria using the Delphi technique, 4 criteria and 16 sub-criteria are obtained which are priority considerations for maritime telecommunications companies in choosing gyro antenna equipment, namely:
   a. Cost criteria with sub criteria, namely: 1. Equipment Price, 2. Unit repair costs, 3. Operational costs, 4. Maintenance costs.
   b. Technical criteria with sub criteria, namely: 5. System capacity, 6. Reliability / Availability of the system, 7. Ability to develop future technologies.
   c. Operational Criteria with Sub-criteria, namely: 8. Ease of configuration, 9. Ease of operation, 10. Ease of monitoring performance, 11. There is a device security systemfeature.
   d. Vendor criteria with sub-criteria, namely: 12. Quality of service support, 13. Speed of procurement, 14. Speed of time to provide spare parts, 15. Provision of technical support and after sales, 16. Ease of coordination.
2. The final results of the analysis process using Delphi, DEMATEL and ANP show that as the best alternative choice of gyro antenna, namely: gyro sailor antenna as the first alternative, KNS gyro antenna as the second alternative, Seatel gyro antenna as an alternative third option.

5. REFERENCES

Alejandro García-Domínguez, (2015). Mobile applications, cloud and bigdata on ships and shore stations for increased safety on marine traffic; a smart ship project, *Proceding of the 2015 IEEE International Conference on Industrial Technology*, Sevilla, Spain, 1532-1537.

Ali, Kalanaki., (2013). *Tender Evaluation for the Telecommunication Industry using the Analytic Network Process,* West Virgina University, Morgantown West Virginia, USA.

Gülçin Büyüközkan, Sezin Güleryüz., (2016). An integrated DEMATEL-ANP approach for renewable energy resources selection in Turkey. *int. J. Production Economics 182*, 435–448.

Gerson Damanik, Iwan Setyawan, Rober Lawang, Daniel D Kameo., (2017). Satellite deployment strategy for an archipelagic state: the case of Indonesia, *Proceding of the 11th International Conference on Telecommunication Systems Services and Applications*, Lombok, Indonesia, 1-6.

Landaeta J., (2006). Current validity of the delphi method in social sciences, *Technological Forecasting & Social Change 73*, 467–482.

Hsuan-Shih Lee, Gwo-Hshiung Tzeng, Weichung Yeih, Yu-Jie Wang, Shing-Chih Yang, (2013). Revised DEMATEL: resolving the infeasibility of DEMATEL. *Applied Mathematical Modelling 37*, 6746–6757.

Mónica García-Melón, Tomás Gómez-Navarro, Silvia Acuña-Dutra., (2012). A combined ANP-Delphi approach to evaluate sustainable tourism, *Environmental Impact Assessment Review 34*, 41–50.

Nikola Kadoi, Blaženka Divjak, Nina Begi cevic Redep., (2019). Integrating the DEMATEL with the analytic network process for effective decision-making, *Central European Journal of Operations Research Vol. 27*, 653-678

Saaty, T. L., (1999). Fundamentals of the analytic network process, *ISAHP 1999*. Kobe, Japan.

Saaty, T.L., Vargas L.G., (2006). *Decision making with the analytic network process economic, political, social and technological applications with benefits, opportunities, costs and risks*, Springer, Pittsburgh.

Saaty TL, (2008). The analytic network process. *Iran J Oper Res 1*, 1–27.

Semih Önüt, Selin Soner Kara, Elif Isik., (2009). Long term supplier selection using acombined fuzzy MCDM approach: a case study for a telecommunication company, *Expert Systems with Applications 36*, 3887–3895

Siamak Kheybari, Fariba Mahdi Rezaie, Hadis Farazmand., (2020). Analytic network process: an overview of applications, *Applied Mathematics and Computation Vol. 367*, 124780

Varma, K., & Kumar, K. S., (2012). Criteria analysis aiding portfolio selection using DEMATEL, *Procedia Engineering 38*, 3649-3661.

Wei-Gu, Li-Rong Wei., (2017). Evaluating and optimizing technological innovation efficiency of industrial enterprises based on both data and judgments, *International Journal of Information Technology & Decision Making Vol. 17*, 9–43.

Yu-Ping Ou Yang, How-Ming Shieh, Jun-Der Leu, Gwo-Hshiung Tzeng., (2008). Novel hybrid MCDM model combined with DEMATEL and ANP with applications, *International Journal of Operations Research Vol. 5*, 3–9.

SALES PREDICTION ON FAST MOVING CONSUMER GOODS USING COMBINED MACHINE LEARNING METHODS

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ABSTRACT

Predicting the sales of the product is becoming more critical for fast-moving consumer goods company especially during unprecedented times. The ability to achieve efficiency for manufacturing, distributing, and marketing for the goods, are really dependent on how accurate the sales forecast is. The effect of wrong sales prediction could lead to consumer behavior changes towards the product, excessive inventory, and out of stocks in the market. Many papers show that machine learning techniques are currently the best practice to predict sales, however, many companies are still struggling to use these machine learning techniques due to many variables that are being needed to forecast the sales for the result to become more accurate. This study proposed a simple framework to forecast the sales of products using the combined supervised machine learning technique between multiple linear regression, decision tree regression, random forest regression, and support vector regression within internal marketing variables such as product price, distribution level, and marketing spends and external variables such as inflation, consumer confidence index and interest rate. The results show that combining random forest regression to forecast the Consumer Confidence Index and then using support vector regression within these variables is quite accurate to predict the sales.

Keywords: sales forecast, machine learning, multiple linear, decision tree, random forest support vector

1. INTRODUCTION

In the last few years, economic development in the world has been very dynamic. In 2007, we saw that there had been a financial crisis in the world which affected almost all countries and directly affected the performance of multi-national companies. Moving to 2020, weexperienced a global problem as the effects of the COVID-19 pandemic, which has spread widelyin various countries and led to a weakening of the economy and consumer purchasing power and resulted in a decline in the performance of multi-national companies. Especially Business to Consumer companies, one of which is engaged in FMCG (Fast Moving Consumer Goods).

With the current uncertain economic conditions, the company's efficiency to avoid high costs is significant. One of the efficiencies that can be achieved by companies engaged in consumer goods is efficiency in the supply chain and marketing. To be able to get this efficiency,it is vital to know in advance the prediction of consumer's purchase regarding goods so that companies can allocate costs appropriately for production, distribution of goods, and marketing (Taralo, Elcio, et al. 2019; Ajay, Kumar, et al. 2019). This prediction error can lead to consumer behavior changes towards our goods, inventory buildup, and out of stocks in the market (Folinas, D; Rabi, S 2012).

Then to be able to find the correct sales prediction, a precise prediction method is needed. Previous traditional methods used by policymakers, which only relied on historical trends and seasonal patterns, now no longer produce accurate predictions (Taralo, Elcio 2019). There have been many publications that explain that machine learning methods can produce better results than other traditional methods (Kandamond (2012); Tarallo (2019)). But unfortunately, there are still many manufacturing companies that have not implemented machine learning methods in their business processes. Based on the McKinsey report The Age of Analytics: Competing in Data-Driven World, 2016, the potential absorbed from the use of machine learning in manufacturing companies is only 20% to 30%. This low potential is due to data still centered on IT systems and stakeholders who are still skeptical of machine learning. Hence, there is room for researchers to determine the scheme of machine learning applications to improve company performance by selecting accurate sales predictions.

2. LITERATURE REVIEW

There have been many publications regarding sales predictions using machine learning methods. Research conducted by Ajay Kumar (2019) tried to make a model using an Artificial Neural Network using a combination of Demand Shaping which consists of marketing activity variables such as sales, promotion, and price of goods, and Demand sensing, which consists of macro variables such as the Consumer Confidence Index, Producer Price Index and the Consumer Price Index. However, in this study, the authors see data that is difficult to obtain, suchas Customer Profile and Web Traffic variables, because this data is usually not found in the company's internal system and requires third-party assistance to receive it. Haekyon Lee (2019) also conducted a combined machine learning method consisting of multiple linear regression, k- nearest, Artificial Neural Network, Support Vector Regression, Classification, and Gaussian into one combined regression model, but requires input from experts in the model. Andres Martinez (2018) also created a framework for predicting goods using three machine learning methods: logistic-lasso regression, extreme learning machine, and gradient tree boosting. T. Qu (2017)tries to predict sales at Semi- Luxury Supermarkets. Still, this paper only uses one method, namely random forest. Farizal (2019) also tries to predict sales of goods using machine learning. Still, in his research, there is only one method used, namely multiple linear regression.

Based on these studies, the authors feel there is still a gap for research development, especially by using machine learning methods and where the input variables can be obtained easily from the company's internal system, and macroeconomic can be obtained from the World Bank data.

3. FRAMEWORK AND MODEL DEVELOPMENT

3.1 Framework of the research

This study aims to create a regression model scheme that predicts sales figures based on existing variables. The method of the regression to be carried out is as follows

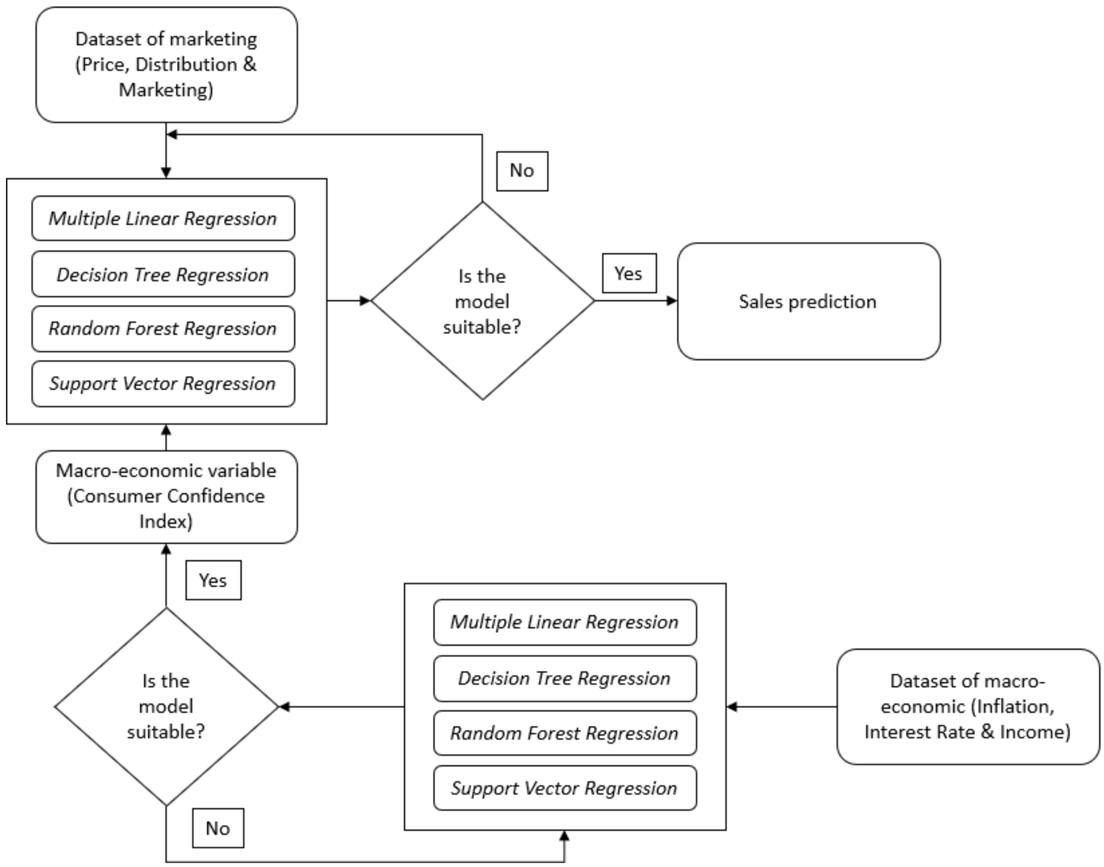

Figure 1. The proposed framework of sales prediction using machine learning

On the managerial side, the variables in the marketing activity datasets such as price, distribution, and marketing are determined by the company's business activities. However, figures such as the Consumer Confidence Index, inflation, interest rates, and income are uncontrollable external factors. This study predicts the Consumer Confidence Index based on the inflation rate, interest rate, and consumer's income first by using the machine learning method. After obtaining the right approach in predicting, the Consumer Confidence Index's prediction results will be used further in the next regression step, namely to predict sales results. In this regression, the variables used are price, distribution, marketing, and the numbers that we have obtained. Then, as before, we will look at the most accurate method in predicting and make the regression method the final approach. The predictions using machine learning will then becompared with the actual results to determine whether the resulting predictions are accurate.

3.2 Dataset

The study uses data from the sales of a fast-moving consumer goods company and macro-economic data taken from the website of one of the world's leading banks. This data consists of 36 months, with the following variable scopes. Sales value, distribution, marketing, price of goods, consumer confidence index, inflation, income per capita, and interest rate.

We can classify the variables in this dataset into two, based on the data source. In the variable sales value, sales distribution, marketing, and price of goods, we can classify it as a marketing activity variable because it is a controlled variable that business people usually set.

Then in the Consumer Confidence Index variable, inflation, per capita income, and interest rate, we can classify these variables as Macro External Variables. These variables cannot be controlled and do not come from internal business. Based on the problem's formulation, we will predict this variable, especially the Consumer Confidence Index variable, affecting sales predictions.

This data will then be split into two; the first dataset consisting of 30 months will become training data, which will be used to train the model. The second dataset composed of 6 months will be used to test the validity of the model that has been made.

3.3 Machine Learning

Machine Learning is a set of algorithms trained to find patterns in large datasets so that with these patterns, we can draw conclusions and predict these patterns with new data (IBM Cloud Education, 2020). The better the algorithm used, the better the prediction results will be issued and more data. Currently, there are many applications of algorithms in Machine Learning, such as music recommendations on a web song player, to the medical field to help analyze imagesfrom CT scans. There are four steps to apply machine learning: preparing the dataset that would be trained, choosing the algorithm, training the algorithm and using the model, and fixing it. This study will use four types of commonly used algorithms: multiple linear regression, decision tree regression, random forest regression, and support vector regression.

Regression itself is a statistical technique used to find a straight line representing data distribution (Wallnau, Larry; Gravetter, Frederick; 2013). While Multiple Linear Regression is a regression technique similar to a regression, but in this case, there are two or more independent variables (Weissberg, Sanford 2005). The following equation denotes this regression model.

$$E(Y|X) = \beta_0 + \beta_1 X_1 + \cdots + \beta_p X_p \quad (1)$$

The decision tree algorithm breaks a dataset into smaller data subsets and simultaneously makes associations in the decision tree (Quinlan, J.R 1986). The result of this algorithm is a tree with decision nodes and leaf nodes in it. The decision nodes themselves have two or more branches that represent the values of the attributes in them. Leaf nodes show the target decision numerically.

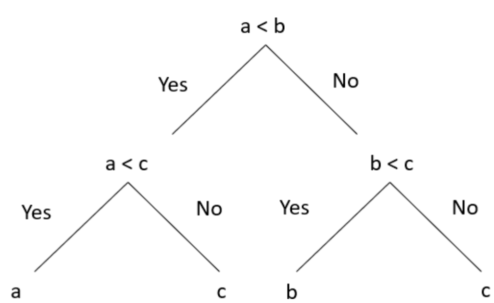

Figure 2. Decision tree regression model

The random forest algorithm uses a decision tree as its basis. This algorithm will split the existing dataset into various decision trees where the predicted results from this decision tree will be averaged to become the final prediction result. we can see the illustration of a random forest in the following figure.

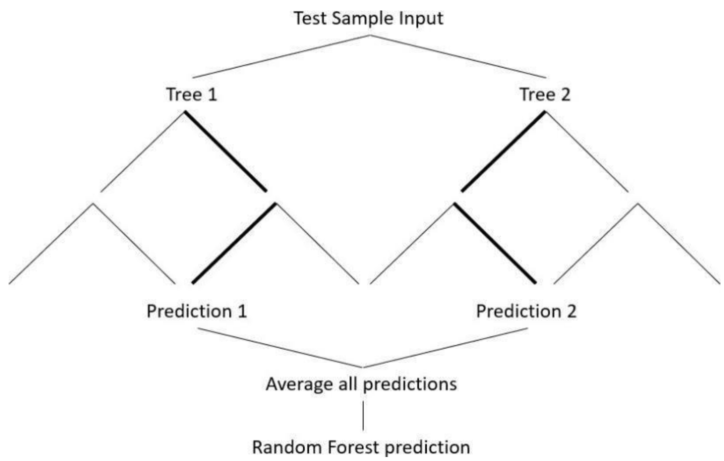

Figure 3. The random forest regression model

In support vector regression, the existing dataset is given a constraint space, where this space is intended to accommodate as many existing datasets as possible. Still, it is conditioned that the constraint space is as narrow as possible. The mathematical equation of support vector regression is as follows.

$$y = f(x) =< w, x > +b = \sum_{j=1}^{M} W_j X_j + b\ , y, b\ \in R, x \in R^M \quad (2)$$

$$f(x) = \begin{bmatrix} w \\ b \end{bmatrix}^T \begin{bmatrix} x \\ b1 \end{bmatrix} = w^T x + b\ x, w \in R^{M+1} \quad (3)$$

$$min_w \frac{1}{2} \|w\|^2 \quad (4)$$

4. RESULTS AND DISCUSSION

Following the previous conceptual model, the first step in data processing is applying a machine learning method to predict the Consumer Confidence Index variable. There are four machine learning methods: multiple linear, polynomial, decision tree, random forest, and support vector. Here is the final result of the comparison between the predicted value and the actual value.

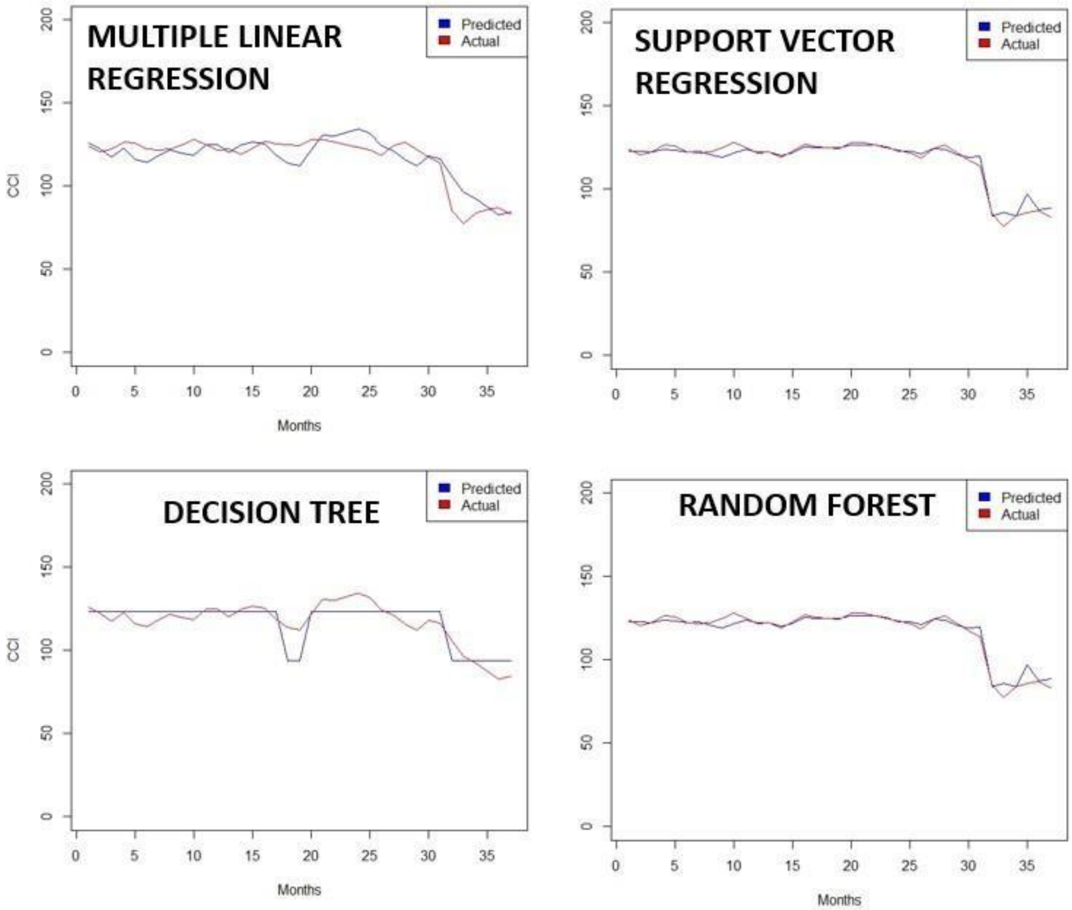

Figure 4. Model output based machine-learning method for CCI

We can compare the actual value and the predicted value of each regression technique from the picture above. In the multiple linear regression method and the decision tree method, it can be seen that the shape of the prediction results is not yet fit to the actual value, mainly when anomalies occur in the data. The historical and seasonal patterns of this data are still not visible in the first two methods. However, in the random forest and support vector methods, theprediction results are quite precise compared to the actual value. Anomalies in the data can be predicted well. Then, to reach each model's details, the author will use each regression technique's R Square value.

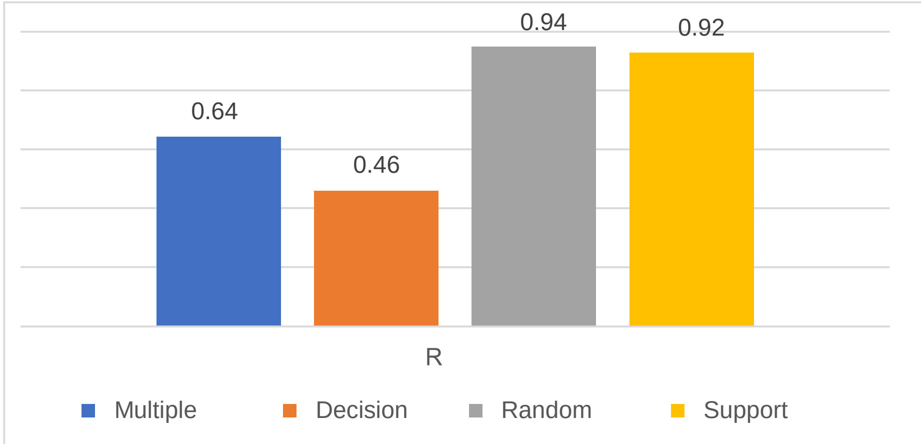

Figure 5. Comparison for R-Square Value on CCI modeling

We will apply the same method in this step, using four regression techniques: multiple linear, polynomial, decision tree, random forest, and support vector.

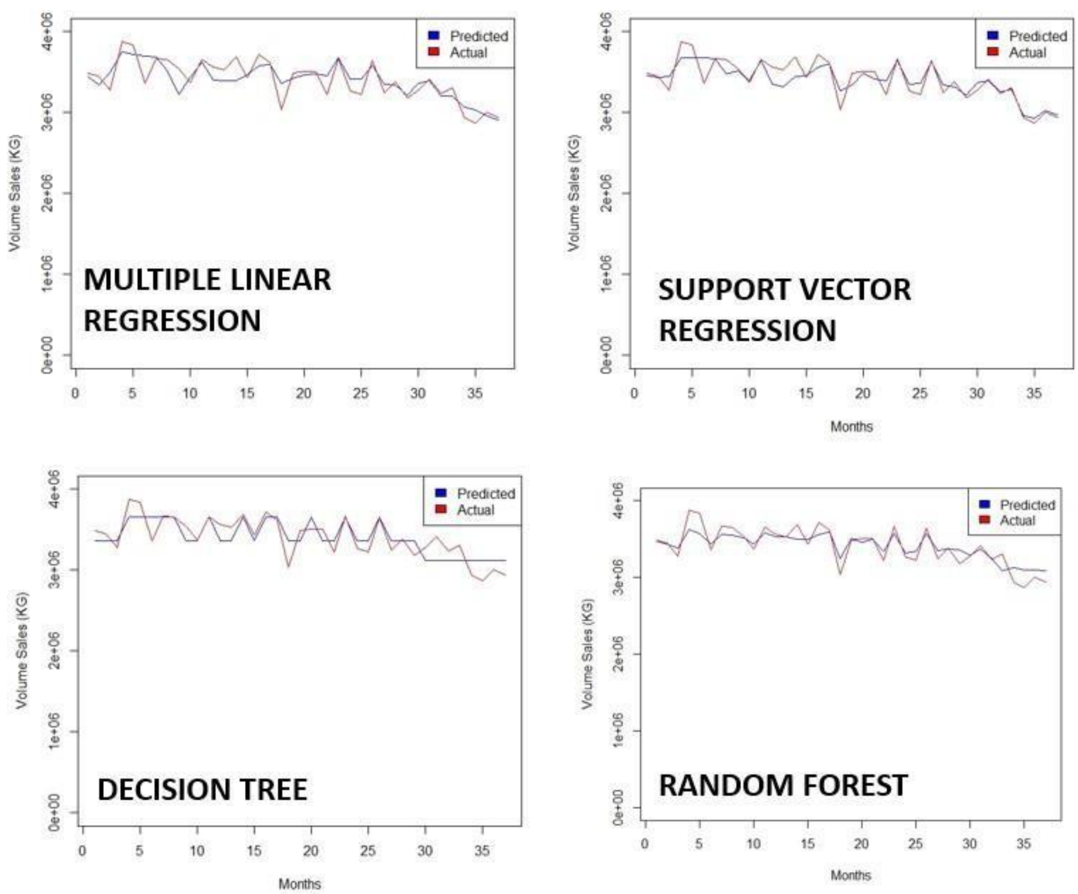

Figure 6. Model output based machine-learning method for sales prediction

Based on the comparison of the predicted and actual values, it can be seen that the predicted values in the Random Forest and Support Vector regression methods are quite fit compared to the other two techniques. The R Square value of each way can be seen in the following graph.

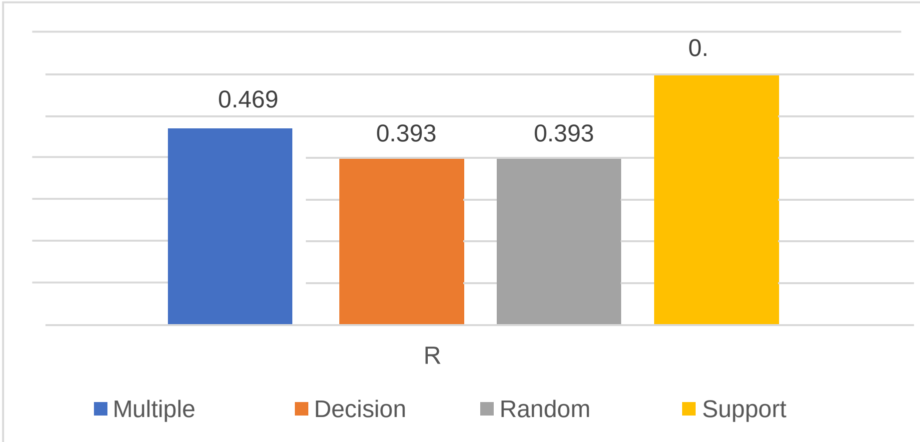

Figure 7. Comparison for R-Square value on sales prediction

We can see that the support vector has the highest R Square value at this regression step compared to other regression methods. With an R Square value of 0.6, the author considers this model to be sufficient to predict sales value based on independent variables, price, distribution, marketing, and the Consumer Confidence Index.

5. CONCLUSION

This study aims to predict the value of sales based on price, distribution, marketing, Consumer Confidence Index, interest rate, inflation, and per capita income. In the first step, predicting the value of the Consumer Confidence Index, the Random Forest regression method gave the best results compared to other methods with an R Square value of 0.98. This value shows that the machine learning method has been very successful at predicting it.

The value of the Consumer Confidence Index is rarely predicted by providers of macro-economic factors such as the World Bank and Trading Economics. The variables released by these providers only include inflation, interest rate, and per capita income. Still, this variable doesnot directly correlate to consumers, so it isn't easy to use it as a decision-maker for goods sales policies. With this prediction scheme, managerial managers can use this method to predict the value of the Consumer Confidence Index to be used as policymakers.

In the second step, where the regression will be carried out based on the Consumer Confidence Index and marketing activity variables' prediction results, the results obtained show that the Support Vector provides the best results compared to other methods. With an R Square value of 0.6, the authors feel this model has been successful enough to predict sales value to make policies within the company. We can conclude that the regression method that we can use simultaneously to predict the sales value of an item is to use the Random Forest method and the Support Vector method.

By looking at the results of this thesis, the authors see that there are still many opportunities to improve this study, both in terms of the regression method used and the dataset used. In this thesis study, the authors use only four regression methods, which are still included inthe supervised learning category. This regression method does not use boosting or bagging, which can further increase the model's precision. Regarding the variables used in marketing activities, the author does not include external factors such as competitors and others. These factors the authors think significantly affect the results' value and can increase the model's ability to predict. Finally, a regression scheme is simultaneously carried out. We see this scheme canstill be developed further considering the two previous factors, namely adding new variables and using other machine learning methods, supervised learning, and unsupervised learning.

6. REFERENCES

Farizal, Qaradhawi, Y., Cornelis, C. I., & Dachyar, M. (2020). Fast moving product demand forecasting model with multi linear regression. *Recent Progress On Mechanical, Infrastructure, and Industrial Engineering: Proceedings of International Symposium on Advances in Mechanical Engineering (ISAME): Quality in Research 2019*

Folinas, D., & Rabi, S. (2012). Estimating benefits of demand sensing for consumer goods organisations. *Journal of Database Marketing & Customer Strategy Management, 19(4)*, 245–261

Gravetter, F. J., & Wallnau, L. B. (2013). *Statistics for the behavioral sciences*. 9^{th} Edition, Wadsworth, Cengage Learning, Canada.

Kandananond, K. (2012). A comparison of various forecasting methods for autocorrelated time series, *International Journal of Engineering Business Management.*

Kumar, A., Shankar, R., & Alijohani, N. (2019). A big data driven framework for demand-driven forecasting with effects of marketing-mix variables. *Industrial Marketing Management*, 1-15

Lee, H., Kim, S. G., Park, H., & Kang, P. (2014). Pre-launch new product demand forecasting using the Bass model: A statistical and machine learning-based approach. *Technological Forecasting and Social Change*, 86, 49–64.

Martínez, A., Schmuck, C., Pereverzyev, S., Pirker, C., & Haltmeier, M. (2018). A machine learning framework for customer purchase prediction in the non-contractual setting. *European Journal of Operational Research*.

Quinlan, J.R. (1986). Induction of decision trees. Machine Learning 1, 81–106

Qu, T., Zhang, J. H., Chan, F. T. S., Srivastava, R. S., Tiwari, M. K., & Park, W.-Y. (2017). Demand prediction and price optimization for semi-luxury supermarket segment. *Computers & Industrial Engineering*, 113, 91–102.

Tarallo, E., Akabane, G. K., Shimabukuro, C. I., Mello, J., & Amancio, D. (2019). Machine learning in predicting demand for fast-moving consumer goods: An exploratory research. *IFAC- PapersOnLine*, 52(13), 737–742

Weisberg, S. (2005). *Applied Linear Regression*, Third Edition, John Wiley & Sons, Inc

EFFECTIVENESS ANALYSIS OF SERVICE SYSTEM BASED ON VISIT PATTERNS TO IMPROVE THE EFFICIENCY OF CUSTOMER SERVICE QUEUING SYSTEM

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ABSTRACT

Competition in the telecommunications industry is fierce. To be able to record maximum profits, cellular operators must be able to run the business more efficiently. One alternative solution is the Cost Leadership program. The concept of Cost Leadership is how a company can have high competitiveness at the lowest cost. For Telkomsel as a cellular operator, one of the routine costs that must be incurred is the cost to provide services at GraPARI. In organizing services at GraPARI, there are two basic things that should be concerned,namely: Service Level Agreement (SLA) and the number of customers visiting GraPARI. These two things are essential factors in determining the number of Customer Services needed. For this reason, it is necessary to define an appropriate mechanism in the calculation process. The accurate number of Customer Services will be a key factor in improving the efficiency of the Customer Service Queuing System. In this study, theEfficiency of the Customer Service Queuing System is measured by the waiting time of queuing and the service time provided by Customer Services in GraPARI. This study conducted a simulation modeling of the observation data and developed a simulation model with an experimental approach. The simulation model of the system under study is "dynamic – stochastic – discrete". The observational data is obtained from queuing machineat GraPARI. After the observational data is available, an analysis of the data is carried outto obtain descriptive statistics that will serve as a reference for the simulation process and input for the simulation software. Next, the simulation process and output analysis of aseries of experimental experiments are carried out with several alternative models. It is expected that the number of Customer Service is a minimum which remains to comply with the Service Level Agreement. From the series of experiments that have been carried out, there are two alternatives models that provide efficiency 9.7% - 12.9%. The results of this study can be an alternative method for Telkomsel in determining the minimum number of customer service at GraPARI. Operational costs for services can be minimized and customer satisfaction can be maintained.

Keywords: Queuing; Waiting Time; Simulation: Dynamic, Stochastic, Discrete; Customer Service Queuing System.

1. INTRODUCTION

The telecommunications industry is one of the businesses with high operating costs, especially the cellular business. The intense competition in the cellular business, forcing operators to look for efficient ways of doing business. One alternative solution is to implement a Cost Leadership Program. The concept of Cost Leadership is how companies can have high competitiveness at the lowest cost (Porter, 2020).

The simple formula for calculating profit is to reduce income with expenses (Wadiyo, 2020). Revenue is earned from sales. While costs are obtained by adding up several components, including operational costs, taxes, interest, etc.

As a cellular telecommunications operator with the widest coverage and the largest number of subscribers in Indonesia, Telkomsel must provide the most service points among existing cellular operators. Because this has become part of Telkomsel' s commitment to providing the bestquality service to its customers. Customers must be comfortable starting from entering the GraPARI until they are leaving. This facility includes several aspects, including physical aspects such as a spacious, clean, and tidy room. Human aspects such as friendly and helpful officers. Meanwhile, system aspects include short queue waiting times, short service times, etc.

Telkomsel as a cellular operator, one of the routine costs that must be incurred is the cost to provide services at GraPARI. In organizing services at GraPARI, there are two basic things that should be concerned, namely: Service Level Agreement (SLA) and the number of customers visiting GraPARI. These two things are important factors in determining the number of Customer Services needed. For this reason, it is necessary to define an appropriate mechanism in thecalculation process. The accurate number of Customer Services will be a key factor in improving the efficiency of the Customer Service Queuing System.

2. RESEARCH FRAMEWORK

2.1 Queuing System

Queuing theory creates models and mathematically formulates the queues that occur. A queue is a waiting line for individuals (customers) or goods that require service by one or more service facilities.

Queuing occurs because the service capacity is not sufficient for customer needs, so customers have to wait. The number of service facilities can be increased to prevent customers from waiting, however this incurs additional costs. A balance must be sought between the costs of queuing against the costs of preventing queues, to obtain maximum benefits because the queuing system in general aims to minimize the total cost of procuring facilities and the waiting time for these services (Wahyu, 2017).

The queuing system can be described as a situation where there are inputs (can be humans, objects, jobs, etc.) to be served or processed, enter the waiting area and queue to get service, and finally exit the system (Herjanto, 2009) . The queuing system can be described as below:

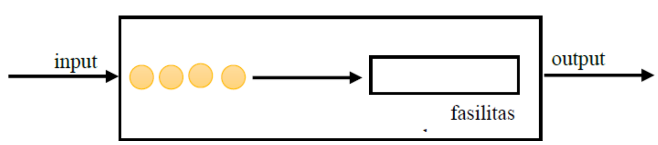

Figure 1. Basic Queuing System

2.2 Queuing Model

The queuing model is an understanding of how service facilities serve queues.

Queuing model has four forms, namely as follows:

a. First Come First Served (FCFS) or First In First Out (FIFO), namely customers who arrive first will be served first.
b. Last Come First Served (LCFS) or Last In First Out (LIFO), the customer who arrives last will be served first.
c. Service In Random Order (SIRO), namely services provided randomly, not depending on the order of arrival.
d. Priority Service (PS), namely services given with a certain priority, a higher priority will be served first (Wahyu, 2017).

Queuing model that implemented by the research object is FIFO (First In First Out).

2.2 Queuing Structure Model

Services in a queuing system consist of one or more processes. This process is called the phase, where each phase contains one or more resources. These resources, whether individual or machine, will provide services to queued customers. The queuing structure model that used in this research is Multi-Channel Single-Phase, like described below:

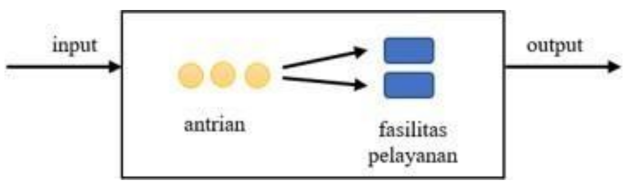

Figure 2. Multi Channel Single Phase

2.3 Queuing System Equation Model

This study uses more than one resource, the queue system equation used can be explained as follows:

Table 1. Equation Model for More Than One Resource

Description	Equation
The average number of subscribers in the system, namely the number in the queue plus the number currently being served	$L = \frac{\lambda\mu(\lambda/\mu)^s}{(s-1)!(s\mu-\lambda)^2} P_0 \pm \frac{\lambda}{\mu}$ $L = L_q \pm \frac{\lambda}{\mu}$
The average time used by the customer in the system, namely the time spent waiting plus service time	$W = \frac{\mu(\lambda/\mu)^s}{(s-1)!(s\mu-\lambda)^2} P_0 + \frac{1}{\mu} = \frac{L}{\lambda}$
Average number of customers in queue	$L_q = \frac{\lambda\mu(\lambda/\mu)^s}{(s-1)!(s\mu-\lambda)^2} P_0 = L - \frac{\lambda}{\mu}$

Table 1. Equation Model for More Than One Resource (cont.)

Average time a customer spends waiting in a queue	$W_q = W - \frac{1}{\mu} = \frac{L_q}{\lambda}$
System utilization factor, namely the probability of resources being used	$\rho = \frac{\lambda}{s\mu}$
The percentage of idle time is the probability that there are no customers in the system	$P_0 = \frac{1}{\left[\sum_{n=0}^{s-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n \pm \frac{1}{s!}\left(\frac{\lambda}{\mu}\right)^s \frac{s\mu}{s\mu-\lambda}\right]}$

Information:

λ : average arrival rate or average arrival rate of customers (units/hour)

$\frac{1}{\lambda}$: inter arrival time (hour/unit)

μ : average service level or average service rate (units/hour)

$\frac{1}{\mu}$: average service time (hour/unit)

s : number of resources

n : the number of customers in the system

2.4 Goodness of Fit

After estimating the distribution type and the value of its parameters based on the data obtained, the next step is to check whether the estimated distribution type matches the data taken. To perform this test, the Kolmogorov Smirnov test was used. The way this method works is by comparing distribution functions (CDF) empiric $F_n(x_i)$ with a hypothesis distribution function (Estimated CDF), $\hat{F}(x)$. So that the test statistics used are as follows:

$$D_n = \sup_x |F_n(x) - F(x)| \tag{2.1}$$

The hypothesis used is as follows:

H_0 : data X is independent random variable that is distributed according to the $\hat{F}(x)$ distribution

H_1 : data X is independent random variable that is not distributed according to the $\hat{F}(x)$ distribution

H_0 will be rejected if $D_n > d_n$, where dn is the value from the Kolmogorov Smirnov table.

2.5 Simulation

Simulation is a technique for creating a model from a real condition or system. The model is a representation of a system that is being observed. The procedures required in simulating the problem are creating the model, validating the model, applying the simulation process, andanalyzing the simulation results.

Model validation is done to ensure that the simulation model reflects the actual system. After the model validation has been carried out, the simulation model must be tested by assigning values to its parameters. If the output analysis of simulation shows conformity with the actual system, the simulation model can be used.

There are several types of simulations. According to nature and time, there are static and dynamic. According to the existence of random variables, there are deterministic and stochastic. According to random variables, there are discrete, continue, mixed of discrete and continue, and Monte Carlo.

The main advantage of using simulation is the ability to solve problems and perform experiments on a system that contains uncertainty problems. In addition, the problem-solving time is short with reliable results.

3. RESEARCH METHODOLOGY

3.1 Research Data Collection Method

The preparation of this thesis is started by collecting data about how the queuing system works, queue transactions, and SLA from research objects. The observational data is obtained from queuing machine at GraPARI Pemuda, Surabaya, from October 1st to 31st October 2019. SLA document contains information about maximum waiting time and service time that has been determined by management of Telkomsel.

3.2 Data Analysis Method

This research analyzes how effective the current system and assesses the possibility to provide an alternative model of the queuing system to improve the system's efficiency. There are several steps to do before running the simulation. The first step is to analyze the observational data to get the type of data distribution, applying Goodness of Fit to the observation data, getting the appropriate expression from the type of data distribution, define the number of replication and replication length.

The simulation results are analyzed using two criteria according to the Service Level Agreement, namely waiting time and service time. The maximum value for waiting time is 1200 seconds, while the maximum value for service time is 900 seconds. The waiting time is used to analyze the effectiveness of the queuing system. Meanwhile, the service time is used to analyze the effectiveness of CS's performance.

The simulation process will be conducted with an experimental approach in Arena Simulator Software. If the waiting time is less than 1200 seconds, a new model will be created by reducing the number of customer service from the initial or the previous model. The process of creating a new model will stop when the waiting time exceeds 1200 seconds.

4. RESULT and DISCUSSION

4.1 Queuing System

There is four time-period along the working hour of the system. The first is from 8 am to 11 am, the second is from 11 am to 4 pm, the third is from 4 pm to 7 pm and the last is from 7 pm to 12 pm. Each period has a different number of Customer Service available as follows:

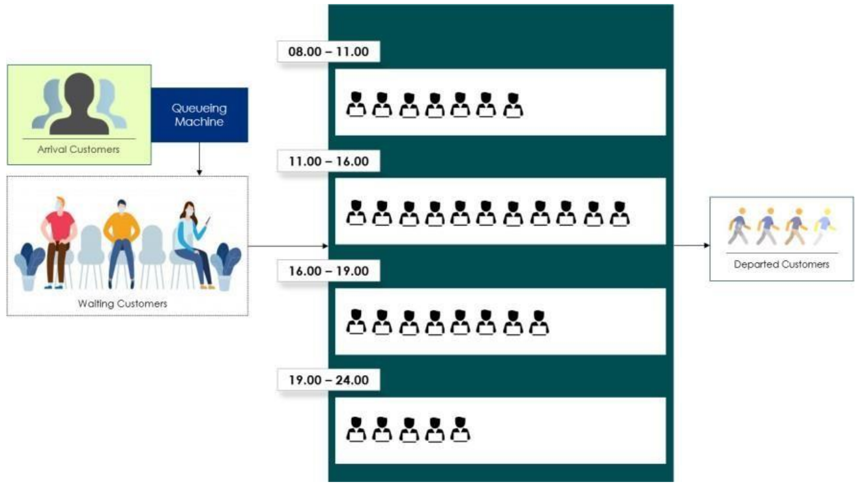

Figure 3. The Queuing System

4.2 Observational Data

From the observational data, an analysis will be carried out to obtain some information that will become the input simulator, namely the distribution of types and expressions of the data. The following is an example of the observed data obtained.

Table 2. Example of Observational Data

DATE	GRAPARI	COUNTER	SERVICE	QNUMBER	QISSUED	QCALLED	QDONE
31-10-19	Surabaya Pemuda	2	UnsubscribePostpaid	1607	08:14:00	08:55:16	09:15:38
31-10-19	Surabaya Pemuda	2	ChangeServicePkg	1605	08:08:52	08:32:11	08:54:46
31-10-19	Surabaya Pemuda	2	ProductAndService	1604	08:04:57	08:22:53	08:32:09
31-10-19	Surabaya Pemuda	2	PkgActivation	1603	08:04:38	08:07:32	08:22:23
31-10-19	Surabaya Pemuda	2	LinkAjaActivation	1632	10:10:08	10:23:54	10:30:28
31-10-19	Surabaya Pemuda	2	Complaint	1630	10:08:26	10:11:13	10:23:54
31-10-19	Surabaya Pemuda	2	Complaint	1643	10:43:38	11:05:05	11:29:08
31-10-19	Surabaya Pemuda	2	Complaint	1651	10:54:04	11:29:09	12:01:12
31-10-19	Surabaya Pemuda	2	Complaint	1661	11:40:55	12:25:15	12:30:57
31-10-19	Surabaya Pemuda	2	PostpaidRegistration	1305	11:59:11	12:01:12	12:24:43
31-10-19	Surabaya Pemuda	2	Complaint	1664	11:53:28	12:30:58	12:55:13
31-10-19	Surabaya Pemuda	2	Complaint	1678	12:59:57	13:00:15	13:22:09
31-10-19	Surabaya Pemuda	11	MissingOrDamagedCard	9850	21:38:57	21:57:42	22:07:51
31-10-19	Surabaya Pemuda	11	Registration	9852	22:15:57	22:16:04	22:22:46
31-10-19	Surabaya Pemuda	11	Registration	9855	23:35:52	23:58:31	23:58:39

4.3 Model Verification

In the verification process, the reference data that will be used to verify the model is descriptive data from observational data, such as the number of customer visits per day, duration of waiting time, and duration of service time. To verify, a simulation process must first be carried out with the initial composition. The output of this process will be compared to verify the model. If the results are conformable, then the model is verified.

Table 3. Comparison of Simulation Output to Observational Data

Measurement Criteria	Period	Simulation Output	Observational Data (CI 95%)	Notes
Number of Visit				
Cashier	08.00 – 20.00	56	48 – 59	Verified
CS	08.00 – 11.00	70	68 – 79	Verified
CS	11.00 – 16.00	149	133 – 150	Verified
CS	16.00 – 19.00	76	67 – 76	Verified
CS	19.00 – 24.00	60	55 – 64	Verified
Waiting Time (second)				
Cashier	08.00 – 20.00	460	439 – 464	Verified
CS	08.00 – 11.00	832	786 - 865	Verified
CS	11.00 – 16.00	624	615 – 668	Verified
CS	16.00 – 19.00	802	763 – 832	Verified
CS	19.00 – 24.00	415	414 – 481	Verified
Service Time (second)				
Cashier	08.00 – 20.00	446	424 – 447	Verified
CS	08.00 – 11.00	899	847 – 921	Verified
CS	11.00 – 16.00	1090	1055 – 1100	Verified
CS	16.00 – 19.00	914	868 – 925	Verified
CS	19.00 – 24.00	992	984 – 1043	Verified

One of the steps that must be passed before developing an alternative model is to verify the initial model by comparing the simulation results of the initial model with the observation data. With a confidence interval of 95%, the comparison results can be seen in Table 3

4.4 Summary of Simulation Output

After simulating several alternative models in each period, a comparison of the simulation output will be carried out as follows:

Table 4. Comparison of Simulation Output among Alternative Models

Period / Model	Waiting Time		Service Time		Number of Queue	
	Average	Half Width	Average	Half Width	Average	Half Width
Period 1 (08.00 – 11.00)						
Model Initial (7 CS)	832.45	181.79	899.54	51.01	7	1
Model Alternative 1 (6 CS)	1077.37	208.06	870.29	46	9	2
Model Alternative 2 (5 CS)	1508.14	228.35	822.97	46.33	12	2

Table 4. Comparison of Simulation Output among Alternative Models (cont.)

Period 2 (11.00 – 16.00)						
Model Initial (11 CS)	624.27	145.59	1090.61	29.33	6	1
Model Alternative 1 (10 CS)	942.93	201.19	1073.21	29.43	9	1
Model Alternative 2 (9 CS)	1533.88	283.67	1076.24	36.06	15	3
Period 3 (16.00 – 19.00)						
Model Initial (8 CS)	802.78	200.57	914.32	38.22	8	2
Model Alternative 1 (7 CS)	1141.36	211.59	888.99	38.87	11	2
Model Alternative 2 (6 CS)	1596.47	253.68	917.96	50.10	16	2
Period 4 (19.00 – 24.00)						
Model Initial (5 CS)	415.66	41.75	992.73	169.73	1	0
Model Alternative 1 (4 CS)	967.09	371.29	955.12	48.79	3	1
Model Alternative 2 (3 CS)	1771.03	370.45	953.46	62	7	1

Analysis of the simulation results was carried out using the main parameters shown in Table 4, namely: waiting time - service time and number of queues. Based on the SLA, the maximum average waiting time is 1200 seconds and the maximum average service time is 900 seconds. Table 4 shows that at each period Model Alternative 1 meets the SLA waiting time target. Meanwhile, Model Alternative 2 produces a waiting time value that exceeds the specified SLA.

5. CONCLUSION

The results of the simulation process can provide an overview for stakeholders in planning the physical design and the number of Customer Services required to deliver excellent service. In terms of efficiency, the results of the initial model simulation process indicate the possibility of increasing efficiency.

From the series of experiments that have been carried out, there are two alternatives models that provide efficiency from 9.7% (6CS/10CS/8CS/4CS) to 12.9% (6CS/10CS/7CS/4CS). The results of this study can be an alternative method for Telkomsel in determining the minimum number of customer service at GraPARI. Operational costs for services can be minimized and customer satisfaction can be maintained.

6. REFERENCES

Banks, J., 2014. Discrete Event System Simulation. 5th ed. New Jersey: Pearson Education. Burhanuddin, A., 2020. Penelitian Kuantitatif dan Kualitatif. [Online] Available at: https://afidburhanuddin.wordpress.com/2013/05/21/penelitian-kuantitatif-dan-kualitatif/ [Accessed 20 May 2020].

Bustani, H., 2005. Fundamental Operation Research. Jakarta: PT Gramedia Pustaka Utama.

Ceballos, G. & Curtis, O., 2004. Queue Analysis at Toll and Parking Exit Plazas: A Comparison between Multi-server Queuing Models and Traffic Simulation. Lake Buena Vista, Florida, ITE 2004 Annual Meeting and Exhibit.

Cildoz, M., Ibarra, A. & Mallor, F., 2019. Accumulating priority queues versus pure priority queues for managing patients in emergency departments. Science Direct, Volume 23.

Fuentesa, A., Heaslipa, K., Sisneros-Kiddb, A. M. & D'Antonioc, A., 2019. Evaluating National Park entrance station queues: A case study in Grand Teton National Park. Science Direct, Volume 7, pp. 363-374.

Glints, 2020. Pentingnya Customer Service (CS). [Online] Available at: https://glints.com/id/lowongan/apa-itu-customer-service/ [Accessed 20 May 2020].

Hasad, A., 2011. Verifikasi dan Validasi dalam Simulasi. [Online] Available at: https://andihasad.com/2011/11/04/verifikasi-dan-validasi-dalam-simulasi-model/ [Accessed 20 May 2020].

Herjanto, E., 2009. Sains Manajemen: Analisis Kuantitatif Untuk Pengambilan Keputusan. Jakarta: PT. Gramedia Widiasarana Indonesia.

Houdt, B. V. & Blondia, C., 2007. Approximated Transient Queue Length and Waiting Time Distributions via Steady State Analysis. TaylorA and Francis Online, pp. 725-744.

Jessica, C., 2020. Berpengaruh dalam Bisnis, Apa Itu Customer Service?. [Online] Available at: https://glints.com/id/lowongan/apa-itu-customer-service/ [Accessed 20 May 2020].

Law, A. M., 2014. Simulation Modeling and Analysis. 5th ed. New York: Mc. Graw Hill Education.

M.Tran, H. & Bukkapatnama, S. T., 2015. Modeling and analysis of the coupled dynamics of machine degradation and repair processes using piecewise affine stochastic differential equations. Science Direct, Volume 76, pp. 87-99.

Moghazy Abdel-Aal, M. M., 2020. Survey-based calibration of a parking entry as a single- server mathematical queuing model: A case study. Science Direct, 59(2), pp. 829-838.

Porter, M., 2020. Cost Leadership in Business Strategy. [Online] Available at: https://en.wikipedia.org/wiki/Cost_leadership [Accessed 20 May 2020].

Rangkuti, A., 2019. 7 Model Riset Operasi dan Aplikasinya. Tebing Tinggi: Firstbox Media Siregar,

K., 2016. Simulasi Dan Pemodelan (Aplikasi Untuk Keteknikan Pertanian). Yogyakarta: CV Budi Utama.

Takahashi, Y. & Miyazawa, M., 2007. Relationship between queue length and waiting time in a stationary discrete-time queue. Taylor and Francis Online, pp. 249-271.

Tayfur Altiok, B. M., 2007. Simulation Modeling and Analysis with Arena. s.l.:Academic Press .

Taylor, N. B., 2017. Predicting queue variability to enable analysis of overload risk. Taylor and Francis Online, pp. 37-57.

Telkomsel, 2020. Daftar GraPARI Telkomsel Nasional. [Online] Available at: https://www.telkomsel.com/en/contact-us/my-grapari [Accessed 20 May 2020].

Wadiyo, S., 2020. Manajemen Keuangan Laporan Laba Rugi. [Online] Available at: https://manajemenkeuangan.net/laporan-laba-rugi/ [Accessed 20 May 2020].

Wahyu, A., 2017. Riset Operasi. Yogyakarta: Instiper Yogyakarta. Wang, J., Baron, H. A.-M. O. & Berman, O., 2019. Tandem queues with impatient customers. Science Direct, Volume 135.

Wulan, 2020. Memahami SLA untuk Mengelola Harapan Pelanggan. [Online] Available at: http://shiftindonesia.com/memahami-sla-untuk-mengelola-harapan-pelanggan/ [Accessed 20 May 2020].

Zirem, D., Boualem, M. & Aïssani, K. A.-A. &. D., 2018. Analysis of a single server batch arrival unreliable queue with balking and general retrial time. Taylor and Francis Online, pp. 672-695.

ANALYSIS OF FACTORS AND RISK PRIORITY NUMBER (RPN) IN MAINTENANCE AND SCHEDULING OF CABIN MATERIALS IN AIRCRAFT TYPE B737-800

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ABSTRACT

Despite slowing global economic growth, the aviation industry in Indonesia is predicted to continue growing. The growth of the aviation industry in Indonesia creates opportunities forthe aircraft maintenance industry to increase its existence and revenue. In carrying out cabinmaintenance, when the component is damaged, the maintenance stepused so far is to replacethe component immediately with the new component due to the short transit time of the aircraft. The objective of this study is to analyze the factors that cause cabin components to break down quickly, using the Failure Mode Effects &Analysis (FMEA) analysis and comparing the Risk Priority Number (RPN) value of each aircraft registration and component, so that priority can be identified for aircraft registration. This research is compiled on the basis of previous research related to the Failure Mode Effects & Analysis (FMEA) analysis. In the first, the Pareto diagram shall be analyzed for each factor, including flight routes, the total flight hours and the number of maintenance performed, so that the dominant factors for each flight are known. The results of the Pareto diagram analysis followed by a fishbone diagram analysis to determine the factors causing damage to the cabin components. Testing is done bycomparing the Mean Time Between Failure (MTBF) value with the Mean Time Limit (MTL) value. Compare the risk priority number (RPN) value of each aircraft registration and component so that maintenance can be prioritized. The results showed that the most common failure components were heater water at 26.64% and oven at 26.48% . Therisk priority number (RPN) value for each registration with the highest RPN is PK-GMA registration with a value of 2159. For Mean Time Limit Analysis (MTL) 8 Part Numberof the 18 components included in the criteria below, including heater water and oven.

Keywords: Mean Time Between Failure, Risk Priority Number, Failure Mode Effect Analysis

1. INTRODUCTION

The Indonesian economy, represented by the growth value of the Gross Domestic Product (GDP), has experienced a decline in growth from 5.2% in 2018 to 5.0% in 2019. Overall, the global aviation industry experienced a decline in performance in 2019 compared to 2018. Passenger traffic(Revenue Passenger Kilometers/RPK) increased by 4.2 per cent in 2019, down from 7.4 per cent in2018. The International Air Transport Association (IATA) estimates that the number of air passengers worldwide will reach 7.8 billion by 2036. The growth of the aviation industry in Indonesia will lead to competition in the aircraft maintenance industry. Aircraft maintenance companies or Maintenance, Repair and Overhaul (MRO) have an important role to play in maintaining the operational, safety and airworthiness aspects of aircraft. Maintenance of components is one of the company's main objectives in increasing revenue, as this segment is considered to be potential and capable of being worked on by the company. The implementation of component maintenance aims to increase the value of the Mean Time Between Failure (MTBF) so that the availability of components is also increased.

Each component has a certain age limit, so that the engine or aircraft component must be replaced when the component cannot work optimally after several repairs have been made (Weckman & Marvel, 2001). Analysis of the minimal repair system used to determine the policy for replacing the component by replacing it in the T-period or when the N-th failure occurs, depending on which component occurs first (Nakagawa & Kowada, 1983). Component reliability analysis is generally divided into two methods, namely quantitative analysis and qualitative analysis. The Failure Mode Effects Analysis (FMEA) is one form of qualitative reliability analysis (Priyanta,2000). Qualitative methods are dynamic, which means that they are always open to changes, additions and substitutions during the analysis process (Srivastava & Thomson, 2009).

Failure Mode Effects Analysis (FMEA) is a methodology used to evaluate system, design, process, or service failures (Stamatis, 1995). Knowing the reliability of the cabin aircraft components by knowing the routes of the B737-800 aircraft which are the destination routes, the frequency of flights to certain areas and the number of flight hours and flight cycles taken by the Failure Mode Effects Analysis (FMEA) method. From the information obtained, it can be used as atool to determine the maintenance program to be carried out next.

2. METHOD

Preventive Maintenance is intended to prevent failure of the equipment/component by replacing or overhauling the equipment before it is damaged. The priority for improvement can be determined by knowing the dominant causes that should be limited first. Improvements to the dominant causative factor will have a greater effect than the resolution of the less significant causes(Sritomo,2003).

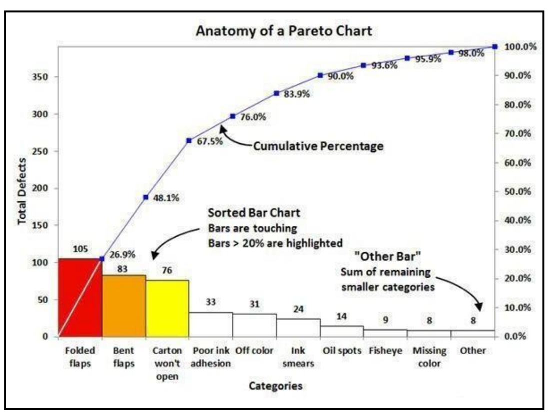

Figure 1. Pareto Diagram (Sritomo,2003)

Pareto diagrams can be used as an interpretive tool to: determine the relative frequency andorder of importance of problems or causes of existing problems and focus attention on critical and important issues through ranking problems or causes of problems in another significant form.

This diagram is often referred to as a diagram of a fishbone. Because it looks like a skeleton of fish. The cause and effect diagram is a diagram showing the relationship between cause and effect. This diagram is used to show the factors that cause (cause) and the characteristics of the quality (effect) caused by these causative factors. This way, you can see what causes the most seriousproblems.

The reliability of the product can be described as the probability value of the components that make up the product to run properly within a certain period of time. The most optimal performance is the Useful Life-Period in Region II. While the limitations of the engine in questioninclude temperature, voltage, etc., all of which are specified in the engine specifications. If the machine is forced to operate outside these limits, the machine will end up failing and its reliability will reach its lowest point. Region II is what determines the life of the equipment, so how to improveit so that the conditions in Region II can be longer.

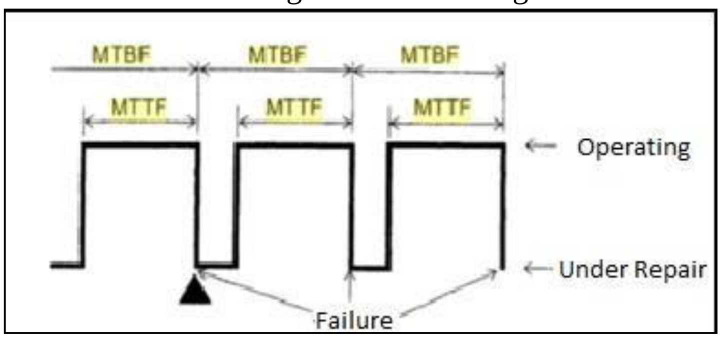

Figure 2. The Difference Between MTBF and MTTF (Hurst,2006)

The method used to explain the occurrence of failures is to state the Mean Time Between Failures (MTBF = Mean Time Between Failure) and Mean Time to Failure (MTTF = Mean Time To Failure). MTBF is calculated by formula:

$$\mathbf{MTBF} = \frac{Total\ Uptime}{Number\ of\ Failures}$$

FMEA is a risk assessment method that focuses more on failure and uses certain scales to conduct risk assessments (Kurniawan, 2013). FMEA is a tool used to analyze the reliability of the system and the causes of its failure to meet the system, design and process reliability and security requirements by providing basic information on system reliability, design and process predictions.

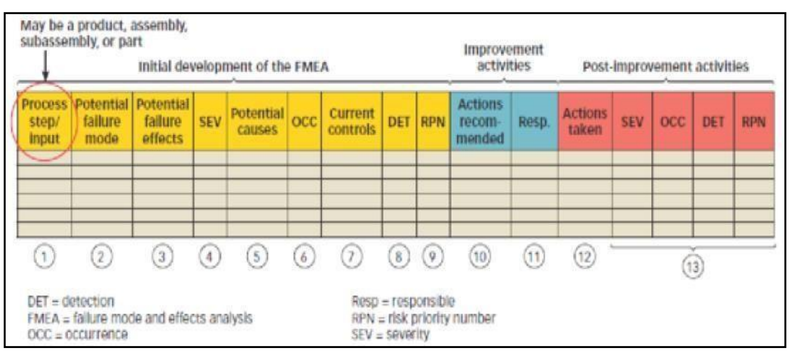

Figure 3. Example of Failure Mode and Effects Analysis (FMEA)

The FMEA analysis focuses on the causes of the damage and the mechanisms by which thedamage occurred. When the cause and mechanism of the failure have been identified for each failuremode, suggestions may be made on the timing of preventive maintenance or the planning of monitoring actions to reduce the failure rate. Each subject is calculated by multiplying the Severity,Occurrence and Detection as in the following equation:

$$\text{RPN} = \textit{Severity} \times \textit{Occurrence} \times \textit{Detection}$$

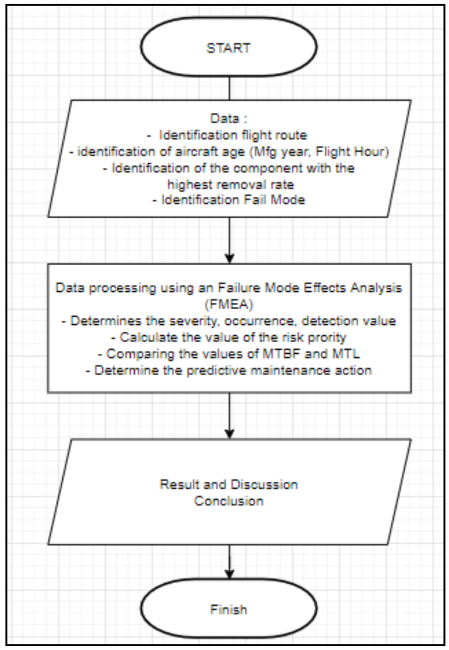

Figure 4. Method of Research Using Failure Mode and Effects Analysis (FMEA)

3. RESULT AND DISCUSSION

3.1 Comparison of Flight Hour (FH) Tables with Mean Time Between Unscheduled Removal(MTBUR) Value

Table of comparisons between Flight Hour (FH) and Mean Time Between Unscheduled Removal (MTBUR) is shown in Table 1.

Table 1. Comparison of Flight Hour (FH) Value with MTBUR

No	Part Name	P/N	FH	MTBUR	REMOVAL
1	BLOWER ASSY (SPEC S417T102-1)	606802-2	214,521.95	23,836	9
2	BLOWER ASSY (SPEC S417T102-5)	645172-2	214,521.95	16,502	12
3	COMPRESSOR ASSY-POTABLE	28823-7	214,521.95	71,507	3
4	FAUCET	AR9030-3D3D492	214,521.95	107,261	2
5	HEATER ASY-WATER, LAV BC3,	24E507040G04	214,521.95	30,646	7
6	HEATER,WATER (AS PN. 4360004-85-0018)	4360004-85-00-18	214,521.95	4,903	175
7	MAST AY	5E2675-15	214,521.95	143,015	3
8	MEGAPHONE (TPN ACR/EM-1A)	ACREM1A	214,521.95	5,877	73
9	OVEN	67262-001-003	214,521.95	357,537	3
10	OVEN	8201-11-0000A	214,521.95	536,305	2

11	OVEN (BOEING P/N BBDREF004976900)	4323070-00-66-26	214,521.95	6,164	174
12	OVEN	4323100-00-66-22	214,521.95	118,542	62
13	RAPID WATER HEATER	L13471-12M	214,521.95	85,809	10
14	RAPID WATER HEATER	L13471-12M-RYAN	214,521.95	286,029	3
15	TOILET (SPEC S417T104-55)	15800-029-3	214,521.95	2,167	99
16	VACUUM TOILET	15800-019-1	214,521.95	214,522	1
17	WATER HEATER DR40 SERIES	72184011B	214,521.95	122,584	7
18	WATER HEATER	AR9042-11	214,521.95	17,877	12
			Total	2,151,083	657

Flight Hour (FH) describes the number of operating hours of the B737-800 aircraft from January 2019 to June 2020. Meanwhile, Mean Time Between Unscheduled Removal (MTBUR) is an operating measurement where, if the component is removed from the aircraft due to failure, the value is the same as the Mean Time. Between Failures (MTBF). The MTBUR value is derived fromFH x The number of components installed in the aircraft divided by the removal part. Part removalis a component that was removed from the aircraft during the period from January 2019 to June 2020. The total components removed during this period were 657 components.

3.2 Mean Time Limit

Mean Time Limit (MTL) is the average time limit for a component that is required to performa maintenance program if the component fails before the time limit, the component must be removed and then sent to the repair shop. The standard Mean Time Between Unscheduled Removal from Manufacture is the component life reference in the cabin components. The comparison table for the Mean Time Limit (MTL) value with the Mean Time Between Unscheduled Removal (MTBUR) isshown in Table 2.

Table 2. Comparison of Mean Time Limit (MTL) Value to MTBUR Value

No	Part Name	P/N	Mean Time Limit (MTL)	MTBUR	Criteria
1	BLOWER ASSY	606802-2	43,800 hrs	23,836 hrs	*Below*
2	BLOWER ASSY	645172-2	43,800 hrs	17,877 hrs	*Below*
3	COMPRESSOR ASSY-POTABLE	28823-7	13,140 hrs	71,507 hrs	*Higher*
4	FAUCET	AR9030-3D3D492	25,500 hrs	107,261 hrs	*Higher*
5	HEATER ASY-WATER, LAV BC3,	24E507040G04	43,800 hrs	30,646 hrs	*Below*
6	HEATER,WATER	4360004-85-00-18	30,300 hrs	4,903 hrs	*Below*
7	MAST AY	5E2675-15	80,000 hrs	143,015 hrs	*Higher*
8	MEGAPHONE	ACREM1A	78,840 hrs	5,877 hrs	*Below*
9	OVEN	67262-001-003	2156 hrs	357,537 hrs	*Higher*
10	OVEN	8201-11-0000A	2156 hrs	536,305 hrs	*Higher*
11	OVEN	4323070-00-66-26	8000 hrs	6,164 hrs	*Below*
12	OVEN	4323100-00-66-22	2156 hrs	118,542 hrs	*Higher*
13	RAPID WATER HEATER	L13471-12M	30,300 hrs	85,809 hrs	*Higher*
14	RAPID WATER HEATER	L13471-12M-RYAN	30,300 hrs	286,029 hrs	*Higher*
15	TOILET	15800-029-3	16,100 hrs	2,167 hrs	*Below*
16	VACUUM TOILET	15800-019-1	16,100 hrs	214,522 hrs	*Higher*
17	WATER HEATER DR40 SERIES	72184011B	3000 hrs	122,584 hrs	*Higher*
18	WATER HEATER	AR9042-11	43,800 hrs	17,877 hrs	*Below*

The Mean Time Limit (MTL) value was compared to the Mean Time Between Unscheduled Removal (MTBUR) value to determine the condition of the components. In this study, 3 criteria areused to determine the condition of the components and it is expected that the components will havenormal conditions or above the mean time limit (MTL).

a. Higher if the value of MTBUR is greater than the value of MTL.
b. Normal If the value of MTBUR is the same as the value of MTL
c. Below If the value of the MTBUR is less than the value of the MTL

Of the components that have the following criteria, 5 of them have a high level of removal during the period from January 2019 to June 2020. This makes it necessary for the company to prioritize the handling and analysis of these 8 components. In order for the Mean Time Between Unscheduled Removal (MTBUR) to be able to enter normal or even higher criteria.

3.3 Flight Route of Pareto

For the echo series, PK-GEM registrations cover the majority of routes with the CGK (Cengkareng Jakarta)-BTH (Hang Nadim Batam) route and the number of flights between January2019 and June 2020 is 825 times. Whereas for the Foxrot series PK-GFY registration, the most frequent flights are CGK (Cengkareng Jakarta)-SUB (Juanda Surabaya) and the number of flights between January 2019 and June 2020 is 1005 times. There are no special cabin units/staff at BTH airport, while there are special cabin crews/staff at SUB airport.

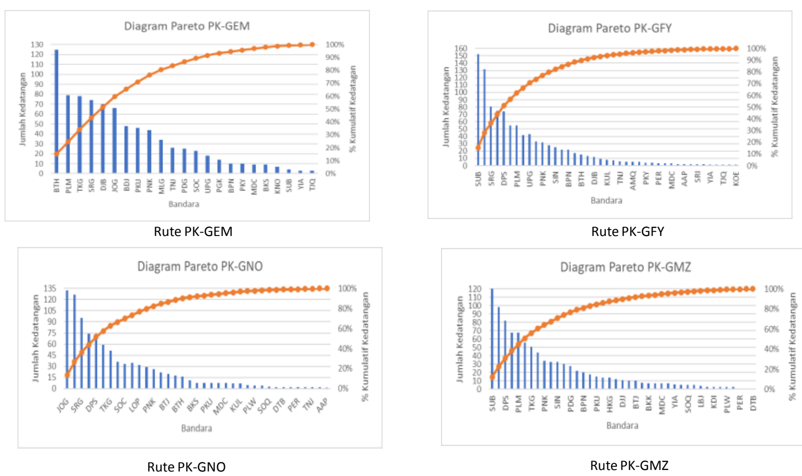

Figure 5. Flight route diagram of Pareto

According to the Pareto principle, 80 per cent of the reaction actually results from only 20 per cent of the action taken. It can therefore be concluded that the CGK-BTH route for registrationPK-GEM, CGK-SUB for registration PK-GFY, CGK-SUB for registration PK-GNO, CGK-SUB for registration PK-GMZ, CGK-JOG for registration PK-GNO are the most research-oriented routes.

3.4 Cabin Components of Pareto

The amount of Cabin Component Damage Data for Boeing 737-800 can be seen in Figure 6.

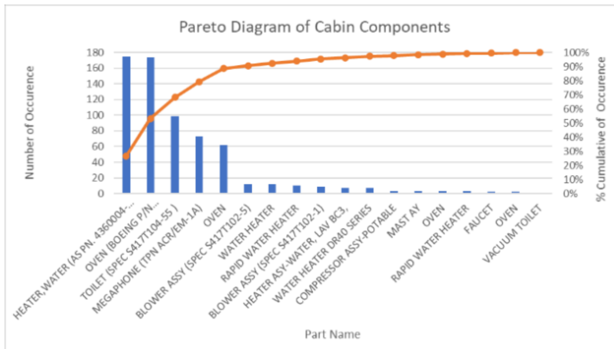

Figure 6. B737-800 Pareto Cabin Components

Based on the picture above, according to the Pareto principle, which states that 80 per cent of the reaction is actually generated by only 20 per cent of the action taken. It can be concluded that20 per cent is a priority during scheduled or unscheduled maintenance and that 4 components are available for light and heavy maintenance, namely the water heater, the oven, thetoilet and the megaphone. These 4 components are vital components when the cabin crewperforms passenger services. Particularly because the Garuda Indonesia airline is a 5-star skytrax aircraft, so that it mustbe excellent in terms of service and the safety aspect is also very importantin flight.

3.5 Fishbone Flight Route

The low frequency of flights to small airports means that the MRO company does not placea large number of personnel, materials and equipment at these small airports because it will result in high costs. One way is to prepare 1 or 2 people living at a small airport (at most) or to send engineering on board during the flight. The Fishbone Chart for Flight Routes is shown in Figure 7.

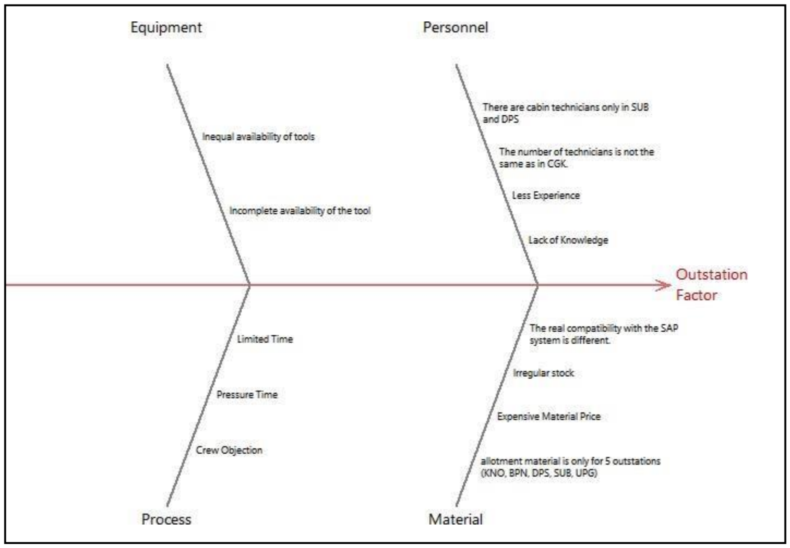

Figure 7. Fishbone Flight Route

Material costs are one of the factors that have so far affected the company's operating costs.Although material costs decreased by 35 per cent from 2019, this is due to the large number of non- flying aircraft carrying out prolonged inspections so that material cost efficiency can be achieved.

3.6 Failure Mode Effects Analysis (FMEA)

After analyzing the Pareto diagram and the fishbone diagram, the next step is to perform theFailure Mode Effects Analysis (FMEA) to obtain the individual Risk Priority Number (RPN) and the Risk Priority Number group (RPN). Of the 73 B737-800 aircraft, 28 were obtained from the Pareto diagram analysis, which was the priority handling when the aircraft was in transit or remainedovernight (RON). The creation of a Failure Mode Effects Analysis (FMEA) table for the components indicated by the files in each fleet can be seen in the table 3.

Table 3. FMEA PK-GFY

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
(DESIGN FMEA)

Aircraft Type: B737-800
Registrasi: PK-GFY
Model Years: 2013

Design Responsibility: PT GMF Aeroasia
Rev Date : 2020

Id Number: 581635
Prepared By : Rommy Hudallah Ramadlan
FMEA Date
Rev

FMEA Process

No	Item and Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential Cause(s) of mechanism(s) of Failure	Occ	Current Design Control	Detc	RPN	Recommended Action(s)
	OVEN AFT	OCM U/S	The oven cannot be operated	7	The oven has been in operation for too long, causing it to overheat, to overheat.	7	Reset the CB, replace the oven	5	245	The monitoring program on condition shall be carried out in accordance with the schedule.
		OVEN NOT HOT	Meals may not be reheated during the flight	6	Putting metal objects like spoons, forks, etc.	8	Reset the CB, replace the oven	4	192	The monitoring program on condition shall be carried out in accordance with the schedule.
	Heater Water	LEAK	May cause flooding in the galley area of the aircraft	6	water connection hose leak, self-ventingvalve leak	8	Replacement of the oring on the nipple, the water level sensor is normal	4	192	The monitoring program on condition shall be carried out in accordance with the schedule.
		NOT HOT	Cannot make coffee or tea on a flight	6	Heating element defective, power cable defective	7	Water quality must comply with regulations	5	210	The monitoring program on condition shall be carried out in accordance with the schedule.
	Toilet Assy	CAN'T FLUSHING	Lavatory may not be used for operations	8	Reset the Flushing Control Unit too often	10	Maximum of 2 times to reset the Flushing Control Unit	2	160	The monitoring program on condition shall be carried out in accordance with the schedule.
							Total RPN		999	

The registration PK-GFY has a total RPN value of 999. Between January 2019 and June

2020, PK-GFY suffered 3 damages to the cabin components, including the oven post aft, the heaterwater and the toilet assy. The calculation of the heater water component is as follows, since it has 2points of potential failure mode, the oven has 2 RPN values. For heater water leakage, the calculationis 6 x 8 x 4 = 192. While the calculation is 6 x 7 x 5 = 210 for heater water not hot.

Table 4. FMEA Analysis Ranking Results

A/C REG	Component Removal	Total RPN	Average	Ranking RPN
PK-GFY	3	999	333	26
PK-GNO	4	1503	375.75	20
PK-GMZ	3	1175	391.67	25
PK-GNH	4	1335	333.75	24
PK-GMX	5	1895	379	10
PK-GNI	4	1903	475.75	8
PK-GFJ	5	1599	319.80	17
PK-GFQ	4	1626	406.50	16
PK-GMY	5	2063	412.60	2
PK-GNK	4	1503	375.75	20
PK-GFN	4	1903	475.75	8
PK-GFO	5	1999	399.80	5
PK-GEM	3	1343	447.67	23
PK-GMP	5	1999	399.80	5
PK-GME	4	1735	433.75	14
PK-GFK	5	2063	412.60	2
PK-GEN	3	967	322	27
PK-GMO	5	1895	379	10
PK-GMK	5	1895	379	10
PK-GMF	4	1559	389.75	18
PK-GFF	5	2063	412.60	2
PK-GFI	5	1895	379	10
PK-GEP	4	1735	433.75	14
PK-GMA	6	2159	359.83	1
PK-GMC	2	597	298.50	28
PK-GMG	4	1503	375.75	20
PK-GMD	4	1559	389.75	18
PK-GMH	5	1987	397.40	7

Following analysis of the FMEA for 28 aircraft, a ranking was carried out to determine priority handling during transit or to remain over night maintenance. Registration that receives priority handling based on the value of the risk priority number (RPN) is PK-GMA. The high risk priority number (RPN) value is affected by the high number of damaged components.

Table 5 RPN Value Rating Results for each component

No	Part Name	Part Number	Component Removal	Maintenance Program	S	O	D	RPN S x O x D
1	BLOWER ASSY (SPEC S417T102-1)	606802-2	9	*Hard Time*	7	6	4	168
2	BLOWER ASSY (SPEC S417T102-5)	645172-2	12	*Hard Time*	7	6	4	168
3	COMPRESSOR ASSY-POTABLE	28823-7	3	*On-Condition Monitoring*	3	4	7	84
4	FAUCET	AR9030-3D3D492	2	*On-Condition Monitoring*	5	4	6	120
5	HEATER ASY-WATER, LAV BC3,	24E507040G04	7	*On-Condition Monitoring*	4	4	6	96
6	HEATER,WATER (AS PN. 4360004-85-0018)	4360004-85-00-18	175	*On-Condition Monitoring*	6	8	4	192
					6	7	5	210
7	MAST AY	5E2675-15	3	*Condition Monitoring*	6	4	5	120
8	MEGAPHONE (TPN ACR/EM-1A)	ACREM1A	73	*On-Condition Monitoring*	7	8	5	280
					7	8	5	280
9	OVEN	67262-001-003	3	*On-Condition Monitoring*	7	7	5	245
					6	8	4	192
10	OVEN	8201-11-0000A	2	*On-Condition Monitoring*	8	7	5	280
					7	8	4	224
11	OVEN AFT	4323070-00-66-26	174	*On-Condition Monitoring*	7	7	5	245
					6	8	4	192
	OVEN FWD	4323100-00-66-22	62	*On-Condition*	8	7	5	280

				Monitoring	7	8	4	224
13	RAPID WATER HEATER	L13471-12M	10	*On-Condition Monitoring*	6	8	4	192
14	RAPID WATER HEATER	L13471-12M-RYAN	3	*On-Condition Monitoring*	6	7	5	210
15	TOILET (SPEC S417T104-55)	15800-029-3	99	*On-Condition Monitoring*	8	10	2	160
16	VACUUM TOILET	15800-019-1	1	*On-Condition Monitoring*	8	8	2	128
17	WATER HEATER DR40 SERIES	72184011B	7	*On-Condition*	6	8	4	192
				Monitoring	6	7	5	210
18	WATER HEATER	AR9042-11	12	*On-Condition Monitoring*	4	6	6	144

The oven and megaphone components have the highest RPN values, and the high occurrence value is one of the factors that affect them.

4. CONCLUSION

Based on the results of the analysis using the Pareto diagram, the Fishbone diagram and theFailure Mode Effects Analysis (FMEA), the factors causing damage to the cabin components, namely the amount of maintenance performed between January 2019 and June 2020. In addition, the number of flight hours and flight cycles is directly proportional to the number of maintenance, because the number of maintenance is calculated on the basis of the number of flight hours so that the more flight hours the fleet has, the more treatments it passes and the number of damaged components is high, such as the PK-GMA registration, which has the most damaged component.

From the analysis using the Pareto diagram, the fishbone diagram and the Failure Mode Effects Analysis (FMEA), the maintenance pattern of the cabin components followed the maintenance program owned by the airline. However, with the changes that occur as a result of some maintenance in the cabin, adjustments are made, such as not lowering the job card for an operating control oven and a water heater with a 2WY interval and a 2YR job card service interval. In addition, the interval adjustment for the toilet assy component is a detailed visual inspection from1MO to 4MO. Cleaning the job. The toilet assy component has an interval of 1C, which means thatit can only be maintained on the base and cannot be maintained on the line due to limited time.

5. REFERENCES

AirlineIndustryOutlook(2020),fromhttps://www.iata.org/en/iata-repository/publications/economic-reports/airline-industry-economic-performance-december-2019---presentation/ [AccessedJune 27, 2020].

Barosz, P., Burlikowska, M.D. dan Roszak, M. (2018), "The application of the FMEA method in the selected production process of a company", *Production Engineering Archives*, Vol. 18, hal. 35-41.

Benjamin S.B. (1995), *Maintainability : A key to Effective Serviceability And Maintenance Management*, A Willey – Interscience Publication, New York.

Bentley, John .P, (1999), *Introduction to Reliability and Quality Engineering*, 2nd edition, Addison-Wesley, England.

Burlikowska, M.D. (2011), "Application of FMEA method in enterprise focused on quality", *Journal of Achievements in Materials and Manufacturing Engineering*, Vol. 45, Issue 1, hal 89-102.

Carlson, C.S. (2012), *Effective FMEAs: Achieving Safe, Reliable, and Economical Products and Processes Using Failure Mode and Effect Analysis*, John Wiley & Sons, Inc., New Jersey, Canada.

Carlson, C.S. (2014). *Understanding and Applying the Fundamentals of FMEAs*. Tutorial Notes on 2014 Annual Reliability and Maintainability Symposium (AR&MS). ReliaSoft Corporation.

Chrysler, C. (1995), *Potential Failure Mode* & *Effect Analysis* (FMEA), 2nd Edition, , Ford Motor Company, General Motors Corporation.

Ebeling, C.E. (1997). *An Introduction to Reliability and Maintainability Engineering*. The McGraw-Hill Companies, Inc. Singapore.

Forsthoffer, W. (2005), *Rotating Equipment Handbook: Principles of Rotating Equipment*, 1st edition, Elsevier Science, Amsterdam.

Giannakis, Mihalis dan Papadopoulos T. (2015), *Supply chain sustainability : A risk management approach*, International Journal Production Economics.

Global Economic Prospects, from https://www.worldbank.org/en/publication/global-economic-prospects [Accessed June 27, 2020].

Hurst, S.K (2006), *Engineering Design Principles*, 1st edition, Elsevier Ltd. The Boulevard, Langford Lane Kidlington, OX5 16B, England.

Nakagawa, T. dan Kowada, M. (1983). "Analysis of a systems with minimal repair and its application to replacement policy". *European Journal of Operational Research*. Vol. 12, pp. 176-182.

Priyanta, D. (2000), *Reliability and Maintenance Teaching Modules. Marine Engineering*, Facultyof Marine Technology, Sepuluh Nopember Institute of Technology. Surabaya.

Smith, D.J. (2005), *Reliability Maintainability And Risk*, Seventh Ed, Butterworth-Heinemann, England.

Sritomo, W. (2003), *Introduction to Industrial Engineering and Management*, Widya Guna, Surabaya.

Srivastava, A. dan Thomson, S.B. (2009). "Framework analysis: a qualitative methodology for applied policy research". *JOAAG*, Vol. 4, No.2.

Stamatis, D.H. (1995), *Failure Mode And Effect Analysis: FMEA from Theory to Execution*, SecondEdition, ASQ Quality Press, Milwaukee.

Stamatis, D.H. (2019), *Risk Management Using Failure Mode And Effect Analysis*, First Edition, ASQ Quality Press, Milwaukee.

Tobias, P.A dan Trindade, D.C, (1995), *Applied Reliability*, 2nd edition, Kluwer Academic Publisher, Norwell, Massachusetts.

Utama, F.Y. (2012), *Modeling and Reliability Simulation of Boeing 737-300/-400 aircraft components at PT. Airline Merpati Nusantara*, master's thesis of engineering, Sepuluh Nopember Institute of Technology, Surabaya.

Weckman, G. R., Shell, R. L., dan Marvel, J. H. (2001). "Modeling the Reliability of Repairable System in the Aviation Industry". *Computers* & *Industrial Engineering*, hal. 51-63.

DETERMINATION OF TRANSFORMER LOAD AT PT PLN (PERSERO) RUNGKUT SUBSTATION TO MAINTAIN TRANSFORMER HEALTH INDEX

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ABSTRACT

As a company engaged in electricity, PLN must be able to supply electricity to customers. The electricity business process starts from generation, transmission and distribution. The distribution system receives electricity from a source, namely transmission using a transformer where the transformer works according to the load on the customer. PT PLN (Persero) seeks to improve services and supply of electricity in Indonesia, including in the East Java region. To improve service, it is necessary to maintain equipment assets. In the distribution system of equipment assets owned, one of which is a transformer. Maintaining the Health Index Transformer through loading according to the standard of 80% is one way to keep equipment assets from being damaged quickly and to maintain the life of the transformer. To determine the load, the analysis was carried out at PT PLN (Persero) East Java's Rungkut Substation Transformer which has many industrial customers. The analysis for determining the transformer load for the following year will be carried out using Time Series Regression with the determination of the transformer loading standard referring to SE 0017 / E / DIR / 2014 which applies to PLN. From the results of this research analysis can be obtained prediction transformer loading for the next year, namely 2021 along with the state of the transformer and the condition of the transformer is still in the sufficient categoryso that if there is an additional load from installing new customers or adding power, the transformer is still capable.

Keywords: Forecasting; Electric Load; Time Series Regression.

1. INTRODUCTION

Electricity consumption in Indonesia has increased every year in line with the progress of the industrial economy and technology with the demand for electricity in Indonesia. Electricity sources in East Java are supplied from various power plants located in Gresik, Tuban, Pacitan and Probolinggo.

Of the 3 PLN business processes, namely Generation, Transmission and Distribution. The distribution system is a system that has an important role with the relationship to energy consumption or consumers, both consumers with high, medium and low voltage. The distribution system receives electrical power from a source, namely transmission, then converts the voltage before it goes to the customer using a transformer to adjust the specifications in the transformer. To maintain electrical reliability, transformer loads are not recommended to reach 100% becauseit causes the transformer to heat up and transformer interference. Damage to the transformer causes reliability to customers to decrease due to disruption of the continuity of electricity service to customers to be disrupted or blackouts. A good transformer loading is if it is loaded with 80% according to SE 0017 / E / DIR / 2014 Regarding the Health Index Transformer. Based on the existing problems from previous research, the researcher wants to take the case of determining the electrical load taking place at the Rungkut Substation Transformer at PT PLN (Persero) East Java. Transformer rungkut substation has a large segment of industrial customers so that the potential loading for transformers is higher than household customers. The determination of the electrical load for the next year, namely 2021, uses the Time Series Regression method, Dordonnat et al (2016). The variables used are X, namely the month and Y, namely the electric load on the transformer. Furthermore, the load data that has been calculated will be calculated the percentage loading of the transformer.

The author hopes that this research can provide input to company management.

2. RESEARCH FRAMEWORK

2.1 Time Series

Time series or what is known as time series are observations obtained based on correlating time sequences so that each observation is taken to correlate with its own variables at the previous time (Wei, 2006).

Time series systematically, defined by the values of Y1, Y2, ... Yi of a variable Y (temperature, sales, etc.) for points in time t1, t2, ti so that, Y is a function of t and is symbolized by Y = F (t), Spiegel et al (2004).

2.2. Time Series Regression Analysis

The model used to determine the relationship between the dependent variable is called Time series regression, yt, t = 1, 2, n and the independent variables are time series based data.

Data that has a seasonal trend pattern can be written with the equation:

$$\begin{aligned} y_t &= y_{t\,(trend)} + y_{t(musiman)} + w_t \\ &= \beta_0 + \beta_1 t + \beta_2 S_{1,t} + \beta_3 S_{2,t} + \ldots + \beta_{s+1} S_{s,t} + w_t \end{aligned}$$

(Suhhartono, Lee dan Hamzah, 2010)

2.3 ANOVA Test

Anova test can be used to analyze a number of samples with the same amount of data in each sample group, or with a different amount of data (Lind, 2012).

Calculates the value of the F distribution (Fcount) based on the comparison of the variance between groups and the variance within the group. In addition, F based on the table (Ftable) is also calculated, based on the value of the degrees of freedom using the F-distribution table.

2.4 MAPE (Mean Absolute Percentage Error)

The average absolute error percentage or MAPE provides an indication of how wrong the forecast is when compared to true values. MAPE is used to measure the accuracy of the estimated model value which is expressed in terms of the average absolute percentage of errors and usually as a comparison of data that has a different time interval scale.

2.5 Transformer Loading Theory

Transformer loading is obtained from the results of forecasting the load divided by the capacity of the transformer, the capacity of the transformer is obtained from the transformer data used.

$$\%\text{Loading} = \frac{St}{K\ transformator} x\ 100\%$$

Where,
St = Load usage in (predicted) year
K transformer = Capacity Transformer (data)

Transforer loading causes the load current to change according to load usage. The equation in calculating load current is:

$$I_{pembebanan} = \frac{S(MVA)}{KV.Cos\varphi.\sqrt{3}}$$

2.6 Rungkut Substation

The Rungkut main station is located in Surabaya. This substation has five transformers with a voltage of 150/22 KV, each with a capacity of 60 MVA. Transformer 1 supplies 9 feeders, Transformer 2 supplies 13 feeders, Transformer 3 supplies 5 feeders, Transformer 4 supplies 9 feeders and Transformer 5 supplies 8 feeders.

3. RESEARCH METHODOLOGY

3.1 Research Data Collection Method

The data used in this study are secondary data. Secondary data were obtained from literature studies, books or other literature studies (Maholtra, 2007). Secondary data for this study were taken from the load data in the ampere unit of the Rungkut Substation PLN UP2D East Java Unit.

3.2 Data Analysis Method

The method of analysis to be performed is time series regression. The results of forecasting electric loads are used for the fulfillment of needs plan and the development plan for the supply of electric power at any time sufficiently and well continuously, Andersen et al (2013). Broadly speaking, making a forecast for the need for electric power.

Time series forecasting model is a statistical technique that uses histrorical data in a certain period. The assumptions of this model estimate past workidians to influence events for the future. This model is the most popular and used.

Data analysis uses time series regression because data patterns tend to be deterministic from year to year and time series regression is able to model data that tend to experience trends and have seasonal patterns. The X variable is the time period (month) and Y is the electrical load for the transformer.

The research variable used in this study is the load data of the Transformer, in this case the load of the Rungkut Substation Transformer, which consists of 5 transformers, 1,2,3,4 and 5 for the period January 2015 until December 2019.

The Out sample data is January 2020 until December 2020, while the data that is predicted or predicted is the period January 2021- December 2021. The data taken is the monthly peak load data.

4. RESULT AND DISCUSSION

4.1 Characteristics of Data Transformer 1 to Transformer 5

The analysis used in determining the load of transformers 1 to transformer 5 at PT PLN (Persero) East Java Distribution Rungkut Substation starts in January 2014 to December 2019. The following is a time series plot image of the load.

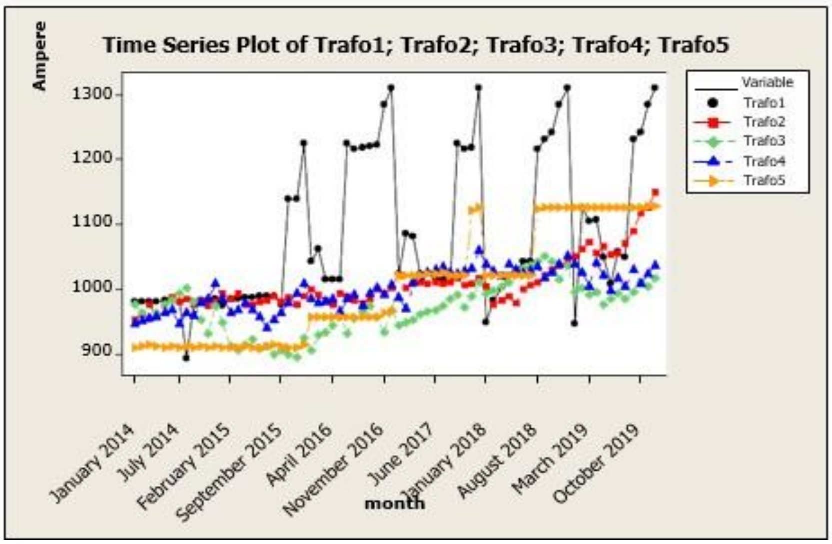

Figure 1. Time Series Plot Data Transformer 1,2,3,4 and 5

The picture above shows that the trend of expenses in January 2014 to December 2019 with load fluctuations tends to occur from December to January in a certain period of year. The load fluctuation in transformer 1 has a tendency to be higher than the fluctuation in load on the other transformers. This is because the customer and the power of the transformer are installed more in transformer 1 than the others. The data characteristics of each transformer can be seen in the following table.

Table 1. Karakteristik Data Transformator

Kind of Transformer	Minimum (Ampere)	Average (Ampere)	Maksimum (Ampere)	Deviasi Standard
Transformer 1	892,0	1.083,1	1.310,0	116,8
Transformer 2	953,0	1.007,2	1.150,0	39,0
Transformer 3	895,0	969,7	1.050,0	39,23
Transformer 4	940,0	998,7	1.059,0	30,54
Transformer 5	910,0	1.001,3	1.127,0	85,4

The table above shows that type 1 transformer has an average load (equal to 1,083.1) which is quite high when compared to other types of transformers. Where the highest load value ever generated on transformer 1 occurred in December 2016, amounting to 1,310.0. In addition, it can also be seen in the table that the tendency for transformer 4 to produce loads tends to be constant when compared to other types of transformers. This can be seen from the resulting standard deviation value of 30.54 when compared to other types of transformers.

4.2 Loading Condition of Transformer 1-5

The loading conditions for transformers 1 to transformer 5 illustrate how the state of the transformer is whether it is in sufficient health or not by looking at the predicted load percentage.

All prediction for years in 2021 from Janury until December. The result of modelling data originally from using time series regresion. Here the characteristic data for transfomer 1, 2, 3, 4 and 5.

Table 2. Characteristic Data Transformer 1

Month	Modeling Data	% Loading Transformer	Health Index Category
January 2021	1108,125	63,90	Enough
February 2021	1159,122	66,8	Enough
March 2021	1150,459	66,34	Enough
April 2021	1144,796	66,016	Enough
May 2021	1136,793	65,55	Enough
June 2021	1166,46	67,26	Enough
July 2021	1172,787	67,63	Enough
August 2021	1185,794	68,38	Enough
September 2021	1266,291	73,02	Enough
October 2021	1296,628	74,77	Enough
November 2021	1321,295	76,19	Enough
Desember 2021	1364,292	78,67	Enough

From January to December 2021, the load of transformer 1 is about 60-80% so that the loadings in the health index of the transformer fall into the sufficient category.

Under these conditions, the implementing unit can plan that if there are customers who want to add power or install new ones, the transformer should not be burdened until the period December 2021 until the next year unless there are old industrial customers who do not subscribe or request disconnection.

Table 3. Characteristic Data Transformer 2

Month	Modeling Data	% Loading Transformer	Health Index Category
January 2021	1.082,29	62,41	Enough
February 2021	1.075,28	62,1	Enough
March 2021	1.081,45	62,36	Enough
April 2021	1.072,44	61,84	Enough
May 2021	1.079,11	62,22	Enough
June 2021	1.082,27	62,41	Enough
July 2021	1.081,27	62,35	Enough
August 2021	1.086,43	62,65	Enough
September 2021	1.090,26	62,87	Enough
October 2021	1.099,42	63,39	Enough
November 2021	1.152,34	66,45	Enough
Desember 2021	1.163,82	67,11	Enough

From January to December 2021, the load of transformer 2 is about 60-70% so that the loadings in the health index of the transformer fall into the sufficient category. With conditions like this, because it is still around 60-70%, the implementing unit can plan that if there are customers who want to add power or install new ones, the transformer can still be optimized to be loaded until the period of December 2021.

Table 4. Characteristic Data Transformer 3

Month	Modeling Data	% Loading Transformer	Health Index Category
January 2021	1.022,07	58,93	Enough
February 2021	1.020,74	58,86	Enough
March 2021	1.019,08	58,76	Enough
April 2021	1.026,75	59,21	Enough
May 2021	1.032,09	59,51	Enough
June 2021	1.029,76	59,38	Enough
July 2021	1.039,1	59,92	Enough
August 2021	1.041,77	60,1	Enough
September 2021	1.044,77	60,24	Enough
October 2021	1.034,28	59,64	Enough
November 2021	1.023,28	59,1	Enough
Desember 2021	1.050,12	60,55	Enough

From January to December 2021, the load of transformer 3 is around 58-61%, so that thetransformer loading health index falls into the sufficient category. With conditions like this, because it is still around 58-61%, the implementing unit can plan that if there are customers who want to add power or install new ones, the transformer can still be burdened until the period

December 2021.

Table 5. Characteristic Data Transformer 4

Month	Modeling Data	% Loading Transformer	Health Index Category
January 2021	1.059,32	61,1	Enough
February 2021	1.048,82	60,48	Enough
March 2021	1.052,16	60,67	Enough
April 2021	1.065,99	61,47	Enough
May 2021	1.058,32	61,1	Enough
June 2021	1.056,32	60,9	Enough
July 2021	1.055,32	60,85	Enough
August 2021	1.055,32	60,85	Enough
September 2021	1.060,32	61,14	Enough
October 2021	1.066,32	61,49	Enough
November 2021	1.073,15	61,88	Enough
Desember 2021	1.090,65	62,89	Enough

From January to December 2021, the load of transformer 3 is around 58-61%, so that the transformer loading health index falls into the sufficient category. With conditions like this, because it is still around 58-61%, the implementing unit can plan that if there are customers who want to add power or install new ones, the transformer can still be burdened until the period December 2021.

Table 6. Characteristic Data Transformer 5

Month	Modeling Data	% Loading Transformer	Health Index Category
January 2021	1.197,43	69,05	Enough
February 2021	1.198,26	69,1	Enough
March 2021	1.197,92	69,08	Enough
April 2021	1.198,25	69,08	Enough
May 2021	1.198,08	69,1	Enough
June 2021	1.198,41	69,1	Enough
July 2021	1.198,91	69,13	Enough
August 2021	1.215,57	70,1	Enough
September 2021	1.215,23	70,1	Enough
October 2021	1.215,40	71,1	Enough
November 2021	1.233,73	71,14	Enough
Desember 2021	1.235,39	71,24	Enough

From January to December 2021, the load of transformer 5 is about 60-70% so that in the health index the loading of the transformer falls into the sufficient category. With conditions like this, because it is still around 58-61%, the implementing unit can plan that if there are customers who want to add power or install new ones, the transformer can still be burdened until the period December 2021.

4.3 Research Implication On The Health Index Transformer

Related to the findings in this study, namely that the transformer loading for the next year is still in the sufficient category, then strategies will be developed to maintain the transformer health index, in this case maintaining the transformer loading, Meyers et al (1988). The program carried out is the installation of a new transformer, transformer selection and routine monitoring of transformer loading.

5. CONCLUSION

From the calculations that have been done, the results of transformer loading in 2021 for transformer 1 load around 60-80%, transformer 2 around 60-70, transformer 3 about 58-61%, transformer 4 around 60-65% and transformer 5 around 60 -70%.

In 2021, the conditions for transformers 2,3,4 and 5 are still in the sufficient category and the loading percentage is still far from 80%. For transformer 1 the condition of the transformer is close to 80%. In Transformer 1 for 2021 the loading of transformer 1 will reach 80% loading so that in the future it is not recommended to add loads from new installers or add power. Meanwhile, for transformers 2,3,4,5 the load of the transformer is still far from reaching 80% so that it can still be optimized to increase the load from new customers or add power. This aims to maintain the health of the transformer so that it is necessary to maintain the transformer loading conditions of not more than 80%.

6. REFERENCES

Dordonnat, Pichavant, Pierrot, (2016). Probabilistic electric load forecasting using time series and semi-parametric regression models. *International Journal of Forecasting*, vol 32:3,pp 1005-1011.

F.M Andersen, H.V Larsen& T.K Boomsma, (2013). Long–term forecasting of hourly electricity load: identification of consumption profiles and segmentation of customes. *Energy Conversion and Management*, vol 68,pp 244-252.

Lind, marchal & Samuel, (2012). *Statistical Tehniques in Bussines and Economics*, New York: McGraw-Hill.

Malhotra, N. and Birks, D., (2007). *Marketing Research An Applied Approach*, Harlow: Prentice Hall.

S.D Meyers., J.J Kelly & R.H Parrish., (1988). *A Guide To Transformer Maintenance*, USA : TMI

Spiegel, R. Murray & Stephens, Larry J, (2017). *STATISTIK Schaum's OuTlines*, Edisi Ketiga. Jakarta, Erlangga

Suhhartono,Lee dan Hamzah, (2010). Calendar variation model based on time series regression for sales forecasts: the ramadhan effects. *Procedings of RCSS 10*, pp 349-361

V. Dordonnat, S.J Koopman, Ooms & Kommet, (2008). An hourly periodic state space model for modelling french national electric load. *International Journal of Forecasting*, vol 24:4 pp 566-587.

Wei, W.W.S., (2006). *Time Series Analysis Univariate and Multivariate Methods*, New York: Pearson education, Inc.

SELECTION OF CO-FIRING CO-FIRING PLTU COAL FOR REDUCING GREENHOUSEGAS EFFECTS USING DEMATEL AND AHP METHODS IN PT PEMBANGKITAN XYZ

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ABSTRACT

About 64% of Indonesia's electricity supply comes from coal-fired power plants, so this has an impact on reducing coal reserves and increasing greenhouse gas emissions. In an international forum the Indonesian government has a target of reducing greenhouse gas emissions around 26% at 2020. Greenhouse gas reduction In the energy sector, it is implemented through the co-firing program of biomass with coal at coal-fired power plants, so that the right, effective and efficient decisioncriteria are needed to get the best co-firing alternative. In relation to these conditions, this study aims to design a model for the selection criteria of a systematic co-firing alternative in PT Pembangkitan "XYZ". The data were processed using Decision Making Trial and Evaluation Laboratory (DEMATEL)and Analityc Hierarchy Process (AHP). Determination of criteria through discussions and interviews with the program evaluation team, experts in the field of generation. The criteria is biomass characteristics, availability of biomass, price of biomass, biomass suppliers, biomass needs, reduction in CO2 emissions, efficiency, boiler design and technology as well as basic costs of electricity production. The study results show that each criterion has a different level of influence and weight. For the most influential power level and affecting the criteria and sub-criteria,DEMATEL shows “CO2 emission reduction” with an index of 11.91 and “biomass price” with an index value of 0.93, on the “biomass price” sub-criteria with an indexvalue of 24.2 and “biomass quality and CO2 emissions”. At the index 1.43 and 1.37.While the weighting of the AHP shows that the criteria "boiler design and technology, availability of biomass and efficiency of power plants with a weight of 9% ,. Based on the combination of the two methods, it can be concluded that the choice of the first cofiring alternative is the co-firing alternative B with a score of 6.60, followed by the co-firing alternative A with a wood pellet score of 5.62 andthe last co-firing alternative C with a score of 6.60. mix of wood pellets with saw dust score of 5.31.

Keywords: *Co-firing* , Biomassa, Green House Gas,DEMATEL , AHP

1. INTRODUCTION

The increase in population, changes in people's living standards is always directly proportional to the increase in demand for electrical energy which has an impact on the high growth rate of CO2 emissions that will be generated from burning fossil energy in power plants and other sectors into the atmosphere which will have an impact on global warming. The largest use of domestic coal is electricity generation at 63.9%. Assuming the level of coal production after2019 remains 400 million tons and there are no additional new reserves, it is estimated that Indonesia's coal reserves of 24,239.96 million will be exhausted within 61 years. In the G-20 meeting in Pittsburg, the Indonesian government committed to reducing 26% greenhouse gas emissions independently by 2020, in the energy sector through the energy sector related to the use of renewable electrical energy as stated in the Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia. Number 39K / 20 / MEM / 2019 concerning Ratification of PT PLN Persero RUPTL Year 2019 to 2028.

PT Pembangkitan XYZ is a coal-fired steam power plant, as a subsidiary of PT PLN Persero, PT Pembangkitan XYZ has a task related to the 10% Transfer of PLTU Capacity to Biomass PLT as stated in RUPTL 2019-2028, PT Pembangkitan XYZ has a development programpower plants with renewable energy from biomass in the form of wood pellets and saw dust, through a mixture of biomass fuels in the combustion process simultaneously in a boiler or called co-firing. Biomass is all biological material derived from plants or animals that can be used to generate heat and / or energy, fuels (including transportation fuels), or substitutes for fossil-based products and materials (Department for Environment; Food and Rural Affairs, 2007). The moisture content in biomass is generally higher than that of fossil fuels. In addition, mixing of biomass from sawdust is also carried out in order to obtain the most optimal results in terms of cost, efficiency and CO2 emission reduction targets. Research related to co-firing biomass with coal with SWOT analysis of direct co-firing coal with waste pellets in CFBC type boilers (Muhammad Fadli, Dianta Mustofa Kamal, Pribadi Mumpuni Adhi) at the mine mouth PLTU witha capacity of 2 x 30 MW in Tabalong owned by PT. Makmur Sejahtera Wisesa (MSW) with a composition ratio of 95% coal to 5% waste pellets.

Based on the description above, this study aims to determine the criteria for selecting an alternative co-firing coal with biomass at PT. The XYZ generation is used to determine the most optimal co-firing alternative weight, related to the sustainability of the co-firing program in similar PLTUs in the future to reduce CO2 as a contributor to Greenhouse Gas (GHG) in the power generation sector, and to reduce dependence on the depletion of coal fossil energy sources.

2. LITERATURE REVIEW

2.1 Renewable Energy

The campaign on the global warming of the world associated with increasing human activities such as increased electricity consumption, increasing number of vehicles, factory smoke, burning forests and the number of buildings using the concept of greenhouses are the main causes. The goal of reducing dependence on fossil fuels by expanding the use of renewable energy and reducing the emission of greenhouse gases such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) resulting from burning fossil fuels. Greenhouse Gases (GHG) found in the atmosphere naturally absorb solar radiation in the lower atmosphere, namely in the troposphere. The concentration of GHG is increasing as a result of the increase in GHG emissions due to human activities (anthropogenic). Due to the high concentration of GHG, the earth's atmosphere temperature is now 0.5°C hotter when compared to the pre-industrial era (Handayani, 2008).

Regarding the program of using renewable energy, it is stated in the 2019-2018 RUPTL

Table 1. Biomass Switching Plan for PLTU

Power plants	RUPTL	RUEN	Emission Reduction> RUEN
		Switching 10% of PLTU Capacity to Biomass Power Plant	Switching 30% of PLTU Capacity to Biomass Power Plant
		25% Luxury Homes use Solar Rooftops	30% Luxury Homes use Solar Rooftops

2.2 Biomass

Biomass is organic material resulting from the photosynthesis process, in various forms including plants, trees, grass, sweet potatoes, agricultural waste, forest waste including livestock manure. Biomass can be used as an energy source. The material contains carbon elements which can generate heat when oxidized, biomass has several advantages or advantages, including renewable so that it can be classified as sustainable energy (Hermawati et al., 2013). Wood pellets are a type of renewable energy fuel made from wood biomass, such as wood waste from the timber industry and harvested wood or compacted woody plants (Sylviani et al. 2013, Tampubolon 2008). Biomass can be converted into energy by various processes, while the factors that influence the choice of conversion technology include the type and amount of biomass, the desired form of energy, user needs, environmental standards and economic conditions (McKendry,2002).

2.3 Co-Firing

Co-firing is the process of burning two different types of fuels in the same combustion device, often operated in a steam generator boiler, co-firing combustion of coal with biomass can be interpreted as part of a system that complements coal-fired boiler devices (Wijayapala and Mudunkotuwa, 2016). Judging from the combustion operation, there are 2 ways of co-firing, namely direct co-firing and indirect co-firing. Direct co-firing is by burning biomass and coal simultaneously, while Indirect co-firing is preceded by biomass gasification, then the resulting gas is fed with coal in the combustion chamber. Since biomass absorbs the same amount of CO2 emitted during its combustion, biomass co-firing does not contribute to the greenhouse effect.Most of the biomass fuels have a lower sulfur and nitrogen content than coal, so NOx and SOx emissions can be reduced by co-firing biomass. From these considerations, co-firing biomass with coal has received great attention in recent years (Mehmood, Reddy and Rosen, 2012).

2.4 Decision Making Trial and Laboratory (DEMATEL)

DEMATEL was developed for the first time by The Science and Human Affairs Program of the Battelle Memorial Institute of Geneva in the period 1972-1976. DEMATEL is used in various fields of research with the aim of simplifying complex problems and transforming complex systems into structured causal relationships. The DEMATEL method can confirm the interdependence among variables / criteria and limit the relationships that describe characteristics in an important system and in recent developments. The final output of DEMATEL is a visual representation of the respondent's thoughts on the interpendency relationship between objects of a problem. Some of the advantages possessed by the DEMATEL model are as follows:

1. DEMATEL provides a systematic approach that identifies criteria, relationships between criteria, and their respective weights for decision making.
2. DEMATEL can be used to answer the core problems of a complex system in order to facilitate decision making

2.4 Analytical Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) developed by Thomas L. Saaty in the late 1960s. Initially, Thomas L Saaty developed the AHP method as a decision-making technique for choosing a complex decision (Saaty TL, 1994), can use pairwise comparison and expert judgment to determine the priority scale of each criterion. decisions and assessments of decision alternatives (Saaty, 1999) In the AHP method, the criteria elements that compose the decision hierarchy are assumed to have a one-way (uni-directional) relationship with elements at different hierarchical levels, for example between criteria and sub-criteria and have no correlation with elements in the cluster. others (Cheng & Li, 2007). All criteria or sub-criteria in the decision hierarchy areassumed to be independent criteria and have no correlation with other criteria at the same level in the decision hierarchy.

Tabel 2. Pairwise Comparison Rating Scale saaty

Intensity of interest	Explanation
1	The two elements are equally important
3	One element is slightly more important than
5	One element is more important than the other
7	One element is clearly more absolutely essential
9	One element is absolutely more important than
2,4,6,8	The values between two adjacent consideration values

3. RESEARCH METHODOLOGY

3.1 Preliminary Study

Problem identification is carried out based on empirical studies and literature studies conducted at the previous stage. Based on the results of empirical studies and literature studies, there are problems related to the implementation of co-firing coal and biomass in PT "XYZ" generation and the plan is in the form of research objectives, problem boundaries and research benefits.

3.2 Literature Study

Literature study aims to understand the characteristics of the problem and determine the methods to be used in solving the problem. This study aims to identify instruments that will be used to support the existing processes in the problem solving method used, such as the criteria and sub-criteria for selecting the most optimal co-firing alternative.

3.3 Data Collection

In determining the alternative selection criteria based on literature studies and other criteria obtained from discussions and interviews of the expert team and the determination of these criteria is based on PLN regulation No 01 / DIR. 2020 concerning the implementation of the co firing program at coal-fired power plants with biomass fuel. The expected output from this stage is a general network of decisions related to the target achievement of the co-firing program for coal-fired power plant with biomass so that it can be used to determine the selection of coal co-firing alternatives with the same biomass in all coal-fired power plants. This stage is carried out through a process of discussion and interviews with a team of experts and questionnaires involving parties related to the process of implementing the coal PLTU co-firing program with biomass especially the evaluation team of the coal PLTU co-firing program, as well as parties who are competent in the coal PLTU. The results of the questionnaire and FGD will then be determined as criteria in selecting an alternative co-firing program for coal-fired power plants. Respondents from the FGD process were a team of experts from the coal fired power plant, Lead Project Management, Lead Renewable Energy, and people who were competent in generation, especially Renewable Energy. The purpose of this process is to determine the criteria and sub-criteria for decisions according to the needs and conditions of implementing the co-firing program.

3.4 Problem Identification

This process is carried out by conducting a literature study of several previous studies. The results of the literature study are collaborated with decision criteria that are adjusted to the expectations of implementing a biomass renewable energy program in the generation sector. The results of this literature study are collaborated with the decision criteria in accordance with the co-firing program of coal-fired power plant with biomass at PT “XYZ” generator.

3.5 Data Processing and Analysis

In this stage, analysis and discussion of the co-firing co-firing model criteria for coal PLTU, the relationship and scale of the co-firing alternative selection criteria for coal-fired power plants, the results of the co-firing assessment for coal-fired power plants, and an assessment of the criteria for selecting co-firing alternatives for coal-fired power plants. The analysis is carried outin relation to several things and the process of selecting an alternative co-firing coal PLTU, including:

a. Decision Making Trial and Evaluation Laboratory (DEMATEL) method The DEMATEL method is used to establish interdependent network relationships between decision criteria. Respondents are expected to provide feedback on their respective levels of influence using the Saaty scale.
b. Analytic Hierarchy Process (AHP) Method The results of determining the questionnaire obtained from the respondents were then analyzed using the AHP method to obtain the weight of the decision criteria / sub-criteria. The results of the questionnaire assessment of the coal PLTU co-firing program against the criteria / sub-criteria combined with the weights which are the output of the AHP method are obtained by the most optimal co-firing alternative.

4. RESULTS OF THIS STUDY AND DISCUSSION

4.1 Identification of Criteria / Sub-criteria co- firing selection alternative

From the discussion and interview process with a team of experts and several competent resource persons in the field of electrical energy generation, there are 5 criteria and 16 sub-criteria

Table 3.Criteria selection co-firing

No	Criteria	Code
1	Biomass characteristics	A1-1
2	Calorie Value of biomass	A1-2
3	The price of wood pellets based on PLN	A2-1
4	Hie price o f saw dust based on PLN regulations	A2-2
5	Availability of biomass in local market	A2-3
6	The cost of producing electricity	A2-4
7	Local area suppliers	A3-1
8	Wood pellet biomass supplier	A3-2
9	Saw dust biomass supplier	A3-3
10	Biomass waste production capacity	A3-4
11	Biomass requirements	A3-5
12	Reduction of wood pellet biomass mix emissions	A4-1
13	Reduction of saw dust biomass mix emissions	A4-2
14	Boiler design and technology	A5-1
15	Efficiency	A5-2
16	Ease of technology implementation	A5-3

for selecting cofiring alternatives

Table 4. Pairwise Comparison Matrik

	A1.1	A1.2	A2.1	A2.2	A2.3	A2.4	A3.1	A3.2	A3.3	A3.4	A3.5	A4.1	A4.	A5.1	A5.2	A5.3
A1.1	0,0	5,2	6,0	6,2	5,5	5,5	5,8	6,0	5,8	5,5	5,9	5,4	5,1	5,0	5,7	5,3
A1.2	7,0	0,0	5,8	5,8	5,5	5,8	5,2	5,7	5,5	5,9	5,6	4,8	4,8	4,8	5,2	5,5
A2.1	5,0	5,0	0,0	5,8	5,9	5,8	5,5	5,5	5,5	5,8	5,1	5,2	5,3	5,2	5,2	5,9
A2.2	5,0	3,0	7,0	0,0	6,0	5,4	5,7	5,9	5,8	6,2	5,8	5,3	5,3	5,0	5,0	6,2
A2.3	9,0	7,0	7,0	7,0	0,0	5,5	5,1	5,1	5,2	5,1	5,2	5,4	5,3	5,1	7,0	5,8
A2.4	7,0	7,0	8,0	4,0	5,0	0,0	5,2	5,4	5,2	5,3	5,5	5,4	5,2	4,8	4,9	5,3
A3.1	4,0	3,0	7,0	7,0	7,0	8,0	0,0	5,2	5,2	5,1	5,0	5,2	5,2	5,1	5,2	5,5
A3.2	4,0	5,0	4,0	4,0	3,0	7,0	7,0	0,0	6,1	5,8	5,5	4,9	5,1	4,8	5,1	7,0
A3.3	4,0	5,0	5,0	4,0	5,0	4,0	5,0	7,0	0,0	5,2	5,7	5,2	5,0	4,8	4,9	5,0
A3.4	5,0	7,0	7,0	4,0	5,0	5,0	7,0	4,0	5,0	0,0	5,4	5,1	5,0	5,3	5,2	7,0
A3.5	7,0	5,0	7,0	5,0	7,0	7,0	7,0	5,0	7,0	3,0	0,0	5,2	5,8	5,8	5,8	5,0
A4.1	7,0	7,0	7,0	3,0	7,0	7,0	7,0	8,0	7,0	4,0	5,0	0,0	5,2	5,8	5,8	5,8
A4.2	7,0	7,0	9,0	5,0	4,0	4,0	3,0	7,0	7,0	4,0	5,0	3,0	0,0	5,9	5,9	5,8
A5.1	9,0	8,0	6,0	5,0	5,0	4,0	5,0	4,0	7,0	7,0	4,0	7,0	5,0	0,0	5,8	5,5
A5.2	9,0	7,0	4,0	7,0	7,0	4,0	5,0	5,0	5,0	7,0	5,0	6,0	4,0	6,0	0,0	5,8
A5.3	5,0	5,0	8,0	5,0	7,0	5,0	6,0	7,0	7,0	7,0	3,0	7,0	5,0	7,0	7,0	0,0

Table 6. Normalize Direct Relation Matrik

	A1.1	A1.	A2.	A2.	A2.3	A2.4	A3.1	A3.	A3.	A3.	A3.5	A4.1	A4.2	A5.	A5.	A5.3
A1.1	0,00	0,06	0,07	0,07	0,06	0,06	0,06	0,07	0,06	0,06	0,06	0,06	0,06	0,05	0,06	0,06
A1.2	0,08	0,00	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,05	0,05	0,05	0,06	0,06
A2.1	0,05	0,05	0,00	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06
A2.2	0,05	0,03	0,08	0,00	0,07	0,06	0,06	0,06	0,06	0,07	0,06	0,06	0,06	0,05	0,05	0,07
A2.3	0,10	0,08	0,08	0,08	0,00	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,08	0,06
A2.4	0,08	0,08	0,09	0,04	0,05	0,00	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,05	0,05	0,06
A3.1	0,04	0,03	0,08	0,08	0,08	0,09	0,00	0,06	0,06	0,06	0,05	0,06	0,06	0,06	0,06	0,06
A3.2	0,04	0,05	0,04	0,04	0,03	0,08	0,08	0,00	0,07	0,06	0,06	0,05	0,06	0,05	0,06	0,08
A3.3	0,04	0,05	0,05	0,04	0,05	0,04	0,05	0,08	0,00	0,06	0,06	0,06	0,05	0,05	0,05	0,05
A3.4	0,05	0,08	0,08	0,04	0,05	0,05	0,08	0,04	0,05	0,00	0,06	0,06	0,05	0,06	0,06	0,08
A3.5	0,08	0,05	0,08	0,05	0,08	0,08	0,08	0,05	0,08	0,03	0,00	0,06	0,06	0,06	0,06	0,05
A4.1	0,08	0,08	0,08	0,03	0,08	0,08	0,08	0,09	0,08	0,04	0,05	0,00	0,06	0,06	0,06	0,06
A4.2	0,08	0,08	0,10	0,05	0,04	0,04	0,03	0,08	0,08	0,04	0,05	0,03	0,00	0,06	0,06	0,06
A5.1	0,10	0,09	0,07	0,05	0,05	0,04	0,05	0,04	0,08	0,08	0,04	0,08	0,05	0,00	0,06	0,06
A5.2	0,10	0,08	0,04	0,08	0,08	0,04	0,05	0,05	0,05	0,08	0,05	0,07	0,04	0,07	0,00	0,06
A5.3	0,05	0,05	0,09	0,05	0,08	0,05	0,07	0,08	0,08	0,08	0,03	0,08	0,05	0,08	0,08	0,00

Table 7. Matrik Identity

1	-0,06	-0,07	-0,07	-0,06	-0,06	-0,06	-0,07	-0,06	-0,06	-0,06	-0,06	-0,06	-0,05	-0,06	-0,06
-0,08	1	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,05	-0,05	-0,05	-0,06	-0,06
-0,05	-0,05	1	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06
-0,05	-0,03	-0,08	1	-0,07	-0,06	-0,06	-0,06	-0,06	-0,07	-0,06	-0,06	-0,06	-0,05	-0,05	-0,07
-0,1	-0,08	-0,08	-0,08	1	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,08	-0,06
-0,08	-0,08	-0,09	-0,04	-0,05	1	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,05	-0,05	-0,06
-0,04	-0,03	-0,08	-0,08	-0,08	-0,09	1	-0,06	-0,06	-0,06	-0,05	-0,06	-0,06	-0,06	-0,06	-0,06
-0,04	-0,05	-0,04	-0,04	-0,03	-0,08	-0,08	1	-0,07	-0,06	-0,06	-0,05	-0,06	-0,05	-0,06	-0,08
-0,04	-0,05	-0,05	-0,04	-0,05	-0,04	-0,05	-0,08	1	-0,06	-0,06	-0,06	-0,05	-0,05	-0,05	-0,05
-0,05	-0,08	-0,08	-0,04	-0,05	-0,05	-0,08	-0,04	-0,05	1	-0,06	-0,06	-0,05	-0,06	-0,06	-0,08
-0,08	-0,05	-0,08	-0,05	-0,08	-0,08	-0,08	-0,05	-0,08	-0,03	1	-0,06	-0,06	-0,06	-0,06	-0,05
-0,08	-0,08	-0,08	-0,03	-0,08	-0,08	-0,08	-0,09	-0,08	-0,04	-0,05	1	-0,06	-0,06	-0,06	-0,06
-0,08	-0,08	-0,1	-0,05	-0,04	-0,04	-0,03	-0,08	-0,08	-0,04	-0,05	-0,03	1	-0,06	-0,06	-0,06
-0,1	-0,09	-0,07	-0,05	-0,05	-0,04	-0,05	-0,04	-0,08	-0,08	-0,04	-0,08	-0,05	1	-0,06	-0,06
-0,1	-0,08	-0,04	-0,08	-0,08	-0,04	-0,05	-0,05	-0,05	-0,08	-0,05	-0,07	-0,04	-0,07	1	-0,06
-0,05	-0,05	-0,09	-0,05	-0,08	-0,05	-0,07	-0,08	-0,08	-0,08	-0,03	-0,08	-0,05	-0,08	-0,08	1

Table 8. Inverse Matrix

1,72	**0,72**	**0,81**	**0,67**	**0,72**	**0,70**	**0,72**	**0,73**	**0,75**	**0,70**	**0,66**	**0,68**	**0,65**	**0,68**	**0,71**	**0,72**
0,78	**1,66**	**0,80**	**0,66**	**0,71**	**0,70**	**0,70**	**0,72**	**0,74**	**0,69**	**0,65**	**0,67**	**0,64**	**0,67**	**0,69**	**0,72**
0,76	**0,70**	**1,73**	**0,65**	**0,70**	**0,69**	**0,70**	**0,71**	**0,73**	**0,68**	**0,64**	**0,66**	**0,64**	**0,66**	**0,69**	**0,71**
0,76	**0,69**	**0,81**	**1,60**	**0,71**	**0,69**	**0,71**	**0,72**	**0,74**	**0,69**	**0,65**	**0,67**	**0,64**	**0,67**	**0,69**	**0,72**
0,86	**0,78**	**0,87**	**0,72**	**1,70**	**0,75**	**0,75**	**0,76**	**0,79**	**0,74**	**0,70**	**0,72**	**0,69**	**0,72**	**0,76**	**0,77**
0,79	**0,73**	**0,83**	**0,65**	**0,71**	**1,64**	**0,71**	**0,72**	**0,74**	**0,69**	**0,65**	**0,68**	**0,65**	**0,67**	**0,70**	**0,72**
0,75	**0,69**	**0,81**	**0,67**	**0,72**	**0,72**	**1,65**	**0,71**	**0,73**	**0,68**	**0,64**	**0,67**	**0,64**	**0,67**	**0,69**	**0,72**
0,72	**0,68**	**0,75**	**0,61**	**0,65**	**0,68**	**0,69**	**1,62**	**0,71**	**0,66**	**0,62**	**0,64**	**0,61**	**0,64**	**0,66**	**0,70**
0,69	**0,65**	**0,72**	**0,59**	**0,64**	**0,62**	**0,64**	**0,67**	**1,62**	**0,63**	**0,60**	**0,61**	**0,59**	**0,61**	**0,63**	**0,65**
0,76	**0,72**	**0,81**	**0,64**	**0,70**	**0,69**	**0,71**	**0,69**	**0,73**	**1,63**	**0,64**	**0,67**	**0,64**	**0,67**	**0,69**	**0,73**
0,82	**0,75**	**0,85**	**0,69**	**0,76**	**0,74**	**0,75**	**0,75**	**0,79**	**0,70**	**1,63**	**0,71**	**0,68**	**0,71**	**0,74**	**0,75**
0,85	**0,80**	**0,88**	**0,69**	**0,79**	**0,77**	**0,78**	**0,80**	**0,82**	**0,74**	**0,70**	**1,68**	**0,70**	**0,74**	**0,76**	**0,79**
0,78	**0,73**	**0,82**	**0,65**	**0,69**	**0,67**	**0,68**	**0,72**	**0,75**	**0,67**	**0,64**	**0,65**	**1,58**	**0,67**	**0,70**	**0,72**
0,84	**0,77**	**0,84**	**0,69**	**0,74**	**0,71**	**0,73**	**0,73**	**0,79**	**0,74**	**0,67**	**0,72**	**0,67**	**1,65**	**0,73**	**0,75**
0,84	**0,76**	**0,82**	**0,70**	**0,75**	**0,71**	**0,73**	**0,74**	**0,77**	**0,73**	**0,67**	**0,71**	**0,66**	**0,71**	**1,67**	**0,75**
0,83	**0,77**	**0,89**	**0,71**	**0,78**	**0,75**	**0,77**	**0,79**	**0,82**	**0,76**	**0,68**	**0,75**	**0,70**	**0,75**	**0,77**	**1,72**

Table 9. Total Relation Matrix

																	D
	0,72	0,72	0,81	0,67	0,72	0,70	0,72	0,73	0,75	0,70	0,66	0,68	0,65	0,68	0,71	0,72	11,34
	0,78	0,66	0,80	0,66	0,71	0,70	0,70	0,72	0,74	0,69	0,65	0,67	0,64	0,67	0,69	0,72	11,21
	0,76	0,70	0,73	0,65	0,70	0,69	0,70	0,71	0,73	0,68	0,64	0,66	0,64	0,66	0,69	0,71	11,06
	0,76	0,69	0,81	0,60	0,71	0,69	0,71	0,72	0,74	0,69	0,65	0,67	0,64	0,67	0,69	0,72	11,16
	0,86	0,78	0,87	0,72	0,70	0,75	0,75	0,76	0,79	0,74	0,70	0,72	0,69	0,72	0,76	0,77	12,11
	0,79	0,73	0,83	0,65	0,71	0,64	0,71	0,72	0,74	0,69	0,65	0,68	0,65	0,67	0,70	0,72	11,26
	0,75	0,69	0,81	0,67	0,72	0,72	0,65	0,71	0,73	0,68	0,64	0,67	0,64	0,67	0,69	0,72	11,18
	0,72	0,68	0,75	0,61	0,65	0,68	0,69	0,62	0,71	0,66	0,62	0,64	0,61	0,64	0,66	0,70	10,63
	0,69	0,65	0,72	0,59	0,64	0,62	0,64	0,67	0,62	0,63	0,60	0,61	0,59	0,61	0,63	0,65	10,17
	0,76	0,72	0,81	0,64	0,70	0,69	0,71	0,69	0,73	0,63	0,64	0,67	0,64	0,67	0,69	0,73	11,11
	0,82	0,75	0,85	0,69	0,76	0,74	0,75	0,75	0,79	0,70	0,63	0,71	0,68	0,71	0,74	0,75	11,81
	0,85	0,80	0,88	0,69	0,79	0,77	0,78	0,80	0,82	0,74	0,70	0,68	0,70	0,74	0,76	0,79	12,30
	0,78	0,73	0,82	0,65	0,69	0,67	0,68	0,72	0,75	0,67	0,64	0,65	0,58	0,67	0,70	0,72	11,12
	0,84	0,77	0,84	0,69	0,74	0,71	0,73	0,73	0,79	0,74	0,67	0,72	0,67	0,65	0,73	0,75	11,77
	0,84	0,76	0,82	0,70	0,75	0,71	0,73	0,74	0,77	0,73	0,67	0,71	0,66	0,71	0,67	0,75	11,74
	0,83	0,77	0,89	0,71	0,78	0,75	0,77	0,79	0,82	0,76	0,68	0,75	0,70	0,75	0,77	0,72	12,24
R	12,56	11,61	13,05	10,61	11,46	11,23	11,42	11,58	12,00	11,14	10,44	10,87	10,38	10,89	11,29	11,65	

Table 10.Total Influence Matrix

	A1.1	A1.2	A2.1	A2.2	A2.3	A2.4	A3.1	A3.2	A3.3	A3.4	A3.5	A4.1	A4.2	A5.1	A5.2	A5.3	TD
A1.1	0,72	0,72	0,81	0,67	0,72	0,70	0,72	0,73	0,75	0,70	0,66	0,68	0,65	0,68	0,71	0,72	11,34
A1.2	0,78	0,66	0,80	0,66	0,71	0,70	0,70	0,72	0,74	0,69	0,65	0,67	0,64	0,67	0,69	0,72	11,21
A2.1	0,76	0,70	0,73	0,65	0,70	0,69	0,70	0,71	0,73	0,68	0,64	0,66	0,64	0,66	0,69	0,71	11,06
A2.2	0,76	0,69	0,81	0,60	0,71	0,69	0,71	0,72	0,74	0,69	0,65	0,67	0,64	0,67	0,69	0,72	11,16
A2.3	0,86	0,78	0,87	0,72	0,70	0,75	0,75	0,76	0,79	0,74	0,70	0,72	0,69	0,72	0,76	0,77	12,11
A2.4	0,79	0,73	0,83	0,65	0,71	0,64	0,71	0,72	0,74	0,69	0,65	0,68	0,65	0,67	0,70	0,72	11,26
A3.1	0,75	0,69	0,81	0,67	0,72	0,72	0,65	0,71	0,73	0,68	0,64	0,67	0,64	0,67	0,69	0,72	11,18
A3.2	0,72	0,68	0,75	0,61	0,65	0,68	0,69	0,62	0,71	0,66	0,62	0,64	0,61	0,64	0,66	0,70	10,63
A3.3	0,69	0,65	0,72	0,59	0,64	0,62	0,64	0,67	0,62	0,63	0,60	0,61	0,59	0,61	0,63	0,65	10,17
A3.4	0,76	0,72	0,81	0,64	0,70	0,69	0,71	0,69	0,73	0,63	0,64	0,67	0,64	0,67	0,69	0,73	11,11
A3.5	0,82	0,75	0,85	0,69	0,76	0,74	0,75	0,75	0,79	0,70	0,63	0,71	0,68	0,71	0,74	0,75	11,81
A4.1	0,85	0,80	0,88	0,69	0,79	0,77	0,78	0,80	0,82	0,74	0,70	0,68	0,70	0,74	0,76	0,79	12,30
A4.2	0,78	0,73	0,82	0,65	0,69	0,67	0,68	0,72	0,75	0,67	0,64	0,65	0,58	0,67	0,70	0,72	11,12
A5.1	0,84	0,77	0,84	0,69	0,74	0,71	0,73	0,73	0,79	0,74	0,67	0,72	0,67	0,65	0,73	0,75	11,77
A5.2	0,84	0,76	0,82	0,70	0,75	0,71	0,73	0,74	0,77	0,73	0,67	0,71	0,66	0,71	0,67	0,75	11,74
A5.3	0,83	0,77	0,89	0,71	0,78	0,75	0,77	0,79	0,82	0,76	0,68	0,75	0,70	0,75	0,77	0,72	12,24
TR	12,56	11,61	13,05	10,61	11,46	11,23	11,42	11,58	12,00	11,14	10,44	10,87	10,38	10,89	11,29	11,65	

Keterangan : Nilai yang diblok adalah nilai total influence matrik dibawah rata -rata keseluruan sebesar 0,7117

4.2 Dispatcher and Receiver Value

From the results of table 7 the values (D + R) and (DR) of the decision criteria show that the subcriteria for wood pellet prices are based on the provisions of PLN, biomass characteristics and ease of technology implementation have the greatest influence on other sub-criteria with values of 24.12, 23.90 and 23.89. Meanwhile, the subcriteria for the level of influence of emission reduction of the mixture of wood pellet biomass and the need for biomass has the greatest effect ofthe other sub-criteria with a value of 1.43 and 1.37.After obtaining the total influence matrixvalue, then determining the Threshold Value to determine the relationship between the criteria / sub-criteria for this decision. According to Shieh (2010), Threshold Value is obtained from the average of all values from the T matrix (Total Relationship Matrix), namely 0.7117. A value below 0.7117 means that the two criteria / sub-criteria are not related to each other. The relationship between the criteria / sub-criteria.

4.3 Hierarchy of Model Selection of co-firing alternatives

Determining the decision network will facilitate the logic of the decision-making system based on criteria and sub-criteria, so a hierarchical model is created as in the following figure: The alternative cofiring Hierarchical Selection System Model as below

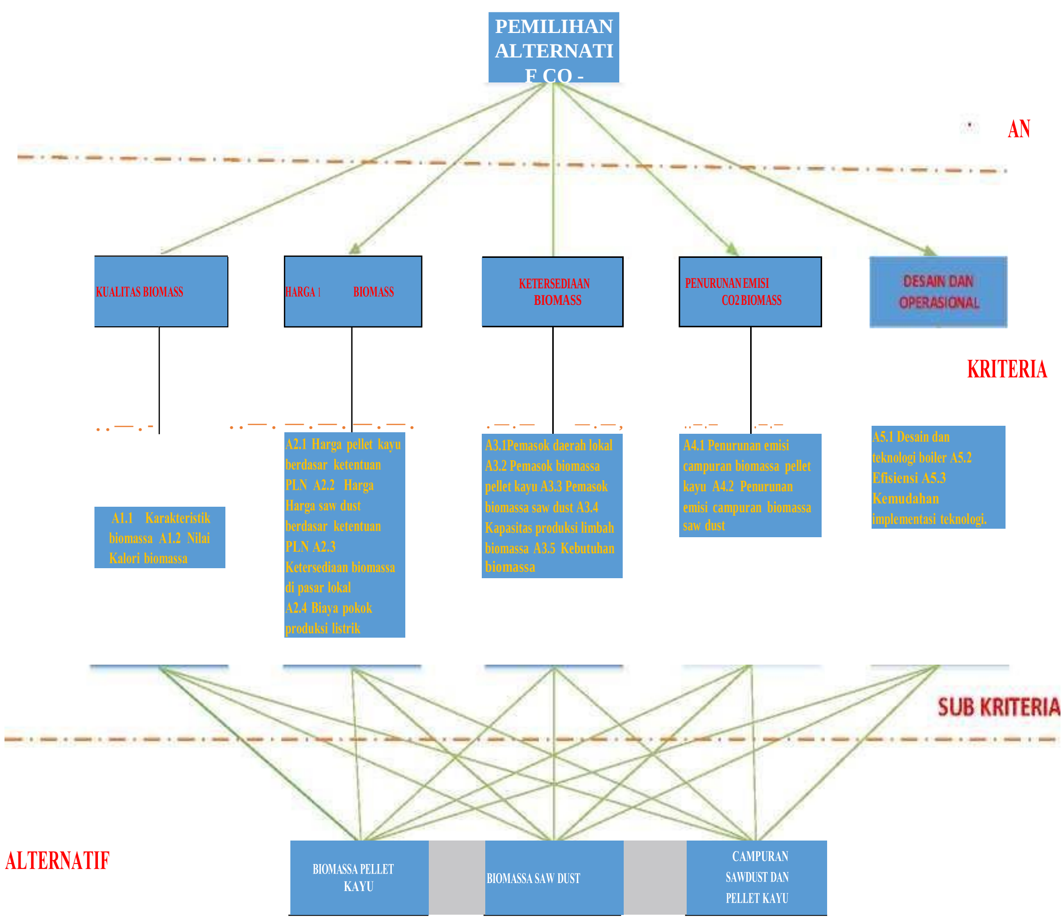

Figure 1. Decision Hierarchy Model

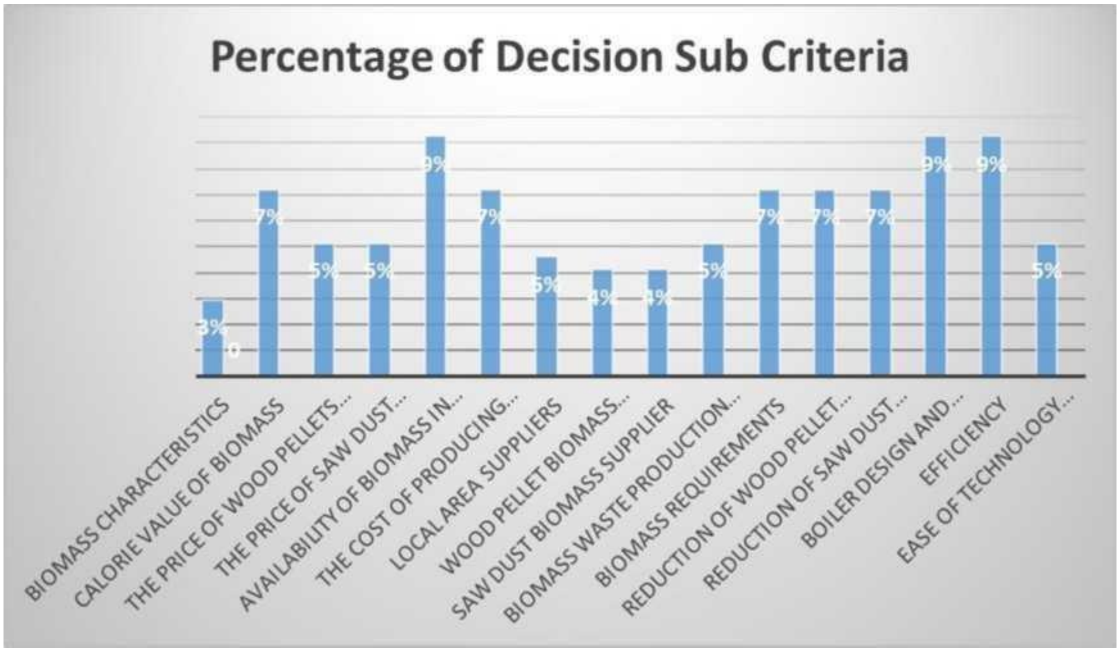

Figure 2.Percentage Decision Criteria Table 11. Calculation of co -firing alternatives

Criteria	Percentage	Co Firing wood pellet		Co Firing Saw dust		Co Firing mix wood pellet and saw dust	
		Value	Total Weight	Value	Total Weight	Value	Total Weight
Biomass characteristics	0,030	7,000	0,207	5,000	0,148	6,000	0,177
Calorie Value of	0,072	3,000	0,216	9,000	0,647	4,000	0,288
The price of wood pellets based on	0,051	5,000	0,257	7,000	0,360	6,000	0,308
The prige of saw dust based on	0,051	6,000	0,308	9,000	0,462	6,000	0,308
Avai lability of	0,092	7,000	0,647	7,000	0,647	7,000	0,647
The cost of	0,072	5,000	0,360	9,000	0,647	6,000	0,431
Local area	0,046	3,000	0,138	5,000	0,230	3,000	0,138
Wood pellet	0,041	3,000	0,123	7,000	0,288	3,000	0,123
Saw dust biomass	0,041	5,000	0,205	7,000	0,288	5,000	0,205
Biomass waste	0,051	3,000	0,154	5,000	0,257	4,000	0,205
Biomass	0,072	5,000	0,360	5,000	0,360	5,000	0,360
Reduction of wood pellet	0,072	7,000	0,503	5,000	0,360	6,000	0,431
Reduction of saw dust biomass mix	0,072	7,000	0,503	5,000	0,360	6,000	0,431
Boiler design and	0,092	7,000	0,647	9,000	0,832	5,000	0,462
Efficiency	0,092	9,000	0,832	5,000	0,462	7,000	0,647
Ease of	0,051	9,000	0,462	5,000	0,257	3,000	0,154
Total Weight			5,92235304		6,6024846		5,31760091

4.4 Discussion

The results of the analysis show that the co-firing alternative B dominates almost every decision sub-criteria. For example, the biomass price sub-criteria, the availability of biomass, the ease of design and boiler technology used, the basic cost of electricity production, the co-firing alternative B using biomass saw dust has a higher index of 6.602 compared to other co-firing alternatives. The lowest total score for the assessment of the co-firing alternative C with a value of 5.317 where the sub-criteria for decisions are the ease of technology implementation, the price of biomass, the supply capacity of suppliers. The ranking of co-firing alternative selection results from the calculation of respondent data is as follows

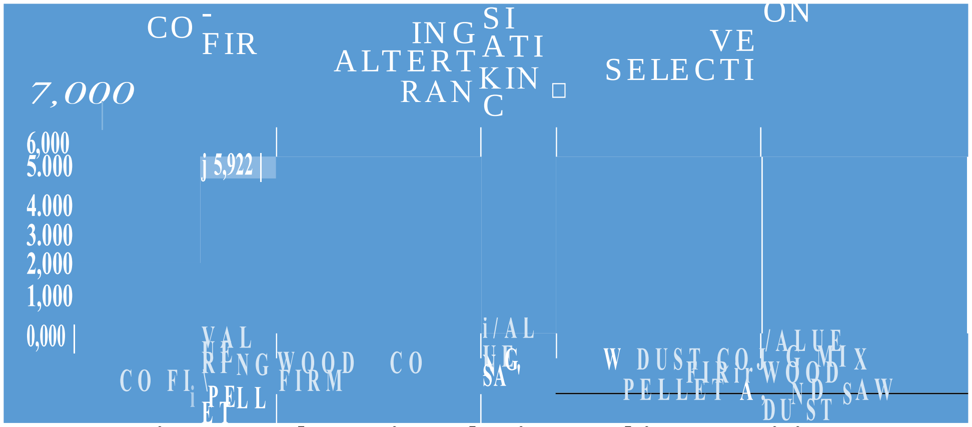

Figure 3 . Alternative Selection Ranking Co- Firing

Figure 4 above shows the co-firing alternative B as the first co-firing alternative with a score of 6.602 and the second rank is the co-firing alternative A with a score of 5, 992, and the last is the co-firing alternative C with a score of 5.318. Based on these results, the co-firing alternative B using biomass saw dust was chosen as an alternative decision for the sustainability of biomass co- firing with coal at PT Pembangkitan "XZY".

5. CONCLUSSION

5.1 Conclussion

Based on the results of the research and analysis and interpretation of the data carried out, it can be concluded that:

1. Interdependence correlation analysis using the DEMATEL method provides an overview of the network between decision criteria / subcriteria, where the subcriteria have the greatest influence on other sub-criteria for the price of biomass with an index value of 0.93.
2. The results of weighting using the AHP method show that the boiler design and technology sub-criteria, the price of biomass and the availability of biomass, with an index value of 9%, this indicates that the evaluation team and planning of the co-funding program prioritize the ease of implementation aspects of equipment and the availability of biomass on an ongoing basis. to support this program ..
3. From the overall analysis and calculation process, it shows that the co-firing alternative B is in the first rank with a value of 6.602, while the second rank is the co-firing alternative A with a value of 5.922 and the last is the co-firing alternative C. From the design of the retrieval system model The decision to choose the co-firing alternative, in choosing the co-firing alternative, not only considers the aspects of price and availability of biomass, but the suitability factor of boiler design and technology is also very dominant related to the implementation of co-firing alternative selection at PT Pembangkitan "XYZ".
4. The impact of reducing greenhouse gases on the implementation of linear biomass co- firing with a percentage of the amount of substitution or composition of a mixture of biomass and coal in the combustion process simultaneously.

5.2 Suggestion

1. PT Pembangkitan "XZY" in decision making needs to consider the sub-criteria for biomass characteristics, availability, generator efficiency and boiler design and technology in the selection of cofiring alternatives where these sub-criteria have the greatest influence on

other sub-criteria. Meanwhile, the emission reduction sub-criteria, biomass mix, biomass requirement and efficiency are the sub-criteria that receive the biggest impact compared to other sub-criteria.
2. The evaluation team of the biomass co-firing program related to the results of selecting cofiring alternatives can provide recommendations based on the weighted score of the criteria or sub-criteria to the Program director for decision making in choosing co-firing alternatives.
3. The selection of this co firing alternative is expected to further increase the use of the renewable energy mix in the energy sector, especially coal-fired power plants, and it needs to be studied in more depth regarding the characteristics of the biomass used because this is likely to have a long-term impact on the condition of generating equipment. for example boiler tubes, heat transfer, volumetric combustion chamber, and others

6. REFERENCES

Ciolkosz D. 2009. Manufacturing fuel pellets from biomass. Penn State Renewable and Alternative Energy Program: energy.extension.psu.edu. The Pennsylvania State University: Penn State Biomass Energy Center and Department of Agricultural and Biological Engineering.

Larson, E. W., & Gray, C. F. 2011. Project Management : The Managerial Process (Fifth edition ed.). (J. Richard T. Hercher, Penyunt.) New York, American: Tim Vertovec.

Natarajan, at. al., 1997. Overview of combustion and gasification of rice husk in fluidized bed reactors. Biomass and Bioenergy 1998; 14(5-6):533-546 Roos, G. (2012). Manufacturing into the future. Adelaide Thinker in Residence 2010-11, Adelaide Thinkers in Residence, Government of South Australia, Adelaide, Australia. Retrieved from http://www.thinkers.sa.gov.au/roosreport/ files/inc/194455830.pdf.

Sylviani, D. H., Suryandari, E. Y. (2013). Analisis biaya penggunaan berbagai energi biomassa untuk IKM (studi kasus di kabupaten wonosobo). Jurnal Penelitian Sosial dan Ekonomi Kehutanan. 1(10): 48-60.

Tampubolon, A. P. (2008). Kajian kebijakan energi biomassa kayu bakar study of fuelwood biomass energy policies. Jurnal Analisis Kebijakan Kehutanan. 5(1): 29-37. Pusat Litbang

TOPIC

Factor Analysis

THE EFFECTSS OF ORGANIZATIONAL CULTURE, KNOWLEDGE MANAGEMENT AND INNOVATION ON PERFORMANCE OF *ONLINE* INDIVIDUAL SUGAR RECOVERY ANALYSIS IN SUGAR FACTORY X

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ABSTRACT

Almost 90% of the sugarcane was supplied by growers. The business process between the sugar factory and the farmers was by sharing the sugar recovery obtained. The sugar recovery was analyzed for each individual truck. To overcome the tight competition for sugarcane, innovation was needed in the analysis system. To overcome the problem, Sugar Factory X is innovating with an Online individual sugar recovery analysis system. The research was conducted by distributing questionnaires to respondents from sugar factories as executors of individual sugar recovery analysis projects. Respondents from sugar factories answered questionnaires related to variables of organizational culture, knowledge management, innovation and project performance. Structural equation modelling (SEM - PLS) was used for data processing. 90 respondents were collected from nine sugar factory. The results showed that organizational culture and knowledge management had not significant effects on project performance either direct or indirect with innovation asmediator. The innovation were significant the performance of the *Online* sugar recovery analysis system.

Keywords: *Organizational Culture, Knowledge Management, Innovation, Performance,* SEM-PLS

1. INTRODUCTION

There are 30 sugar factories with a milling capacity of 150,835 tons cane per day in East Java. If it operates for 150 days, 22,625,000 tonnes of sugarcane was needed, equivalent to an area of 301,670 ha (assuming productivity of 75 tonnes/ha). The total area of existing sugarcane was 189,964 ha, resulting in a deficiency of 111.70 ha. There are sugar factories that reduce their milling days so that their profits are also reduced. Almost 90% of sugarcane in East Java was supplied by sugarcane growers. The relationship between factories and growers was a partner, where growers supplies sugarcane to factories to be processed into sugar. Growers get profit from the share of sugar that was sent to factories. The profit sharing assessment process uses an individual sugar recovery analysis system.

The system that runs manually and submits the results a day after the analysis process causes growers to distrust the results of the analysis. Suhada et al, 2012 stated that problems in thesugar recovery analysis arose due to moral hazard and distrust of the system. These problems have become the culture of each institution, both growers and factories. The existence of the problems and the distrust can interfere with harmony and fairness in delivering transparent analysis results in partnerships. The moral hazard that develops from the analysis is the lack of transparency in the manual data processing. The growers believe that the analysis result data can still be "changed" because everything was done by factories. Meanwhile, with the decline in growers's trust in the the system, growers only pursue the weight of sugarcane without paying attention to its quality. Growers consider that sending good and low-quality sugarcane will be rewarded equally. Several studies regarding the satisfaction level of growers with factories were related to the problem of sugar recovery analysis (Rachmadan et al, 2012; Tjahaja, 2010; Rochmatika, 2006).

For this reason, Sugar Factory X has an initiative by innovating the old ARI system to be automatic. The difference in the new system is in the management of analysis and information of results. In this system, the identification of the sample uses a barcode and the results of the analysis from the tool were automatically proceed into the computer. The analysis results can be issued after 5 minutes of sampling.

The performance of a project can be measured from the cost, implementation time and customer satisfaction. In addition, variables that can support project performance include: organizational culture, knowledge management and innovation. Previous research suggested that organizational culture in the long term will affect the project performance (Shahzad et al, 2012). Alavi, 2005 also support that the success of a project can be affected by how to manage cultural diversity, including human resource (HR) of the organization. Valenciat, 2011 reveal that the innovation process that develops in an organization is closely related to the organizational culture that has been formed within the organization. The innovation behaviour that develops in the organization is a form of culture that has been formed. inside the organization. The existence of elements of organizational culture and innovation means that a dynamic project can achieve good performance.

The aim of this research was to identify and examine the influence of organizational culture, knowledge management and innovation on the performance of an online individual sugar recovery analysis project in a sugar factory.

2. RESEARCH FRAMEWORK

2.1 Organizational Culture

Organizational culture is interpreted as the assumptions, values and beliefs contained in every individual in the organization. This belief is hidden and formed for a long time (Miron, et al, 2004). Thus culture can trigger innovative behavior within the organization. Furthermore, organizational members will try to increase commitment to the organization through creating innovation.Cameron and Quinn (1999) developed a cultural model which was later known as OCAI (Organizational Culture Assessment Instrument). This model was developed to map and measure the level of organizational culture. There were four dimensions: adhocracy, clan, market and hierarchy. The organizational culture model of OCAI consists of two main dimensions,namely External Focus versus Internal Focus and Flexibility and Discretion vs Stability. With the mapping of gaps, systematic changes can be made so as to reduce these differences (Cameron and Queen, 2006).

2.2 Knowledge Management

Alavi and Leidner 2001 revealed that the definition of knowledge management is a management discipline that is related with sharing, creation and acquisition and systematic use of knowledge in organizations. Furthermore, it can increase the company's competitiveness through innovation. Meanwhile, Lloria (2008) states that knowledge management is a set of instrument to enable the creation and dissemination of knowledge to achieve organizational goals.

The process of increasing the knowledge of the organization is known as the knowledge management cycle. There are several dimensions in the knowledge management cycle: creation, capture, organization, storage, dissemination, application, acquisition, compilation/transformation and use. Some researchers use this dimension, Lawson (2003) uses six dimensions: creation, capture, organization, storage, dissemination, application. Furthermore, there are severalresearchers such as Chin-Loy and Mutjaba (2007) and Jones (2010) using the same dimensions.

2.3. Innovation

Knox (2002) stated that innovation was a process which provides a level of novelty and added value to an organization. Innovation consists of developing new procedures, products, solutions and services. Product innovation is an important part that can lead to improving company performance, Naranjo-Valencia et al (2015). Massa and Testa (2008) in stating the academic definition of innovation was an emphasis on the scientific novelty of work, while for entrepreneurs, innovation is anything that can lead to financial gain.

Organization for Economic Co-operation and Development (OECD) stated the definition of innovation was the implementation of changes to new products, processes, methods in business and customer relationship. There are four types of innovation:

a. Product innovation is a significant change made to improve existing goods or services.
b. Process Innovation is a significant change made in existing production methods.
c. Organizational Innovation is the application of new organizational methods that refer to organizational changes, business practices and external relations
d. Marketing Innovation represents a change in the application of marketing methods including promotion, packaging and product placement and pricing.

In this study, the innovation dimension that will be used refers to the OECD (2005). Several studies have referred to this innovation dimension, including research by Gunday, et al. (2011) and Hassan, et al. (2013) conducted at manufacturing companies; Varis and Littunen(2010) on small and medium enterprises.

2.4. Project Performance

Besteiro, et al. (2015) defining project performance as a complex and depending on the type of organization and project being implemented. Jugdev, et al. (2013) stated that project success is part of the organization's strategic perspective and some of the influence comes from stakeholder expectations. Previous research has suggested several variables with respect to project performance appraisal. Pinto and Slevin (1988) suggest that project performance can be evaluated

based on the cost-time-quality. Meanwhile, Jugdev and Muller (2005) stated that project performance can be evaluated based on behavioural aspects such as client relationship. Other indicators that can be used in performance appraisal are customer satisfaction (Freeman and Beale, 1992). Project environments such as radical and incremental change (Raz et al, 2002) and cross-cultural perceptions (Pinto, 2013) are also used as indicators of project performance measurement.

Loon et al (2013) in Harahap (2014) stated that performance can be measured subjectively and consists of six dimensions, namely: output, efficiency, service delivery, responsiveness, democratic standards, and development. The output dimension describes an attitude in maintaining the quantity and quality of work. Efficiency is a characteristic that aims to provide fast and efficient service. Service delivery is a service system that has an impact on customers. Responsiveness is the payment of customers or users for the services provided. Democratic shows transparency and openness in carrying out work. Development is an attitude that shows that the organization is always growing and learning to deal with.

3. RESEARCH METHODOLOGY

3.1. Samples and Questionaire

This research was a confirmatory type, by identifying and testing the relationship between variables to determine their EFFECTS. The variables tested in this study were organizational culture, knowledge management, innovation (innovation culture, product innovation, process innovation) and performance (output, efficiency, service, responsiveness, democratic and development). The data was collected by deploying questionnaire. Distribution of the questionnaire was carried out at the level of the General Manager, Manager, Assistant Manager and staff involved in the implementation of an individual sugar recovery analysis project.

3.2. Analysis

The statistical test used to measure the influence between variables was using structural equation modelling - partial least square (SEM-PLS). This method was used for a small sample size. According to Chin in Latan and Ghozali (2012), the PLS method does not require distribution conditions for parameter estimation. For that, it does not require a significance test. The SEM-PLS evaluation model is carried out by measuring the outer model (measurement) and the inner model (structural).

The outer model was evaluated using convergent validity and discriminant validity. Convergent validity evaluation was done by measuring the the correlation between constructs in the latent variable. The criteria used in measuring individual item reliability was the loading factorvalue. If the loading factor value is > 0.7, it can be said that the construct was good to use. The acceptable limit for loading factor values is > 0.5. If in the evaluation the loading factor value is below 0.5; then the item must be remove from the measurement model.

The inner model was evaluated using four criteria : R^2, f^2, Q^2 and goodness of fit (GoF). The next step is to evaluate the value of R square (R^2), which is the interpretation made by exogenous variables on the variability of endogenous variables. The R^2 criteria can be classified asfollows: 0.67 (substantial); 0.33 (moderate); 0.19 (weak), Chin (1998) in Yamin and Kurniawan (2011: 11). The next step is evaluating the f^2. Cohen (1988) stated that the criteria for the f^2 are :
0.02 (small); 0.15 (moderate); 0.35 (high). The next structural model testing phase is Q^2 predictive relevance. The model has a good value if the number of Q^2 is > 0. The final stage is to evaluate the GoF index criteria GoF values between 0 to 1 with the interpretation of the values: 0.1 (low), 0.25 (moderate), and 0.36 (high).

3.4. Hypotesis

This research will identify the relationship and influence between variables. The independent variable (X) consists of organizational culture (adhocracy culture, clan culture, market culture, hierarchy culture) and knowledge management . Meanwhile, the dependent variable is innovation (innovation culture, product innovation, process innovation) and performance (output, efficiency, service, responsiveness, democratic, development). The research model is presented as follows:

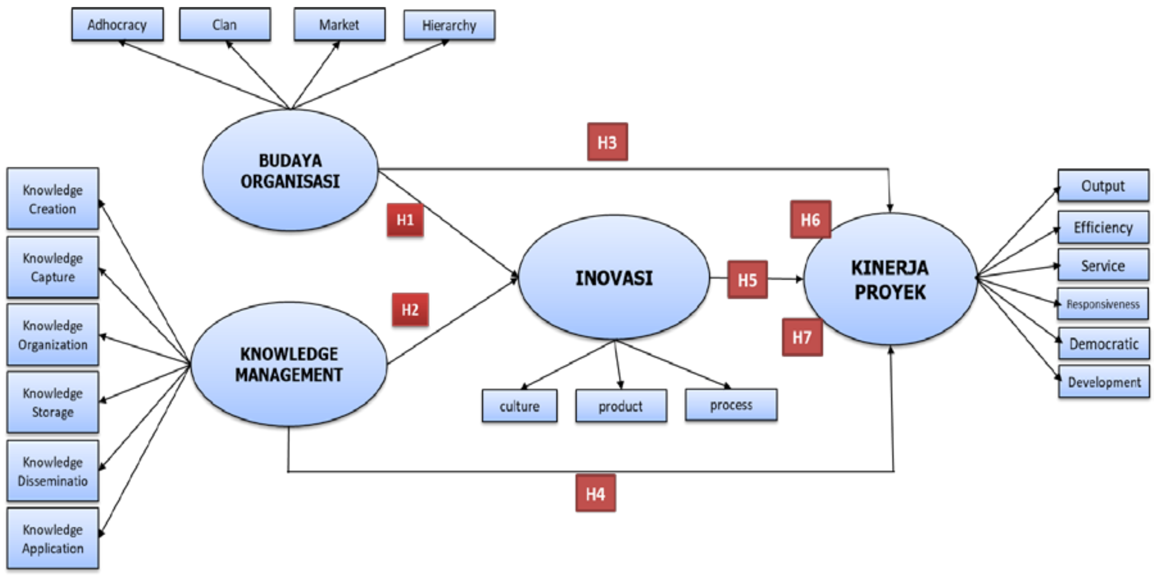

Figure 1. Research Framework

Based on the proposed research model, the research hypothesis is compiled as follows:
H1: Organizational culture has a direct effect on innovation
H2: Knowledge Management has a direct effect on innovation
H3: Organizational Culture has a direct effect on Project Performance
H4: Knowledge Management has a direct effect on Project Performance
H5: Innovation has a direct effect on project performance
H6: Organizational Culture has an effect on Project Performance through Innovation
H7: Knowledge Management has an effect on project performance through innovation

4. RESULT AND DISCUSSION

The validity and reliability tests were carried out on 45 questions asked to the respondents. Validity test was carried out to determine the accuracy of the questions in measuring these variables. Reliability test was carried out to measure the level of consistency of questions in producing answers related to the research variables. The results of the calculation of the r-valueare compared with the r table at the real level (α) 5%. According to Sugiyono (2012), if the value of r-count ≥ r-table, then the data is valid. The limit of the r table value is 0.30. Based on statisticaltesting of 45 research instruments, it shows valid results with the calculated r-value greater than 0.3, respectively. The results of the reliability test shown in Table 1 below :

Table 1. Realibility Test Result for Research Instrument

Variabel	Cronbach's Alpha	R-Table	Decision
Organizational Culture	0.788	0.700	Reliable
Knowledge Management	0.923	0.700	Reliable
Innovation	0.815	0.700	Reliable
Project Performance	0.777	0.700	Reliable

Table 1 shows that the variable Organizational Culture, Knowledge Management, Innovation and Project Performance is included in the reliable category because it has a Cronbach's Alpha score> 0.700. Based on the validity and reliability test, all question instruments in the questionnaire meet the requirements. If the instrument is repeated, it will show no different results. The overall test of the model shows in Figure 2.

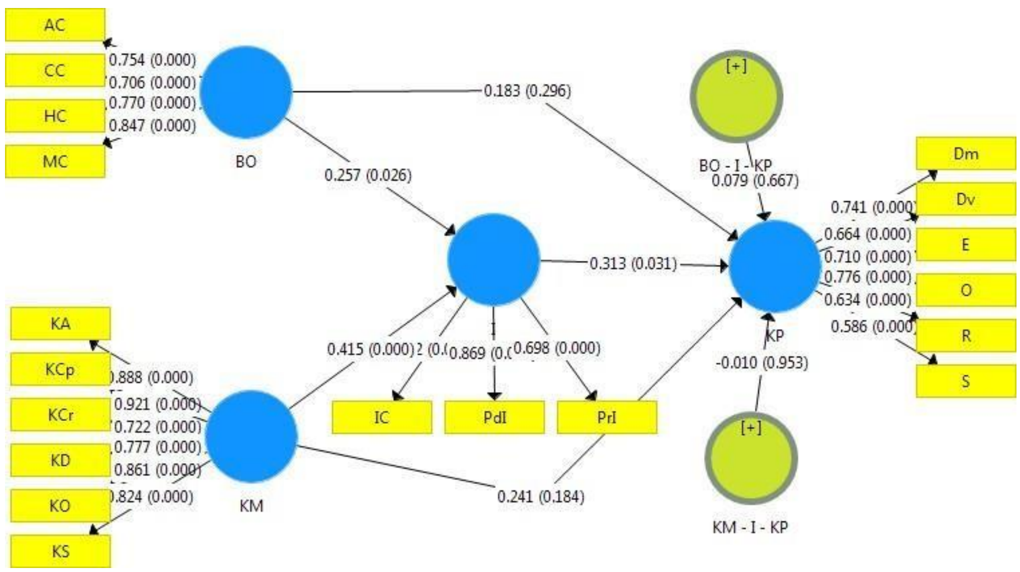

Figure 2. SEM – PLS Full Model

The results of the recapitulation of the individual item reliability analysis show that all loading factor values of the manifest variable are > 0.5. It can be concluded that the proposed model does not have a convergent validity problem (individual item reliability). The results of the evaluation of internal consistency reliability show that all variables meet the criteria, where the Cronbachs Alpha and Composite Reliability values are > 0.6. Based on this, the proposed model does not have problems with internal consistency reliability. Meanwhile, the evaluation results for all variables have an AVE value> 0.5, so that all variables in the study meet the requirements based on their AVE value. The results of the discriminant validity evaluation, show that all the square root values of the AVE are greater than the correlation between constructs and other constructs.

Table 2. Evaluation for Inner Model

Variables Endogen	R Square	Criteria	Q^2		GoF	
			Result	Criteria	Result	Criteria
Innovation	0.395	Middle	0.661	> 0	0.499	High
Project Performance	0.440	Middle				

The results of R^2 value of the innovation variable and project performance were 0.395 and 0.440, respectively. This shows that the variability of innovation which is able to be explained by Organizational Culture and Knowledge Management have the moderate criteria. Furthermore, the variability of Project Performance which can be explained by Organizational Culture, Knowledge Management and Innovation falls into the moderate criteria. The Q^2 test is ideal if the endogenous latent variable has a reflective measurement model. The results of the calculation of Q^2 based on the R^2 value of the innovation variable and project performance produce a value of 0.661 (> 0). These results indicate that the exogenous latent variables fall into the good category so that they are able to clarify and predict the endogenous variables. The GoF calculation results obtained a value of 0.499, respectively.

Based on the evaluation of the outer model shows that the model meets the requirements. The evaluation results of the inner model show that the exogenous latent variable is good (appropriate) as an explanatory variable that is able to predict the endogenous variable.

Hypothesis testing based on the probability value and t-statistic. For probability values, the p-value with $\alpha = 5\%$ is less than 0.05. The t-table value for $\alpha = 5\%$ was 1.96. A summary of the results of hypothesis testing was presented in Table 3.

Table 3. Result of Hypotesis

Hypotesis	Statement	T hitung	P Value	Decision
H_1	Organizational culture has a direct effect on innovation	2.228	0.026	Significant
H_2	Knowledge Management has a direct effect on innovation	3.828	0.000	Significant
H_3	Organizational Culture has a direct effect on Project Performance	1.046	0.296	Not Significant
H_4	Knowledge Management has a direct effect on Project Performance	1.329	0.184	Not Significant
H_5	Innovation has a direct effect on project performance	2.165	0.031	Significant
H_6	Organizational Culture has an effect on Project Performance through Innovation	0.431	0.667	Not Significant
H_7	Knowledge Management has an effect on project performance through innovation	0.06	0.953	Not Significant

Based on empirical facts and data processing using SEM-PLS, the proposed model meets the criteria where the combined performance of the measurement and structural models is very good. Hypothesis testing shows that the variables of Organizational Culture and KnowledgeManagement have a positive EFFECTS on innovation, but have no EFFECTS on project performance. Hofstede (1988) states that naturally every individual in an organization will build a culture that is learned from the environment, both from within the organization and from other groups. Every organization must have a culture that differentiates it from other organizations.

Organizational culture has a significant EFFECTS on innovation. This is consistent with previous research conducted by Prajogo and Mc Dermott (2010), where the four dimensions of organizational culture in the OCAI model have a significant EFFECTS on product and process innovation. This is also consistent with the findings of Tornatzky and Fleisher (1990), where an external orientation of the cultural dimension drives innovation throughout the organization, including the application of new tools and processes. The Online Individual Sugar Recovery Analysis System is a form of process innovation and technology application that adapts to the latest developments. However, organizational culture variables have no EFFECTS on project performance. This contrasts with several previous studies (Valencia et al, 2015; Chin-Loy and Mutjaba, 2007) which state that organizational culture affects company performance. Previous researchers used the OCAI model to measure the effect of organizational culture on company performance. Cameron and Quinn, 2006 have validated the OCAI method compared to a Likert response scale to measure the same dimensions of variable. The trial show that the model is valid with a coefficient of 0.764. Therefore, the selection of the OCAI model for the relevant organizational culture variables is used to determine their EFFECTS on project performance.

The innovation variable has a positive EFFECTS on the performance of the online individual sugar recovery analysis project. The category of innovation carried out by SugarFactory X in terms of the online individual sugar recovery analysis system is technical innovation and process innovation (Damanpour, 1991). Both categories of innovation emphasize changes or modifications to processes using technology. The development of the system is still needed, one ofwhich is the delivery of information on analysis results quickly using an application via a smartphone. The innovation process requires investment which can directly or indirectly influenceon improving company performance (Ciptono, 2006). The application of the online individual sugar recovery analysis system was expected to motivate growers to improve the quality of sugarcane which has a positive impact in increasing sugar production.

5. CONCLUSION

The influence of organizational culture, knowledge management and innovation on project performance in this research was carried out using structural equation modelling (SEM-PLS). Questionnaires (90 sets) were distributed to managers and staff in an online individual sugar recovery analysis project at sugar factory X. The results of model evaluation using the SEM PLS method showed that the model met the requirements statistically.

The results shows that Organizational Culture has no influences on Project Performance either directly or through innovation media. Knowledge Management has no influences on Project Performance, either directly or through innovation media. Innovation has a significant influences on project performance.

These research results were expected to have an impact on management for improvements, especially in organizational culture and knowledge management. A more in-depth identification of the organizational culture of each sugar factory was needed, in order to formulate the best strategy for organizational culture management. Innovation needs to be maintained and developed as a strategy for dealing with competitors. Continuous innovation will have a positive impact on projects developed within the company. The innovation that grows in the organization is influenced by the existing organizational culture and well-managed knowledge management.

6. REFERENCES

Alavi, M., Kayworth, T.R and Leidner, D.E. (2005). An empirical examination of the influence of organizational culture on knowledge management practices. *Journal of Management Information System.* 191-224.

Besteiro, É.N.C., Pinto, S.J. and Novaski, O.(2015).Success factors in project management. *Business Management Dynamics*, Vol 4. No 9, 19-34.

Cameron, K., and Quinn, R. (1999). *Diagnosing and changing orga-nizational culture. Based on the competing values framework*.Reading, MA: Addison-Wesley.

Cameron, K,S, and Quinn, R.E. (2006). Diagnosing and Changing Organizational Culture. (Ed rev.) San Fransisco, CA : Jossey-Bass A Wiley Imprint Inc.

Chin-Loy, C. and Mujtaba, B. G. (2007). The influence of organizational culture on the success of knowledge management practices with North American companies. *International Business & Economics Research Journal, 6*(3).

Ciptono. W. S, (2006). A Sequential Model Of Innovation Strategy-Company Non Financial Performance Links. *Gajah Mada International journal of Bussiness*, 8, 2 : 137-178

Damanpour, F. (1991) Organizational Innovation: A Meta-Analysis of Effects of Determinants and Moderators. *Academy of management Journal*, 34, 555-590.

Damanpour, F. and Gopalakrishnan, S. (2001). The dynamics of the adoption of products and process innovations in organizations.*Journal of Management Studies*, *38*, 45-65.

Freeman, M.A and Beale, P. (1992). Measuring project success. *Project Management Journal.* 23 (1). 8-17.

Gunday, G., Ulusoy, G., Kilic, K., and Alpkan, L. (2011). Effects of innovation types on firm performance. *International Journal of Production Economics*, 133(2), 662–676.

Hassan, M. U., Shaukat, S., Nawaz, M. S., and Naz, S. (2013). Effects of Innovation Types on Firm Performance: an Empirical Study on Pakistan's Manufacturing Sector. *Pakistan Journal of Commerce and Social Sciences*, Vol 7. No 2, 243–262.

Hofstede, G. (1988). The confucius connection: From culturalroots to economic growth. *Organizational Dynamics*, Vol 16. No 4. ,4-22.

Jugdev, K and Muller, R. (2005). A retrospective look at our evolving understanding of project success. *Project Management Journal*. Vol 36, No 4. 19-31.

Loon, Vandenabeele, & Leisink. (2013). Public Value-Based Performance: The Development and Validation of a Measurement Scale. *11th Public Management Research Conference.* Wisconsin.

Massa, S and Tessa, S. (2008). Innovation and SMEs : misaligned perspectives and goals among enterpreneurs, academics and policy makers. *Technovation.* 28, 393-407.

Miron, E., Erez, M. and Naveh, E. (2004). Do personal characteristics and cultural values that promote innovation, quality and efficiency compete or complement each other? *Journal of Organizational Behavior*. Vol 25. 175-199.

Pinto, J.K and Slevin, D.P. (1988). Critical success factor across project lifecycle. *Project Management Journal*. 67-74.

Prajogo, D, and Mc Dermott, C.M. (2010). The relationship between multidimensional organizational culture and performane. *International Journal of Operatioan and Production Management*. Vol 31, No 7, 712-735

Rachmadan, A.A., Wibowo, R dan Hapsari, T.D. (2012) Hubungan tingkat kepuasan, tingkat motivasi dan produktivitas tebu petani mitra kredit PG Ddjombang Baru. *Berkala Ilmiah Pertanian*. 15 hlm.

Rochmatika, R.L. (2006). Kajian Kepuasan Petani Tebu Rakyat Terhadap Pelaksanaan Kemitraan Pabrik Gula XYZ. Skripsi. Bogor: Program Studi Manajemen Agribisnis Institut Pertanian Bogor

Shahzad, M., Ying, Q., Ur Rehman, S., Zafar, A., Ding, X., Abbas, J., (2019). Impact of knowledge Absorptive Capacity on Corporate Sustainability with Mediating Role of CSR: Analysis from the Asian Context. *Journal of Environmental Planning and Management.* 1– 27.

Suhada B, Sa'id EG, Rusastra IW, Sukardi. (2012). Rekayasa kelembagaan kemitraan pabrik gula dengan petani tebu dalam mendukung peningkatan kinerja industri gula tebu nasional.*Jurnal Manajemen dan Kewirausahaan*. 4(1):60-74.

Tjahaja, A.I (2010). Tingkat Kepuasan dan Kepatuhan Petani Tebu Terhadap Pola Kerjasama dengan Pabrik Gula Gempolkrep. *Jurnal Pertanian Mapeta*. ISSN : 14411-2817. Vol XII. No. 2. April 2010 : 72 -144

Valencia , Julia C. N.; Valle, Raquel S. & Jimenez, Daniel. (2011). "Inovation or imitation? The role of organizational culture". *Management Decision*. Vol.49 No.1, 55-72.

Varis, Miika & Littunen, Hannu., (2010), Types of Innovation, Sources of Information and Performance in Entrepreneurial SMEs. *European Journal of Innovation Management*. Vol. 13, No. 2, pp. 128-154.

FACTORS AFFECTING THE DELAY OF THE EMPLOYEE PERFORMANCE INDICATOR IN PT PERKEBUNAN NUSANTARA X

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ABSTRACT

PT Perkebunan Nusantara X collaborates with consultants in preparing employee performance indicators. In its implementation, the project was late from the originally planned target. This study aims to determine what dominant factors are the causes of the delay in preparing employee performance indicators and what strategies can be used to increase the chances of the project being completed.

In using the Fault Tree Analysis (FTA) method to determine the factors that influence project events, 30 basic events were obtained from owners and consultants. Data from 20 respondents who filled out the questionnaire took 10 main factors causing the project to conduct in-depth interviews with experts involved in the project. The results of the final calculation obtained data that the factors that influence project delays from the owner have aprobability of 0.88 and a consultant of 0.72. The overall probability of events affecting the delay in the preparation of performance indicators is 0.97.

Strategies that can be used by PT Perkebunan Nusantara X to increase the chances of completing the preparation of Employee Performance Indicators using the SWOT Matrix focus on the SO strategy (Strengths-Opportunities), WO strategy (Weaknesses-Opportunities), ST (Strengths-Threats) strategy, and WT strategies (Weakness-Threat).

Keywords: Employee Performance Indicators, Project Delay, *Fault Tree Analysis (FTA), SWOT*

1. INTRODUCTION

1.1 Research Background

According to Proboyo (1999), each project usually has an implementation plan and schedule, when the project started, when completed, how the project is done, and how its resources.Planning and project implementation schedule refers to the conditions and forecasts that existed at the time the plans and schedules were made. According to Gebrehiwet and Luo (2017), a project isusually recognized as successful when it is completed on time, with a budget according tospecifications, and stakeholder satisfaction. However, most projects did not finish on schedule, and delays were considered one of the most common problems causing many negative effects on projects.

According to Aziz and Abdel-Hakam (2016), delays affect each party in different ways for either the owner or the contractor, the effect is different but not the same as a consultant who is considered the least affected party. To reduce the risk of delays and cost overruns in project implementation, in the project planning stage there must be preparation for planning, scheduling, and cost evaluation (Al-Hazim, Salem, and Ahmad, 2017).

PT Perkebunan Nusantara X has also experienced delays in project completion, in the preparation of *Key Performance Indicators* (KPI) / Employee Performance Indicators. *Key Performance Indicator* (KPI) is an indicator used to monitor the level of achievement of acompany's performance targets. In this case it is often referred to as the Company KPI. Basically, the determination of the Company's KPIs must be based on the Company's vision and mission fora certain period of time.

The preparation of Employee Performance Indicators for PT Perkebunan Nusantara X is a new thing because previously there were none, in 2019 it is planned that all permanent employees total 2777 people, starting from the position of General Manager (BOD-1 = 1 level below the Board of Directors), Manager (BOD-2 = 2 levels below the Board of Directors), Assistant Manager (BOD-3, = 3 levels below the Board of Directors) then Young Assistant (BOD-4 = 4 levels below the Board of Directors). Employee Performance Indicators are structured so thateach employee has measurable performance targets in achieving organizational goals. Given the large *scope of* work, the preparation of this Performance Indicator was carried out by the Consultant of PT. Magnet Solusi Integra by remaining accompanied and *supported* by personnel from the HR Department. The completion of work is carried out in stages per position level and based on a work contract with a schedule plan as follows:

Table 1. Schedule for preparation of performance indicators

Position	Level	Number of	Completions
General Manager	BOD-1	32 org	March 31 2019
Manager	BOD-2	103 org	31 May 2019
Assistant Manager	BOD-3	317 org	31 August 2019
Young Assistant	BOD-4	2325 org	31 December 2019

Preparation of Employee Performance Indicators for PT Perkebunan Nusantara X until the deadline of 31 December 2019 has just been completed for Position 1 level at under the Board of Directors (BOD-1) - General Manager 32 people. This delay in preparing the individual performance of each employee at the end of 2019 cannot be measured using a-based Performance Indicator *balanced scorecard* so that the Company cannot measure the performance targets per individual as expected. In 2019, employee performance appraisal uses the old system.

1.2 Problem Formulation

Problems raised in this Thesis are:

1. What factors influence the delay in preparing Employee Performance Indicators and which ofthese factors is dominant?
2. What strategies can the Company use to increase the chances of completing the process ofpreparing the Employee Performance Indicators?

1.3 Research Objectives

Objectives of this study are as follows:

1. To investigate the factors that influence the delay in the preparation of Performance Indicatorsat PT Perkebunan Nusantara X
2. Knowing the strategies that can be used by PT Perkebunan Nusantara X to increase thechances of completing the preparation of Employee Performance Indicators

1.4 Benefits Research

Benefits of this research are:

1. Can provide evaluations and solutions regarding delays in the preparation of Employee Performance Indicators to related parties
2. Can provide references and empirical evidence for academics as a scientific contribution to thestudy of delays in the preparation of Employee Performance Indicators

1.5 Benefits Research

To keep problems within their scope, avoid overly broad discussion, and there is limited time so that this research can be well directed according to the research objectives, it is necessary to provide limitations on the research to be carried out, such as:

1. This research was conducted in PT Perkebunan Nusantara X
2. Project data used is a project for the preparation of Employee Performance Indicators.
3. This study focuses on finding the factors that cause delays in the preparation of Employee Performance Indicators and strategies that can be used by the Company to increase the chancesof completing the process of preparing the Employee Performance Indicators

2. METHOD

Below is an illustration of the research flow starting from the research background, the methods used, what kind of results will be obtained through this research so that it provides an overview of how this research will run. The stages of this research method will be described in a *flow chart.*

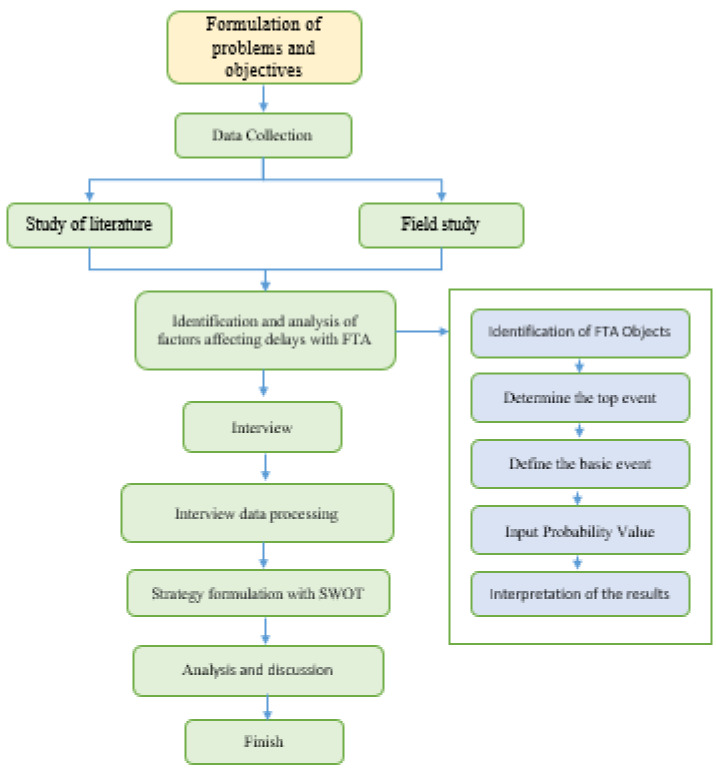

Figure 1. *Flow chart* research flow chart

3. RESULTS AND DISCUSSION

3.1 Data Collection

Object of research taken in this study is a project for compiling employee performance indicators at PT Perkebunan Nusantara X. The project is carried out in stages starting from the BOD-1, BOD-2 levels, BOD-3 and later just BOD-4. Preparation of performance indicators is prioritized for Leaders who hold managerial positions (levels BOD-1 to BOD-3 or starting from General to Assistant Manager). The preparation of employee performance indicators for thepositions of General Manager, Manager, and Assistant Manager is planned for completion on August 31, 2019 with a total of 452 performance indicators.

Table 2. Completion Target for compilation of employee performance indicators

Position	Level	Number of	Completions
General Manager	BOD-1	32 org	31 March 2019
Manager	BOD-2	103 org	31 May 2019
Assistant Manager	BOD-3	317 org	31 August 2019
Young Assistant	BOD-4	2325 org	31 December 2019

The preparation of Employee Performance Indicators for PT Perkebunan Nusantara X until the deadline of 31 December 2019 has just been completed for the position of General Manager total 32 people. This delay in preparing the individual performance of each employee at the end of 2019 cannot be measured using a-based performance indicator *balanced scorecard* so that the Company cannot measure the performance targets per individual as expected. In 2019, employee performance appraisal uses the old system.

3.2 Identification of the Causes of Delays

In 2020, the performance indicators of the existing General Manager, the performance indicators of the Manager and Assistant Manager that are being drafted must be *reviewed* again due to changes in company rules and changes in Organizational Structure 3 times, namelychanges to the Organizational Structure on 29 January 2020, 12 March 2020, and 16 June 2020. Changes in company rules and changes in the Organizational Structure have changed employee performance indicators in several sections which have resulted in delays, not in accordance with the planned completion targets.

3.3 Questionnaires

Initial data in this study were the *basics* of delays in the project, which were determined based on a literature study on the project which was then screened. *The basic events* obtained are reprocessed using a questionnaire method, to validate existing initial data.

The questionnaire was distributed to employees at the Head Office of PT Perkebunan Nusantara X who were involved in the project of preparing performance indicators with 20respondents, namely:

1. Head of Division (BOD-1 = 1 level below the Board of Directors) totaling 10 people.
2. Head of Affairs (BOD-2 = 2 levels below the Board of Directors) totaling 10 people. The selection of respondents is based on active involvement in the preparation of the project.

3.4 Combination of Basic Events

The process of drawing the FTA (diagram *Fault Tree Analysis*) has been carried out. The next step is to analyze the *Fault Tree* quantitatively using the law *logic gate* where there are probabilities in addition (*or gate*) and multiplication (*and gate*).

The purpose of this analysis is to find a *minimum cut set*. *Cut set* is a combination that forms a fault tree. If all factors occur, the peak event or major risk will occur. *Minimal cut set* is a combination of the smallest events. Table 3 the probability for each obtained *basic event* is a follows:

Table 3. Probability of basic event

No.	Event Code Event	Name	Probability
1	A.1.1.1	Interview schedule concurrently with company meetingschedule	0.6
2	A.1.1.2	time duration determination	0.4
3	A.1.2	Monitoring and evaluation does not work	0.4
4	A .2.1.1	Company management is slow in making decisions	0.4
5	A.2.1.2	Company late provide direction	0.4
6	A.2.2.1	Not all parts are involved in the process of compiling	0.4
7	A.2.2.2	There is no PIC for each scope of work	0.05
8	A.2.2. 3	Lack of company control over ongoing projects	0.4
9	A.3.1.1	Too many data changes	0.4
10	A.3.1.2	Application of too high standards for each job	0.6
11	A.3.1.3	Increase or decrease in work coverage	0.8
12	A.3.2.1	Late payment for consultant work	0.6
13	A.3.2.2	There is no penalty for late work	0.4
14	A.3.3.1	There is a change in the company's organizationalstructure	0.8
15	A.3.3.2	There is a change in company rules	0.6
16	B.1.1.1	The absence of *timeline* a clear at each stage of work	0.2
17	B.1.1.2	The work plan is not well structured	0.4
18	B.1.2. 1	Weekly action plan that did not work	0.4
19	B.1.2.2	The work target did not match the plan	0.6
20	B.1.3.1	The method of implementing the work t inaccurate	0.4
21	B.1.3.2	The results of the job evaluation cannot be done	0.4
22	B.1.3.3	The results of the coordination meeting are not followed up	0.4
23	B.2.1	There is a difference in the data to be processed	0.4
24	B.2.2.1	Absence of comparative data	0.4
25	B.2.2.2	Consultant does not get the required data from thecompany	0.2
26	B.3.1.1	The consultant does not master the company's businessprocesses	0.6
27	B .3.1.2	The competence of the consultant team is not the same	0.4
28	B.3.1.3	The number of employee complaints about the ongoing project	0.6
29	B.3.2.1	There is a miscommunication between the company and the consultant	0.4
30	B.3.2. 2	Lack of coordination between the company and consultants	0.2

3.5 Analysis of project delays *(owner)*

Search for the probability value *of the intermediate event* main with code A (events that affect project delays caused by the *owner*) required probabilities of each *basic event*, following the FTA diagram Figure 2 and Table 4 is a value *minimal cut set* and probability value for each *basic event.*

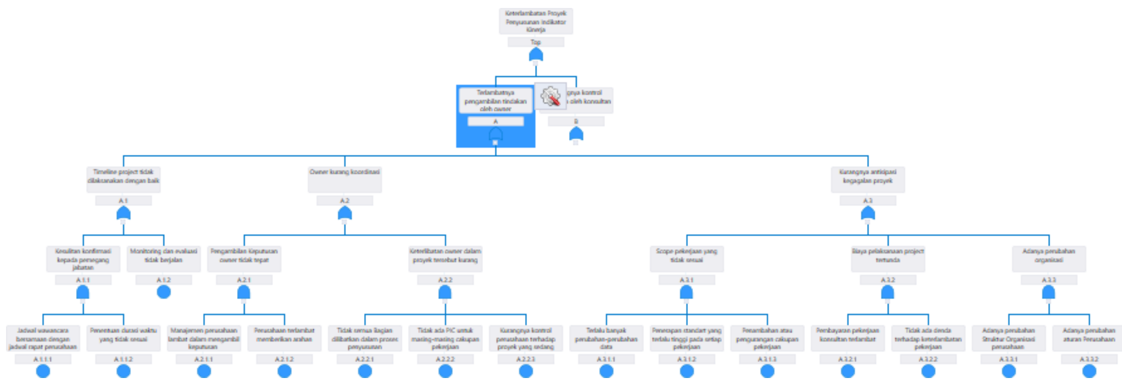

Figure 2. FTA Code A Diagram

From Figure 3.1, the minimum combination can be calculated *cut set* with the following equation:
(A.1+A.2+A.3) - (A.1*A.2) - (A.1*A.3) - (A.2*A.3) + (A.1*A.2*A.3)
(0.54+0.17+0.68) - (0.54*0.17) - (0.54*0.68) - (0.17*0.68) + (0.54*0.17*0.68)
= 0.88

Based on the above equation, the combination is calculated *minimum cut set* based on theprobability value in Table 4. The results of the probability *cut set* in the event of not implementing the project caused by the *owner* of 0.88

Table 4. Minimal cut set (owner)

Code	Name Event	Probability
A.1	Timeline project is not implemented properly	0.54
A.2	Owner lacks coordination	0.17
A.3	Lack of anticipation project failure	0.68
Minimal Cut Set		**0.88**

3.6 Analysis of project delays (consultants)

Searching for the probability value of the main intermediate event with code B (the event that causes the project not to be implemented is due to the *consultant*) required probabilities from each *basic event*, following the FTA diagram Figure 3.2 and Table 3.4 are the values *minimum cut set* and probability value for each *basic event* in the event of project delays caused by the consultant are **0.72**

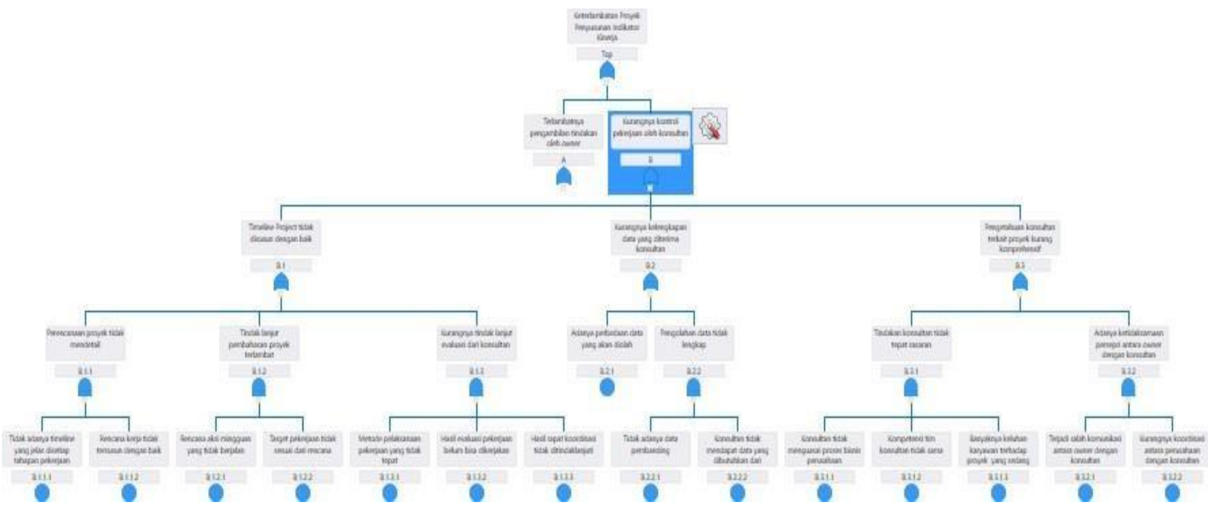

Figure 3. FTA Diagram Code B

From Figure 3, the minimum combination can be calculated *cut set* with the following equation:
(B.1+B.2+B.3) - (B.1*B.2) - (B.1*B.3) - (B.2*B.3) + (B.1*B.2*B.3)
(0.35+0.45+0.21) - (0.35*0.45) - (0.35*0.21) - (0. 45*0.21) + (0.35*0.45*0.21)
= 0.72

Based on the above equation, the calculation of the combination is carried out *minimum cut set* based on the probability value in Table 5. The results of the probability *cut set* in the event of not carrying out the project due to the *owner* of **0.72**

Table 5. Minimal Cut Set (consultant)

Code	Name Event	Probability
B.1	Timeline Project is not well prepared	0.35
B.2	Lack of completeness of data received by consultants	0.45
B. 3	The consultant's knowledge regarding the project is less comprehensive	0.21
Minimum Cut Set		**0.72**

3.7 Total Number of Probabilities

The next stage is to calculate the total number of combination probabilities *minimum cut set* for the *Top Event*. Where for the event "Delay in taking action by the *owner* (A)" the probability is 0.88 and the event "Lack of control over work by the consultant (B)" the probabilityis 0.72. Then each *minimum cut set* added will find the total value of the probability *minimum cut set* for the *top event*, which is:

Table 6. Total probability

Code	Name Event	Probability
A	Delay in taking action by the owner	0.88
B	Lack of work control by consultants	0.72

(A+B) - (A*B)
(0.88+0.72) -
(0.88*0.72)
= 0.97

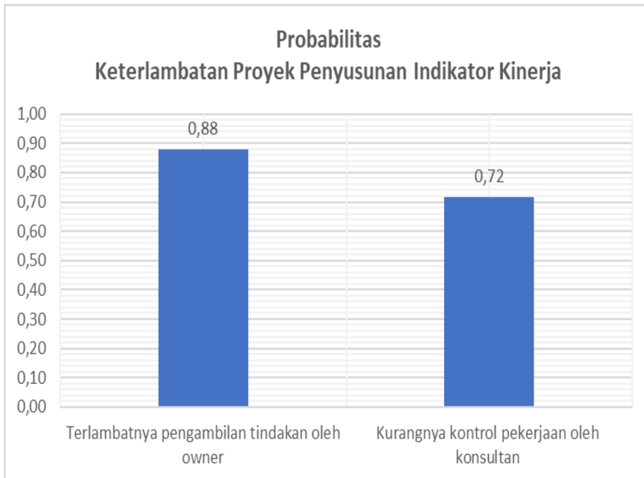

Figure 4. Probabilitas

Probability comparison chart Figure 4 is a probability comparison chart *minimum cut set* for each event *intermediate* which shows the probability of each main. From the graph above, it can be seen that the probability of the event being late in taking action by the *owner* such as *the project timeline is* not implemented properly, the owner lacks coordination, the lack of anticipation of project failure has a probability value of 0.88 and the event of lack of work control by the consultant such as *the project timeline is* not compiled with good, the lack of complete datareceived by the consultant, the consultant's knowledge related to the project is less comprehensive,has a probability value of 0.72.

This means that the delay in the project preparation of employee performance indicators is more influenced by the delay in taking action from the *owner* than by the lack of control over the work by the consultant.

3.8 Dominant factors affecting project delays

From the results of the questionnaire found 10 dominant events which according to respondentsare the factors that influence the delay in the preparation of performance indicators, as follows:

Table 7. Dominant factors affecting the delay

No	Code	Name Incidence	Owner	Consultant
1	A. 3.3.1	There is a change in the company's organizational structure	√	
2	A.3.1.3	Increase or decrease in the scope of work	√	
3	B.3.1.1	The consultant does not master the company's business processes		√
4	A.3.1.2	Application of standards that are too high in every job	√	
5	B.1.2.2	Job targets are not in accordance with the plan		√
6	B.3.1.3 The	The number of employee complaints about the ongoing project		√
7	A.3.3.2	There is a change in company rules	√	
8	A.1.1.1	Interview schedule concurrently with company meeting schedule	√	

9	A.3.2.1	Late payment for consultant work	√	
10	B.1.2.1	Weekly action plan that does not work		√
Total			**6**	**4**

From data above, the dominant factors that influence the delay in the preparation of performance indicators are mostly caused by the owner, such as changes in the company's organizational structure, addition or reduction of job coverage, application of too high standards for each job, changes in company rules, interview schedules along with the schedule. company meetings, and the consultant's job payment is late.

3.8 SWOT Strategy

From the Matrix above, the strategy that can be used by the Company is the

1. SO - Strengths Opportunities Strategy
   - Involving the Internal Team in making Performance Indicators using paperwork and methods from previous Consultants
2. WO - Weakness Strategy Opportunities (Weaknesses - Opportunities)
   - Working papers adjusted to business processes to achieve company targets
   - Improve data collection methods and project planning
3. ST Strategy - Strengths Threats (Strengths - Threats)
   - Change Performance Indicators only at Changing Organizational Structure
   - Creating a timeline and target completion of Employee Performance Indicators
4. WT Strategy - Weakness Threats (Weaknesses - Threats)
   - Forming an Employee Performance Indicator Preparation Team consisting ofrepresentatives from all divisions and Work Units for quick completion

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusion

From this research some conclusions were drawn, including:

1. Analysis using the method *Fault Tree Analysis* (FTA), obtained the
   1) *Basic Event* of the delay in the project of preparing employee performance indicators at PT Perkebunan Nusantara X as many as 30 *basic events* from 2 (two) events that affected the project's delays, namely the late collection owner action and lack of control over the work by consultants.
   2) The probability of events affecting the project delays from the *owner is* 0.88 and that of the consultant is 0.72. This means that the factors that influence project delays are mostly caused by the owner rather than the consultant.
   3) The 10 (ten) *basic events* that most dominantly affect project delays are changes in the company's organizational structure, addition or reduction of job coverage, application oftoo high standards for each job, changes in company rules, interview schedules along with company meeting schedules, late consultant job payments , consultants do not master the company's business processes, job targets are not in accordance with the plan, many employee complaints about ongoing projects, weekly action plans that are not running.
2. Strategies that can be used by PT Perkebunan Nusantara X to increase the chances of completing the preparation of Employee Performance Indicators, using the SWOT Matrix are as follows:

1. Involving the Internal Team in the production of Performance Indicators using working papers and methods from previous Consultants
2. Working papers are adjusted to business processes to achieve targets company
3. Improving data collection methods and project planning
4. Changing Performance Indicators only on the changed Organizational Structure
5. Creating a timeline and target completion of Employee Performance Indicators
6. Forming an Employee Performance Indicator Compilation Team consisting ofrepresentatives of all Divisions and Work Units to complete quickly

4.1 Suggestions

Suggestions can be given to This final project research, which is related to the analysis of project delays in the preparation of performance indicators, is:

1. The preparation of employee performance indicators that have not been completed can be compiled independently without involving a consultant on the basis that the Company has an Internal Team that has been involved in the preparation of these performance indicators.
2. Creating *timeline* a clear and work plan in the completion of the preparation of performance indicators.
3. Improve the methods and previous working papers that are adjusted to business processes to achieve the targets of the company.
4. Forming a performance indicator team consisting of representatives from all divisions incharge of reviewing targets and performance achievements each year and updating them according to organizational conditions and changes.

5. REFERENCES

Al-Hazim, Nabil, Zaydoun Abu Salem, and Hesham Ahmad. 2017. "Delay and Cost Overrun inInfrastructure Projects in Jordan." *Procedia Engineering* 182: 18–24.

Arlina CAM, Nasution AH, Hanoum. S (2019), Cascading Key Performance Indicator and Strategy Map Formulation based on Balanced Scorecard, *Journal of Science and Arts, ITS.*

Aziz, Remon F. and Asmaa A. Abdel-Hakam. 2016. "Exploring Delay Causes of Road Construction Projects in Egypt." *Alexandria Engineering Journal* 55 (2): 1515–39.

Budihardjo, M (2002), *Practical Guide to Employee Performance Appraisal*, Achieve Success,East Jakarta.

Callahan, MT (1992), *Construction Project Scheduling*, McGraw-Hill, New York.

David, Fred R (2008), *Strategic Management*, Salemba Empat, Jakarta

Gebrehiwet, Tsegay and Hanbin Luo. 2017. "Analysis of Delay Impact on Construction Projects Based on RII and Correlation Coefficient: Empirical Study." *Procedia Engineering* 196 (June): 366–74.

Kocecioglu, D (1991), *Reliablity Engineering Handbook*, Englewood Cliffs: Prentice-Hall, Volume 2.

Levis and Atherley (1996), *Delay Construction*, Langford: Cahner Books

Project Management Institute. (2017). *A Guide To The Project Management Body ofKnowledge: PMBOK Guide*, Sixth Edition. Newtown Square, Pennsylvania.

Proboyo, Budiman (1999), *Delay in Project Implementation Time*: *Classification and Ranking ofthe Causes*, Civil Engineering Dimensions Vol I.

Rosyid, DM (2007), *Introduction to Reliability Engineering*, Airlangga University Press, Surabaya.

ANALYSIS OF IDENTIFICATION AND GROUPING FACTORS AFFECTING THE LEAD TIME OF TELECOMMUNICATION TOWER BUILT TO SUIT (B2S) CONSTRUCTION (CASE STUDY: PT. TOWER BERSAMA INFRASTRUCTURE, TBK.)

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ABSTRACT

Competition in the Tower Sharing service telecommunications industry is getting tighter along with the emergence of new Tower Provider entrants. On Time Delivery is an effort to win the industrial market to win the competition. This requires a development plan with a lead time duration approved by telecommunication operator subscribers. In this study, to analyze the identification and grouping of the influence of factors that affect the lead timefor the construction of a built to suit (B2S) telecommunication tower in the work area of PT. Tower Bersama Infrastructure, Tbk. East Java Regional.

Research will be carried out on a telecommunication tower built to suit (B2S) construction project in the East Java Regional work area in the period 2019 to 2020.

This study aims to identify the factors that influence the lead time for the built to suit (B2S) construction project of telecommunications towers in the work area of PT. Tower Bersama Infrastructure, Tbk East Java Regional. The benefits of this research can be one of the basic ideas/ideas for planning the development of a telecommunication tower built to suit (B2S) development project for telecommunication operators and tower providers in an effort to make decisions to determine the lead time duration of the built to suit (B2S) construction of telecommunication towers. The results of this study obtained 10 indicators from the Pre SITAC variable, 10 indicators from the SITAC variable, 10 indicators from the Licensing variable, and 10 indicators from the CME variable, which affect the Lead Time variable.

Keywords: Identification and Grouping Factor, Lead time, Tower Provider.

1. INTRODUCTION

On time delivery project is the fulfillment of the Delivery Project within the agreed time frame or Lead Time. The lead time given for the Delivery Project for the construction of a telecommunication tower built to suit (B2S) is 140 days from the telecommunication operator's order, starting from the agreement of the Kick of Meeting (KOM) to the completion of the construction of the telecommunication tower built to suit (B2S), which is stated by Site Ready For Installation (RFI) status. Therefore, an analysis is needed to identify the factors that influence the lead time for the built to suit (B2S) construction project of telecommunications towers in the work area of PT. Tower Bersama Infrastructure, Tbk. East Java Regional.

In the period 2019 to 2020, the work area of PT. Tower Bersama Infrastructure, Tbk. The East Java region received orders for built to suit (B2S) construction projects for 195 telecommunication towers. Where the achievement of the 195 site project is divided into: RFI Ontime as much as 81 sites (42%), RFI Overdue as much as 62 sites (32%), and Project Cancel as much as 52 sites (27%) of orders from telecommunication operators. RFI Overdue and Project Cancel order found two intersecting problem categories, namely building permits (IMB) and commcase, which means that Project Cancel sites have the potential to be resolved even though they require more than the lead time specified. Therefore, an analysis is needed to determine how much influence these factors have on the lead time for the construction of a built to suit (B2S) telecommunications tower in the work area of PT. Tower Bersama Infrastructure, Tbk. East Java Regional.

Analysis is needed to determine the identification and grouping of factors that affect lead time. The research model is made in one direction only and makes a research operational model with the concept of researching and making the Pre-Site Acquisition (Pre-SITAC), Site Acquisition (SITAC), Permit for IMB, and Civil, Mechanical, Electrical (CME) assumed asvariable X, and Lead Time as variable Y.

2. METHOD

This research was conducted by the author including the stages of literature study, problem identification, determinants that affect lead time, development of a hypothesized model, data collection, analysis, and conclusions. Each stage makes clear the purpose and purpose of that stage.

2.1 Study of Literature

Literature study is carried out by looking for theories that are relevant to the problem under study. After collecting related theories and research, the authors conducted a comparison of previous studies. This stage produces a theoretical framework on which the research is based.
The difference between this thesis and the results of previous research is that this research has differences in the case studies studied, namely the construction of built to suit (B2S) telecommunication towers. Development of research indicators and variables in accordance with the research object of telecommunication tower construction with limited time and capacity of the author so that the research model is made in one direction only and makes research operational models in researching and making the stages of Pre-Site Acquisition (Pre-SITAC), Site Acquisition (Pre -SITAC), Permit and Civil, Mechanical, Electrical (CME) as variable X, and leadtime as variable Y.

2.2 Identification of Problems

At this stage the authors conducted preliminary data collection by interviewing and literature study methods. The interview aims to determine the problems of the factors that affect the lead time for the construction of telecommunications towers at PT. Tower Bersama Infrastructure, Tbk. in the East Java Region. Meanwhile, literature study is carried out by reading journals, conferences, or textbooks related to existing problems. This stage produces research questions that have been resolved in this study.

2.3 Look for Factors that Influence Lead Time

The stage of determining the factors that affect the lead time begins with data collection and recapitulation of some of the data needed in variables that affect lead time, including the preparation of stakeholder interviews and identification of standard data as research guidelines. The activities carried out include:

1. Extracting opinions, the process of extracting opinions, by conducting open questionnaires to respondents to provide opinions on research variables, what indicators affect the lead time for the construction of a built to suit (B2S) telecommunication tower.
2. Stakeholder interviews, by setting and conducting interviews with selected respondents who are considered to have interests and roles in this research, both from company management, partners, and telecommunications operator customers.
3. Grouping the factors that affect the lead time, from the results of opinion exploration and stakeholder interviews, it can be done grouping the dominant factors that affect the built to suit (B2S) development lead time of telecommunication towers in the work area of PT. Tower Bersama Infrastructure, Tbk. East Java Regional. The results of extracting opinions, it can be formulated what factors affect the lead time for the construction of a built to suit (B2S) telecommunication tower in the work area of PT. Tower Bersama Infrastructure, Tbk. East Java Regional.
4. Verification process, The verification process, at this stage the factors that affect the lead time for the construction of built to suit telecommunication towers (B2S) in the work area of PT. Tower Bersama Infrastructure, Tbk. After being grouped, for the East Java region, a verificationprocess was carried out. This verification process can then determine the factors that affect the waiting time.

Table 1. Grouping of factors affecting lead time through opinion gathering

<table>
<tr><th>Variable X</th><th>Indicators</th><th>Variable Y</th></tr>
<tr><td rowspan="6">Pre-Site Acquisition (Pre-SITAC)</td><td>X1.1</td><td rowspan="24">Lead Time</td></tr>
<tr><td>X1.2</td></tr>
<tr><td>X1.3</td></tr>
<tr><td>X1.4</td></tr>
<tr><td>X1.5</td></tr>
<tr><td>X1…n</td></tr>
<tr><td rowspan="6">Site Acquisition (SITAC)</td><td>X1.1</td></tr>
<tr><td>X1.2</td></tr>
<tr><td>X1.3</td></tr>
<tr><td>X1.4</td></tr>
<tr><td>X1.5</td></tr>
<tr><td>X1…n</td></tr>
<tr><td rowspan="6">Permit for IMB</td><td>X1.1</td></tr>
<tr><td>X1.2</td></tr>
<tr><td>X1.3</td></tr>
<tr><td>X1.4</td></tr>
<tr><td>X1.5</td></tr>
<tr><td>X1…n</td></tr>
<tr><td rowspan="6">Civil, Mechanical, Electrical (CME)</td><td>X1.1</td></tr>
<tr><td>X1.2</td></tr>
<tr><td>X1.3</td></tr>
<tr><td>X1.4</td></tr>
<tr><td>X1.5</td></tr>
<tr><td>X1…n</td></tr>
</table>

3. RESULT AND DISCUSSION

In order to analyze & develop the factors that influence the size of the lead time for the built to suit (B2S) construction project of telecommunication towers in the work area of PT. Tower Bersama Infrastructure, Tbk. East Java Regional, data collection was carried out through a survey using a questionnaire. Respondents taken as samples are people who work as part of Project Management at Telecommunication Operators, PT. Tower Bersama Infrastructure, Tbk., And Partners from PT. Tower Bersama Infrastructure, Tbk. Related to the telecommunications tower infrastructure industry. After collecting the data, then the data will be analyzed descriptively and analyzed statistically. The process of collecting and analyzing this data is described in detail in this chapter. In this study, data collection was carried out using a questionnaire. There are several stages in the process of distributing questionnaires to respondents to collect data, namely:

1. First stage data collection (search for factors that affect lead time, validation of respondents)
2. Second stage data collection (grouping of factors that affect lead time)

3.1 First stage data collection (search for factors affecting lead time, respondent validation)

The questionnaire that will be distributed to respondents in this study consists of questions that have been compiled to capture the aspirations of the respondents, what factors affect the lead time for the construction of built to suit (B2S) telecommunications towers based on the identification of latent variable indicators. In the early stages of data collection, before the questionnaire was distributed to respondents, a consultation was conducted with the respondent (respondent validation) with the aim of obtaining corrections to the questionnaire that had been compiled. Questions and statements in the questionnaire were clarified to respondents to see whether the questions and statements could reflect what factors influenced the lead time for the construction of a built to suit (B2S) telecommunication tower. In this study, the validation of respondents was carried out by 50 respondents who are experienced in the field of infrastructure projects.

3.2 Second stage data collection (grouping of factors that affect lead time)

Based on the results of the response validation above, in the aspiration screening questionnaire what factors affect the lead time for the construction of a built to suit (B2S) telecommunication tower. The dominant factors affecting the lead time of the built to suit (B2S) construction of these telecommunications towers can be grouped as shown in Table 2.

Table 2. Grouping of factors affecting lead time

Variable X	Indicators		Variable Y
Pre-Site Acquisiti on (Pre-SITAC)	X1.1	The limited availability of land that can be acquired to become a candidate for telecommunication towers	*Lead Time*
	X1.2	Nominal point does not meet the requirements of local PEMDA tower licensing regulations (cell plan zoning, tower height limitations, tower types, distance between towers)	
	X1.3	The legality status of the acquired land has not met the licensing requirements	
	X1.4	The duration of the candidate approval process by telecommunications operators is too long	
	X1.5	The candidates have not met the network planning needs of telecommunication operators	
	X1.6	Road access to the candidate telecommunication tower is not sufficient	
	X1.7	Profiles of landowners who will be candidates, which can have a positive impact on people's consent	
	X1.8	The location of the nominal area is on corporate-owned land	
	X1.9	HR understanding in determining candidates is not in accordance with the needs of telecommunications operators	
	X1.10	The land rental value obtained exceeds the specified budget limit	
Site Acquisiti on (SITAC)	X1.1	The process for permitting radius residents to obtain approval for telecommunication tower construction is too long	
	X1.2	The SITAC value obtained exceeds the specified budget limit	
	X1.3	The refusal of radius residents to build telecommunication towers in candidate locations that have been approved by telecommunication operators	
	X1.4	The social jealousy of radius residents towards the owner of the land to be acquired	
	X1.5	The legality status of the acquired land has not met the licensing requirements	
	X1.6	Nominal point does not meet the requirements of local PEMDA tower licensing regulations (cell plan zoning, tower height limitations, tower types, distance between towers)	

	X1.7	Different public understanding of the function of telecommunication tower construction	
Variable X	**Indicators**		**Variable Y**
	X1.8	The ability of human resources in the socialization and negotiation process in getting the affection of radius citizens	*Lead Time*
	X1.9	Characteristics of the economic, social and cultural level of the community that affect the approval of telecommunication tower construction	
	X1.10	The level of population density affects the number of radius residents in approving the construction of telecommunications towers	
Permit for IMB	X1.1	The regulations related to the construction of telecommunications towers in each city and district have different rules	
	X1.2	The bureaucratic process requires a long duration in the process of obtaining a telecommunications tower permit	
	X1.3	The candidate point is outside the Cell Plan Zoning that has been determined by local regulations	
	X1.4	The duration of scheduling a survey to review the location of telecommunications tower construction is too long	
	X1.5	There are additional procedures for candidates who are on agricultural land	
	X1.6	The duration of completing the licensing requirement documents is too long	
	X1.7	There are additional procedures for candidates in the airport area to agree on the height of the telecommunication tower	
	X1.8	The legality status of the acquired land has not met the licensing requirements	
	X1.9	The moratorium policy, related to the PERDA procedure being drafted	
	X1.10	The work of the CME could not be carried out until the Permit was issued	
Civil, Mechanical, Electrical (CME)	X1.1	Additional time is required for the PLN connection process because PLN network expansion is required	
	X1.2	Weather factors that limit the working hours of the telecommunication tower construction process	
	X1.3	Delays in the process of delivering tower materials related to distance and mode of transportation	
	X1.4	Quality of human resources in managing CME projects	
	X1.5	Required additional processing time for special design/stacking/borepile/camouflage of telecommunication towers	
	X1.6	Limited availability of tower materials/natural materials required	
	X1.7	Geographical contours that impact the foundation type design and CME implementation process	
	X1.8	Readiness of partner funding to accelerate the construction of telecommunications towers	
	X1.9	Performance partners who have not met the specified targets	
	X1.10	Road access to the location of the telecommunication tower construction is not sufficient	

In this study, the results that have been obtained are the identification of factors that affect the size of the lead time for the built to suit (B2S) construction project of telecommunications towers in the work area of PT. Tower Bersama Infrastructure, Tbk. East Java Region:

1. Variable Pre Site Acquisition (Pre SITAC), with 10 indicators
2. SITAC variable, with 10 indicators
3. Variable Licensing, with 10 indicators
4. Variable CME, with 10 indicators

4. CONCLUSION

After the research data analysis has been completed, the authors draw conclusions on the results of the research conducted. Through the data that has been collected and analyzed, it can be concluded that the factors that affect the lead time of the built to suit (B2S) construction project of telecommunication towers can be identified and grouped in the working area of PT. TowerBersama Infrastructure, Tbk. East Java Regional. So that based on the conclusions obtained, several suggestions can be given so that further research can be even better.

From the conclusions obtained in this study, suggestions are given that can be used by the next researcher to develop this research to the next level.

5. REFERENCES

Andreas, Kurniadi Djukardi & Adhiarta, Emil Semiawan. (2018). Model of Project Performance Indicators in the Regional High-rise Residential Building Sector D.K.I Jakarta. Jakarta. JOURNAL FORUM MECHANICS.

Assauri, Sofjan. (2008). Production and Operations Management. Jakarta. Publishing Institute, Faculty of Economics, University of Indonesia.

Ating Somantri and Sambas Ali Muhidin. 2006. Applications of Statistics in Research.

Yogyakarta: Faithful Library.

Chin, W., & Newsted, P. (1999). Structural equation modeling analysis with small sample using partial last square. In R. Hoyle (Ed.), Statistical strategies for small sample research (pp. 307-341). London: Sage Publication.

Ghozali, Imam. (2008). Structural Equation Modeling, Edition II, Diponegoro University, Semarang.

Hair, Jr. et.al. (2010). Multivariate Data Analysis (7th ed). United States: Pearson.

Hardjowigeno, Sarwono and Widiatmaka. 2007. Evaluation of Land Suitability and Land Use Planning. Yogyakarta: Gadjah Mada University Press

Karisma, Dwi Aprilya. (2019). Analysis of the Effect of Controlling Odor Inventory on Supply Chain Performance Using Partial Least Square (Case Study at Sanan Tempe Industrial Center, Malang). Essay. Faculty of Agricultural Technology. Brawijaya University. Poor

Joint Regulation of the Minister of Home Affairs (Number: 18 of 2009), Minister of Public Works (Number: 07 / PRT / M / 2009), Minister of Communication and Information (Number: 19 / PER / M.Kominfo / 03/2009), and the Head of Investment Coordinating Board (Number: 3 / P / 2009 concerning Guidelines for the Construction and Sharing of Telecommunication Towers

Reinartz, W, Kumar, V (2012), “The customer relationship management: Concept, Strategy,Tools”, Springer, London.

Saptono, Kaelan. Bambang, Purwoko & Rosalendro, Eddy. (2020). Analysis of the Factors Causing Delay in Completion of Ligh Rail Transit (LRT) Project on Cawang-East Bekasi. Jakarta. International Journal of Research and Review.

Sarwono, Jonathan & Narimawati, Umi. (2015). Making Thesis, Thesis and Dissertation Wold, H. O. (1982). Soft Modeling: The Basic Design and Some Extensions. In K.

G. Jöreskog, & H. O. Wold (Eds.), Systems under Indirect Observation: Causality, Structure, Prediction (pp. 1-54). Amsterdam: North-Holland.

Yamin, S., & Kurniawan, H. (2011). The New Generation Processes Research Data with Partial Least Square Path Modeling. Bandung: Salemba Infotek.

Zulfikarijah, Fien. (2005). Inventory Management. Poor. Muhammadiah University Malang.

CRITICAL SUCCESS FACTOR OF SECURITY MATURITY MODEL IMPLEMENTATION: A SYSTEMATIC LITERATUREREVIEW

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ABSTRACT

Generally, Maturity model shows how human and devices carry out their duties, this includes leadership, effective governance, level of awareness and devices capabilities. Security maturity models aim to identify and explore the strength and weakness in the Information system's security of certain organization. Many security maturity models have been created and used around the world including in Indonesia. However, because oftoo many models of maturity,there was confusion and misapplication of the model that is incompatible with the organization's goals. Besides that, the human factor is also one of the causes of the unsuccessful implementation of the maturity model. Therefore, this study aims to identify and discuss the factors that influence the success of implementing the security maturity model. This study uses Kitchenham Techniques to collect papers/articles and to identify critical factors. There are 9 of 25 Articels use as references to get the critical success factors. From selected articels, there are 20 item of critical success factors that influence the security maturity model implementation.

Keywords : Factors, Implementation, CSF, Security Maturity, Model

1. INTRODUCTION

An evaluation of the Indonesian e-Government system's security must be carried out to determine the current situation of implementing security in the system and ensure the system's continuity by planning improvements to implement security for the system. The maturity model is considered as one of the standard tools known in performance evaluation. The term maturity has been used in various areas or disciplines, and the definition of maturity concept also depends on the context in which maturity is used [1]. A maturity model is a tool for evaluating the effectiveness of an organization in achieving specific goals. Organizations can identify where their practices are weak or not taken seriously and where their practices are solid using the maturity model. [1] In the context of cybersecurity, a maturity model can help distinguish between organizations that have good security and organizations that do not have security. One reason for using the maturity model is that this model can provide organizational leaders with a way to measure the progress made in managing security and its operating strategy.

Using maturity assessments to track organizational improvement makes it possible to find these changes and contextual link changes in the organization. However, use the security maturity model to compare an organization's level of security maturity with other organizations. It will not get information from contextual factors that have an impact on other organizations. Thus it is impossible to know why other organizations have lower or lower maturity than these organizations. Nowadays, information system security is needed to secure the data and information in the system. Several Critical Factorscan influence the performance of information system security. By knowing these Critical Factors, an organization can improve its information system security performance [2].

The diversity of models shows that not all security maturity models can be used in various sectors. An improper security maturity model can produce subjective and transparent assessments because appraisers can give different results for the same answers without clear assessment guidelines available at each government agency.

This study discuss the critical factor of the security maturity model's implementation. This paper aims to provide knowledge about what factors can influence the implementation of the security maturity model so that it is expected to minimize failures or discrepancies in implementing the security maturity model. This study is a systematic literature reviewby kitchenhum. In this systematic literature review will identify and analyze critical factors from previous research related to security maturity model implementation from 2010 until 2020. This paper consists of 4 (four) section, Introduction, Methodology, Discussion, and Conclusion.

2. METHODOLOGY

This section discusses the methodology to identify and discuss the critical success factors of Security Maturity Model Implementation. This study uses the Kitchenham method which widely used in information technology-related [3]. This method aims to analyze the state-of-the-art by providing the problem formulation, the information source, the search strings, the criteria for inclusion and exclusion of the collected paper, the quantitative analysis to be done, and the templates for ordering the information gathered from the papers. It has 8 (eight) phases: (1) Identified the needs and research question, Identified the keywords and literature sources, (3) Identified Inclusion and Exclusion criteria, (4) Identified Relevant studies, (5) Selected primary studies, (6) Extract data, (7) Synthesize data.

2.1 Identified The Need and Research Question

This study intends to identify the success factor for implementing the maturity security model, thus helping the researcher or organization improve the maturity security model's use in evaluating the organization's maturity security. To achieve that purpose, this study specifies the research question: "*What are the success factors of implementing a security maturity model?*".

2. 2 Identified Keywords and Literature Source

This study collects articles from different studies from 2010 until 2019 from IEEE and Science Direct Database. The articles must contain 2 (two) main focus, which is (1) Security Maturity Models, (2) Critical Factors of Security Maturity Models. Those relevant studies should have specific keywords: "Implementation AND Maturity AND Security AND Model.".

2.3 Identified Inclusion and Exclusion Criteria

The collected paper should meet the inclusion criteria to be used in the critical factor's identification, and discuss articles that do not meet the inclusion criteria: (1) Paper about security maturity model implementation; (2) Complete Paper; (3) Paper in English; or included in exclusion criteria: (1) Not related to Research question and Bias Literature; (2) DuplicatePaper, (3) Unpublished Article.

2.4 Identified Relevant Studies

Relevant Studies were collected mostly from IEEE and Science Direct database with the keyword " Implementation Security Maturity Model". There are 25 relevant studies found in these phases which are [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [1], [26], and [27].

2.5 Select Primary Studies

Collected papers must be selected according to the inclusion criteria to get the relevant article. The selection processis divided into 4 (four) phases. The first phase is to identify literature through determine keywords and removing duplicate papers. The second phase is literature screening, which identified relevant studies that will be used in this research. The thirdphase is to see literature eligibility according to the research question: What are the success factors of implementing a security maturity model. The last step is to summarize the relevant studies for the final synthesis.

From the primary study selection process, 9 (nine) papers will be extracted to get the analysis data to answer the research question.

1. Quantifying the Strength of Security Systems [4]
2. Comparative Study of Cybersecurity Capability Maturity Models [17]
3. Assessment methodology for a maturity model for interorganizational systems - The search for an assessmentprocedure [9]
4. Towards a framework of critical success factors for implementing Supply chain information systems [23]
5. A multiple integrated approach for modelling critical success factors in sustainable LSS implementation [27]
6. A study on the preparedness of information security framework area based on the assessment of information securityindex in Ministry of XYZ [10]
7. Information Security Evaluation using KAMI Index for Security Improvement in BMKG [20]
8. Dynamic Capability Maturity Model for Improving Cyber Security [11]
9. Using the Information Security Index to Measure University Information Security Management Concepts andStrategies [24]

2.6 Extract Data

Collected papers have been read and reviewed and mark the key factors that influence the implementation of the security maturity model. The Critical Factors of security maturity model implementation from each paper can be seen in Table 2.

No	Title of Papers/Articles	Critical Success Factors
1.	Quantifying the Strength of Security Systems [4]	1. Have physical and technical evidence 2. Conduct periodic assessments
2.	Comparative Study of Cybersecurity CapabilityMaturity Models [17]	3. Determine the vision, mission and requirements for implementing the security maturity model
3.	Assessment methodology for a maturity model for interorganizational systems - The searchfor an assessment procedure [9]	4. Prepare supporting applications
4.	Towards a framework of critical success factors for implementing Supply chain information systems [23]	5. Effective communication 6. Forming an assessment team 7. Have access to all information systems 8. Configure, test and troubleshoot 9. Monitor and evaluate assessor performance 10. Manage data exchange 11. Determine the budget and implementation time
5.	A multiple integrated approach for modelling critical success factors in sustainable LSS implementation [27]	12. Provide education to evaluation targets 13. Gather respondents according to the evaluated field
6.	A study on the preparedness of information security framework area based on the assessment of information security index in Ministry of XYZ [10]	14. Get leadership support 15. Ensuring document completeness
7.	Information Security Evaluation using KAMI Indexfor Security Improvement in BMKG [20]	16. Determine the competence of the assessment team
8.	Dynamic Capability Maturity Model for ImprovingCyber Security [11]	17. Identify the sources needed to conduct the evaluation 18. Defi ning maturity planning

9.	Using the Information Security Index to Measure University Information Security Management Concepts and Strategies [24]	19. Knowledge of the security maturity model 20. Designing an evaluation scheme

2.7 Synthesize data

At the previous stage, there are 20 Critical Factors found in 9 papers. In this stage, there is no eliminated factor based on similar meaning, similar Critical Factors, and similar context. Every key factor is supported by the concept within and across the studies. Critical Factors have the same level of importance. Critical Factors of Security Maturity Model Implementation:

1. Have physical and technical evidence
2. Conduct periodic assessments
3. Determine the vision, mission, and requirements for implementing the security maturity model
4. Prepare supporting applications
5. Effective communication
6. Forming an assessment team
7. Have access to all information systems
8. Configure, test, and troubleshoot
9. Monitor and evaluate assessor performance
10. Manage data exchange
11. Determine the budget and implementation time
12. Provide education to evaluation targets
13. Gather respondents according to the evaluated field
14. Get leadership support
15. Ensuring document completeness
16. Determine the competence of the assessment team
17. Identify the sources needed to conduct the evaluation
18. Defining maturity planning
19. Knowledge of the security maturity model
20. Designing an evaluation scheme

3. RESULT AND DISCUSSION

In this section, each of the Critical Factors is explained. There are 20 factors for security maturity modelimplementation.

3.1 Have physical and technical evidence

Technical evidence can provide the assessment team with a clearer or more real condition of the information system. This physical and technical evidence is obtained from observing the system or performing penetration testing. This evidence will make the assessment results more objective and balanced because they are received from the data.

3.2 Conduct periodic assessments

The sustainability of the security maturity model determines the recency of the substance of the security assessment.A security maturity model that is developed or updated periodically (at least annually) will provide concrete evaluation results as technology development.

3.3 Determine the vision, mission, and requirements for implementing the security maturity model

Determining the vision and objectives for implementing the security maturity model, the vision and goals are determined to be the "map" when implementing the security maturity model implementation to achieve the organization'swishes and expectations.

3.4 Prepare supporting applications

Application support in terms of assessment documents, some models provide broad coverage of all relevant assessment documentation. In contrast, other models do not include documents and emphasize the scope and benefits of the study. According to Mettler et al., there are categories of application support grouping, divided into 3 (three) differentareas: no documentation, handbooks or textual descriptions, and software assessment tools.

3.5 Effective communication

Conducting an evaluation using a security maturity model requires effective communication within and among all participating organizations. Open and frequent communication is essential to obtain the data and opinions needed. If thereis a lack of communication, then evaluation failures may arise.

3.6 Forming an assessment team

In carrying out the evaluation, it is necessary to form a special team to carry out the assessment. This team can consistof academics, practitioners, or analysts who have skills in information security.

3.7 Have access to all information systems

Having access to all information systems is essential for implementing the security maturitymodel. This is so that theassessment team can obtain information and data as a whole and objectively for later assessment.

3.8 Configure, test, and troubleshoot

Perform configuration, test and troubleshoot, perform configuration searches, testing, and troubleshoot to obtain physical or technical evidence as evaluation material. It can also help agencies identify weaknesses and deficiencies in information systems so that they can make improvement plans.

3.9 Monitor and evaluate assessor performance

After aligning the vision and objectives of implementing the security maturity model, great attention should be paid to the assessment team's performance. Misaligned rater performance hinders the implementation process and results fromimplementing the security maturity model.

3.10 Manage data exchange

In conducting the evaluation, there is the possibility of obtaining confidential data, so it is important to manage dataexchange during the assessment. The assessment team must be able to ensure thatthe data they receive remains secure andconfidential.

3.11 Determine the budget and implementation time

Determining the appropriate budget and execution time can support the implementation of the security maturity model. Budget support can provide motivation and meet the needs of the assessor. The implementation time is determined according to the needs or the pre-planned assessment scheme so that there will be no time extension or budget overruns.

3.12 Provide education to evaluation targets

The evaluator or the evaluation target should be given education related to the evaluation carried out using the security maturity model. This is to equalize the perspective on the implementation of the security maturity model.

3.13 Gather respondents according to the evaluated field

Respondents need to obtain data and information about the information system at the agency. Of course, respondents must have the competence and understanding of the conditions and areas of information security.

3.14 Get leadership support

Leaders have several responsibilities, one of which is to provide financial support, time, and facilities. Also, leaders are responsible for increasing employee motivation, giving direction, and giving permission for implementation. Lack of leadership support will lead to failure in implementing the maturity model.

3.15 Ensuring document completeness

In the security assessment process, document completeness can determine the quality of the assessment results. During the assessment, documents needed include policy documents, system development documents, and documents of Weaknesses / Threats / Accidents that have occurred.

3.16 Determine the competence of the assessment team

The assessment team's competence can influence the success of conducting a security evaluation using a security maturity model. This is because assessors who have knowledge or skills related to security will be more objective and easier to understand the conditions and models of security maturity itself. The assessment team is expected to have a background in information security/technology, experience in information security, or have an information security certification.

3.17 Identify the sources needed to conduct the evaluation

Identify resources needed to conduct the evaluation be done before implementation so as not to hamper the implementation of security maturity model implementation. Sources in this case include respondents, officials who will be interviewed, or information systems that will be reviewed.

3.18 Defining maturity planning

Defining maturity planning is needed to provide a flow and stages of evaluation using this maturity model to achieveevaluation objectives.

3.19 Knowledge of the security maturity model

Evaluators and evaluation targets must know the security maturity model so that there are no knowledge differencesor misunderstandings and communication failures.

3.20 Designing an evaluation scheme

Designing an evaluation scheme, an evaluation scheme is needed to provide an overview of how evaluation using this maturity model is carried out to achieve evaluation objectives.

4. CONCLUSION

Security maturity model aims to identify and explore the strength and weakness in the Information system's security of certain organization. There are many security maturity model created around the world with different purposes, for example KAMI Index for Information system security in Indonesia or PRISMA for Information Security Program. Each security maturity model has different evaluation level and standard Because of the differencies, There can be errors in choosing a model in conducting a security evaluation. Other than that, human errors are often the reason for failure in the implementation of the security maturity model. Therefore, critical success factors have great relevance for evaluators/practicionerto improve the implementation security maturity model.

This study has comprehensively review the implementation security maturity models that can help to identify andunderstand the critical factors that influence the successful implementation of the security maturity model. There are 9 of 25 Articles used in this study mostly from 2010 until 2019 related to implementation of security maturity model.

In practical terms. Critical Factors can help organizations pay attention and focus on critical areas that can improve the security maturity model implementation. The finding can significantly help the practitioner or organization to control the process and developing guidelines for implementing security maturity models, so that the results obtained from implementing the model are objective, comprehensive, and comparable to other organizations.

This research is still needed in subsequent stages in empirical studies, or a case study of a list of Critical Factors proposed to support the study's validity and particularly useful as a recommendation for security maturity model implementation.

5. REFERENCES

I. Mantra, M. S. Hartawan, H. Saragih, and A. A. Rahman, "Web Vulnerability Assessment and Maturity Model Analysis on Indonesia Higher Education," *Procedia Comput. Sci.*, vol. 161, pp. 1165–1172, 2019.

P. Rahayu and D. I. Sensuse, "CSF for implementation e-portfolio model: A Systematic Review," *2015 Int. Conf. Inf. Technol. Syst. Innov. ICITSI 2015 - Proc.*, 2016.

M. K. Najafabadi and M. N. Mahrin, "A systematic literature review on the state of research and practice of collaborative filtering technique and implicit feedback," *Artif. Intell. Rev.*, vol. 45, no. 2, pp. 167–201, 2015.

D. Lie and M. Satyanarayanan, "Quantifying the Strength of Security Systems," *Proc. 2Nd USENIX Work. Hot Top.Secur.*, pp. 3:1--3:6, 2007.

X. Y. Ge, Y. Q. Yuan, and L. L. Lu, "An information security maturity evaluation mode," *Procedia Eng.*, vol. 24, pp. 335–339, 2011.

G. Karokola, S. Kowalski, and L. Yngström, "Secure e-government services: Towards a framework for integratingIT security services into e-government maturity models," *2011 Inf. Secur. South Africa - Proc. ISSA 2011 Conf.*, no.C, 2011.

P. Upadhyaya, S. Shakya, and M. Pokharel, "E-government security readiness assessment for developing countries: Case study: Nepal Govt. organizations," *Asian Himalayas Int. Conf. Internet*, pp. 1–5, 2012.

F. Setiadi, Y. G. Sucahyo, and Z. A. Hasibuan, "Balanced E-Government security framework: An integrated approach to protect information and application," *Proc. 2013 Int. Conf. Technol.Informatics, Manag. Eng. Environ.TIME-E 2013*, pp. 95–98, 2013.

N. Frick, T. F. Küttner, and P. Schubert, "Assessment methodology for a maturity model for interorganizational systems - The search for an assessment procedure," *Proc. Annu. Hawaii Int. Conf. Syst. Sci.*, pp. 274–283, 2013.

M. Rizal and Y. G. Sucahyo, "A study on the preparedness of information security framework area based on the assessment of information security index in Ministry of XYZ," *2013 Int. Conf. Adv. Comput. Sci. Inf. Syst. ICACSIS2013*, no. March, pp. 55–59, 2013.

R. M. Adler, "A dynamic capability maturity model for improving cyber security," *2013 IEEE Int. Conf. Technol. Homel. Secur. HST 2013*, pp. 230–235, 2013.

Z. Yunos, R. Ahmad, and M. Yusoff, "Grounding the component of cyber terrorism framework using the groundedtheory," *Proc. 2014 Sci. Inf. Conf. SAI 2014*, pp. 523–529, 2014.

Kautsarina and H. Gautama, "Information security readiness of government institution in Indonesia," *2014 2nd Int.Conf. Inf. Commun. Technol. ICoICT 2014*, no. January 2013, pp. 1–6, 2014.

R. De Bruin and S. H. Von Solms, "Modelling Cyber Security Governance Maturity," *Int. Symp. Technol. Soc. Proc.*, vol. 2016-March, pp. 1–8, 2016.

N. T. Le and D. B. Hoang, "Can maturity models support cyber security?," *2016 IEEE 35th Int. Perform. Comput. Commun. Conf. IPCCC 2016*, pp. 1–7, 2017.

I. G. N. Mantra, M. Alaydrus, and H. M. Misni, "The web security and vulnerability analysis model on Indonesia Higher Education institution," *2016 Int. Conf. Informatics Comput. ICIC 2016*, no. Icic, pp. 154–157, 2017.

A. M. Rea-Guaman, T. S. Feliu, J. A. Calvo-Manzano, and I. D. Sanchez-Garcia, "Comparative Study of Cybersecurity Capability Maturity Models," *Int. Conf. …*, vol. 1, no. November, pp. 30– 42, 2017.

M. Sukmana and C. Meinel, "E-government and security evaluation tools comparisonfor Indonesian egovernmentsystem," *ACM Int. Conf. Proceeding Ser.*, pp. 96–103, 2016.

N. Benias and A. P. Markopoulos, "A review on the readiness level and cyber-security challenges in Industry 4.0," *South-East Eur. Des. Autom. Comput. Eng. Comput. Networks Soc. Media Conf. SEEDA-CECNSM 2017*, 2017.

D. I. Sensuse, M. Syarif, H. Suprapto, R. Wirawan, D. Satria, and Y. Normandia, "Information security evaluation using KAMI index for security improvement in BMKG," *2017 5th Int. Conf. Cyber IT Serv. Manag. CITSM 2017*,2017.

D. I. Sensuse, A. Nasbey, Nordianto, R. Dewiyanti, R. Novira, and M. F. Dzulfikar, "PeGI in practice: The e- government assessment in National Library of Indonesia," *2017 5th Int. Conf. Cyber IT Serv. Manag. CITSM 2017*,2017.

F. Setiadi, P. H. Putra, Y. G. Sucahyo, and Z. A. Hasibuan, "Determining components of national cyber security framework using Grounded Theory," *Proc. 2nd Int. Conf. Informatics Comput. ICIC 2017*, vol. 2018-Janua, pp. 1–6, 2018.

J. M. Denolf, J. H. Trienekens, P. M. Wognum, J. G. A. J. Van Der Vorst, and S. W. F. Omta, "Towards a framework of critical success factors for implementing supply chain information systems," *Comput. Ind.*, vol. 68, pp. 16–26, 2015.

L. Hakim and A. Tarigan, "Using the Information Security Index to Measure University Information Security Management : Concepts and Strategies," vol. 4, no. 5, pp. 1623–1635, 2018.

H. F. Yoseviano and A. Retnowardhani, "The use of ISO/IEC 27001: 2009 to analyze the risk and security of information system assets: case study in xyz, ltd," *Proc. 2018 Int. Conf. Inf. Manag. Technol. ICIMTech 2018*, pp. 21–26, 2018.

F. Ghaffari and A. Arabsorkhi, "A New Adaptive Cyber-security Capability Maturity Model," *9th Int. Symp. Telecommun. With Emphas. Inf. Commun. Technol. IST 2018*, pp. 298–304, 2019.

V. Swarnakar, A. R. Singh, J. Antony, A. Kr Tiwari, E. Cudney, and S. Furterer, "A multiple integrated approach for modelling critical success factors in sustainable LSS implementation," *Comput. Ind. Eng.*, vol. 150, no. August,p. 106865, 2020.

DETERMINANTS OF PURCHASING FUEL (BBM) NON-SUBSIDY IN SURABAYA CITY WITH THEORY OF PLANNED BEHAVIOR

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ABSTRACT

Fuel oil is one of the materials that is still needed by humans. The lack of domestic fuel supply causes problems that must be resolved by the government, namely by increasing oil reserves or allowing oil and gas companies to be able to sell BBM freely on the Indonesian market. Indonesian society is faced with various choices of fuel provided by producers. In this study, researchers tried to find consumer preferences as a factor in determining the type of non- subsidized fuel at Pertamina and non- Pertamina gas stations. Consumers are expected to be able to make decisions to buy non-subsidized fuel with various considerations and independently. The method of determining respondents will use convenience random sampling in the city of Surabaya, because in the city of Surabaya there are many private petrol retailers (non- Pertamina). Consumers can determine their choice by using the Theory of Planned Behavior approach to purchase certain products or services. By using the Theory of Planned Behavior method, consumer desires can be predicted so that consumer satisfaction can be fulfilled by producers and producers are ableto determine the right business marketing strategy so as to increase profit as much as possible. This study aims at the influence of attitude toward behavior, subjective norms, perceived behavior control, and intention toward consumer behavior. This research methodused a regressive quantitative research design survey type. Determination of respondents using convenience random sampling in the city of Surabaya with a total of 280 respondents,because in that area there are many private petrol retailers (non- Pertamina). The analysis technique uses multiple linear regression. The results of this study indicate that attitude toward behavior and intention have a significant effect on the possibility of making consumer behavior to buy fuel at certain retail gas stations, while subjective norm and perceived behavior control are negative so that it is not possible to make consumer behaviorto buy fuel at certain retail gas stations.

Keywords: Non-Subsidized Fuel, Consumers, Theory of Planned Behavior

1. INTRODUCTION

Fuel oil (BBM) is one of the materials needed by humankind. The world's total oildemand is 7.3 million barrels per day (bpd) from 2017 to 2023 (Sebayang, 2018). International Energy Agency (IEA) predicts that global oil demand in 2020 is estimated to be only 9.3 million barrels caused by the Covid-19 pandemic compared to 2019 (Pristiandaru, 2020). The non-subsidized fuel contribution of RON 90 also experienced an increase in consumption from 12.9% to 18% compared to the previous year after the removal of subsidized RON 88 fuel from market circulation (BPH-MIGAS, 2019). With the elimination of subsidized fuel RON 88, it caused a shift in the new segment to BBM with RON 90 and 92 which could be a problem due to higher prices. Indirectly, consumers are forced to choose the RON type of fuel. This actually creates an opportunity for non- Pertamina gas station retailers to be able to compete with Pertamina because they have the same minimum RON value of 90. Currently, Indonesian consumers are faced with various choices of fuel provided by producers. They have to make decisions to buy with various considerations. Ajzen (1991). Theory of Planned Behavior (TPB) shows that behavior is influenced by intention. Intention is influenced: attitude toward the behavior, subjective norms, and perceived behavioral control. TPB is a popular method for identifying determinants based on consumer behavior by researchers and practitioners.

The previous research of TPB based theory has widely studied in consumer behavior topics. The prediction of tourist behavior (Ahmad et al., 2020), the intention of consumers to adoptan environmentally friendly life (Alzubaidi et al., 2020), retirement planning (Hoffmann & Plotkina, 2020), purchase intention and sharing economic behavior (Lo et al., 2020), subjective norms and perceptions of student behavior (Zhang & Li, 2020), pro-environmental behavior(Gatersleben et al., 2002), purchase intention for environmentally friendly skin care products, (Hsu et al., 2017), and determinants of halal-food consumption (Vanany et al, 2019) using TPB framework. a few previous researches using TPB framework to determine significant factor to purchase fuel oil (non- subsidy).

2. LITERATURE REVIEW

2.1 Type of Fuel in Indonesia

Crude oil can be used as fuel after going through the refining and processing process. The basic process of refining oil is distillation and cracking. quoting from BPH Migas.

2.2 Fuel Consumption and Product

During the past 15 years, the average fuel consumption per year has been higher than the average oil production per year. Therefore, domestic petroleum production has not covered fuel consumption, so to cover the shortfall, the government imports crude oil and fuel from abroad. The price and product comparisons of each type of fuel at the non-subsidized fuel retail that canbe found in the city of Surabaya can be seen in Table 1.

Table 1 Comparison of Non-Subsidized Fuel Products (Sumber: (BPH-MIGAS, 2019))

Type of Fuel (RON)	Company	Product	Price / Liter (Rp)
90	Pertamina	Pertalite	7.650
	Shell Indonesia	Regular	8.400
	Total Indonesia	Performance 90	9.200
	British Petroleum	BP 90	10.550
92	Pertamina	Pertamax	9.850
	Shell Indonesia	Super	9.950
	Total Indonesia	Performance 92	10.050
	British Petroleum	BP 92	10.800
95	Pertamina	-	-
	Shell Indonesia	V-Power	11.500
	Total Indonesia	Performance 95	11.250
	British Petroleum	-	-

Figure 1 represents a comparison of the market share of non-subsidized fuel in the city of Surabaya

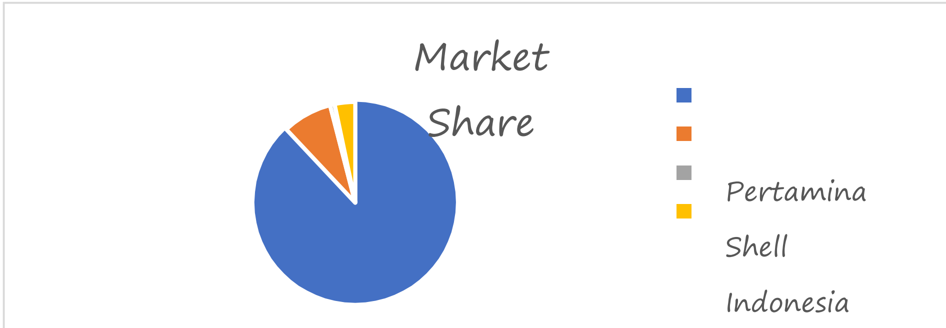

Figure 1. Comparison of the Market Share of non-subsidized BBM (Sumber: (BPH-MIGAS, 2019))

Figure 1 shows that the retail distribution of Pertamina gas stations is much higher than those of non-Pertamina gas stations in Surabaya. This is because Pertamina is an Indonesian state-owned company that is tasked with meeting domestic fuel needs. The retail distribution of fuel gas stations is directly proportional to the market because the volume of the amount of fuel sold is more and it is easier to reach the public because the location of the retail petrol stations is easier toreach. In addition, the price factor is also one of the determinants of consumer preference in purchasing this type of fuel (Mosahab et al., 2010) Indonesian people are still sensitive to prices, namely the consumption of RON 90 is far superior to RON above 90.

2.3 Customer Behavior

Benefit from understanding *customer behavior* (Noel, 2009) is a retailer that is able to identify and know the target segment to be targeted so that it can evaluate potential opportunity solutions. In addition, retail makes it possible to know the size and optimum profit potential of each segment which is more priority, and discourages competitors from playing in the targeted segment, so that products are not easily substituted by competitors' products. Consumers can makea choice on the information they have been looking for and integrate it carefully, so that consumersare able to know the products they will buy or use. The level of consumer awareness will be in linewith the value of an item that is worth buying, the higher the value of an item, the higher the level of caution in buying will be and vice versa

2.4 Theory of Planned Behavior

Ajzen (1991) has introduced TPB. Intention or intention to perform various types of behavior can be predicted with a high degree of accuracy ranging from attitudes to behaviors, subjective norms, and perceived behavioral control. This intention and understanding of behavior control explain the big differences in actual behavior. Attitudes, subjective norms, and perceived behavioral control have been shown to be related to the primary appropriate behavior, norms, and control beliefs about behavior, but the true nature of these relationships remains uncertain. (Ajzen, 1991) so that further research is needed.

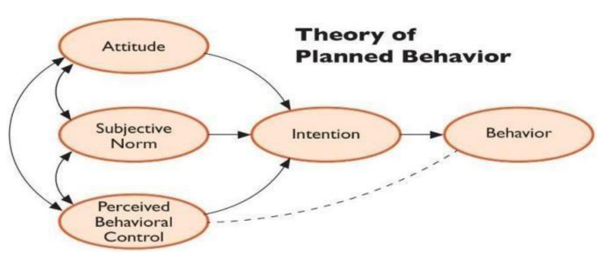

Figure 2. Theory of Planned Behavior (Ajzen, 1991)

Researchers adopted this model to examine TPB in the petroleum retail sector. The research variables and sub-variables are adjusted to the needs in order to measure the required indicators. Based on this study, a research framework can be formulated in Figure 3.

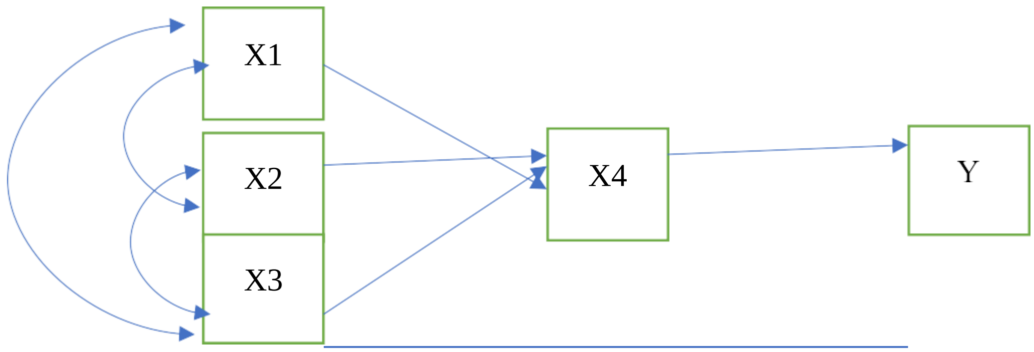

Figure 3. Relationship Between Research Variables (Source: Adoption of the Ajzen Model) Information:

X1 : Consumer attitudes towards purchasing fuel non-subsidy
X2 : Social norms that apply to consumers purchasing fuel non-subsidy
X3 : Perceptions of consumer behavior control purchasing fuel non-subsidy
X4 : Consumer's intention purchasing fuel non-subsidy
Y : Consumer decision purchasing fuel non-subsidy

Based on Figure 3, the following hypothesis can be formulated:

H1 : There is an influence of knowledge with people's Attitude Toward Behavior on determining the purchase of certain types of fuel
H2 : There is the influence of the community's Subjective Norm on determining the purchase of certain types of fuel
H3 : There is the influence of the community's Perceived Behavior Control on determining the purchase of certain types of fuel
H4 : There is an influence of Intention on determining the purchase of certain types of fuel

3. RESEARCH METHOD

3.1 Research Design

This study used a regressive quantitative research design, survey type. This study seeks to collect research data based on a sample to conclude the population related to the relationship between research variables.

3.2 Research Variables and Measurements

This research variable was developed and adopted from Ajzen (1991) and (Lortie & Castogiovanni, 2015). In detail, the research variables and measurement indicators can be seen in Table 2.

Table 2. Research Variables

Variable	Indicator
Customer Attitude	Cognitif
	Affective
	Conative
Subjective Norm	Normative beliefs
	Motivation to obey
Perceived Behavior Control	Control belief strength
	Power of control factor
Intention	Performance Intention
Behavior	Target
	Action
	Context
	Time

3.3 Population and Sample

The population of this study includes all consumers who make decisions to buy fuel for various needs in Indonesia. The population is very large, therefore, the sample was taken using purposive random sampling method. The sampling criteria are: (a) fuel consumers come from the city of Surabaya, (b) able to make decisions to buy fuel with RON 90 and 92 at various retail Pertamina and non-Pertamina gas stations, (c) data collection time lasts for three days (d) total sample of 280 respondents. The number of samples is five times the number of indicators used to be processed using the multivariate analysis method (Hair et al., 2010).

3.4 Instrument Research

The instrument is a tool at the time of research using a method (Arikunto, 2006). The instruments and data collection techniques of this study used a questionnaire. The items in the questionnaire were developed based on variable measurement indicators. The complete research instrument is presented in google form. The validity test is used to measure whether a questionnaire is valid or not. The results of the research are considered valid if there is a similarity between the data collected and the data that actually occurs on the object under study (Kuncoro, 2009).

Validity testing uses the Pearson product moment formula which is done by calculating the correlation between each question item score of each variable with the total score of the variable. The results of this test, value df can be calculated as follows df = n-2 or 30-2 = 28, with a significance level of 0,05 then obtained r Table of 0,3061 (one tail). Reliability testing of the reliability level of a research construct can be seen from the statistical results Cronbach Alpha (α). The results are reliable because they provide a Cronbach Alpha value > 0,60 (Ghozali, 2016).

4. DATA COLLECTION AND PROCESSING

4.1 Data Collection

The data used in this study are primary data collected through questionnaires distributed to research respondents. Respondents in this study were the people of Surabaya who could be met by researchers both in person when filling in fuel and people who filled out questionnaires online. This research was conducted on 23 to 30 January 2021. The number of questionnaires distributed was 280 respondents. The following are the results of a descriptive analysis regarding gender, age,type of vehicle, level of education, and monthly income.

4.2 Data Processing

a. Classic Assumption Test

The heteroscedasticity test is carried out to test whether in a regression model there is a constant inequality of the residual variance from one observation to another, then it is called heteroscedasticity. (Singgih Santoso, 2000). The results of heteroscedasticity testing in this study can be seen in Table 3.

Table 3. Heteroskedasticity Testing Result

Variable	Value of Significance	Standard of Significance Value	Remarks
Attitude (X1)	0,812	0,05	Not occur
Norm (X2)	0,239	0,05	Not occur
Control (X3)	0.746	0,05	Not occur
Intention (X4)	0.857	0,05	Not occur

The significance value of each variable exceeds the predetermined standard significance value limit of 0.05. This shows that there is no heteroscedasticity disorder in the regression model. The normality test is to test whether in a regression model, the dependent variable and the independent variable or both have a normal distribution or not. The results of normality testing in this research can be seen in Table 4.

Table 4. Kolmogorov-Smirnov Normality Test Results

		Unstandardized Residual
N		30
Normal Parameters	Mean	0
	Std. Deviation	0.393
Most Extreme Differences	Absolute	0.117
	Positive	0.105
	Negative	-0.117
Test Statistic		0.117
Asymp. Sig. (2-tailed)		0.2

In Table 4 it is known that the significance value of Asymp. Sig. (2 tailed) 0.2 which is greater than 0.05. In accordance with the basis of decision making in the Kolmogorov-Sminrnov normality test, it can be concluded that the data are normally distributed. Thus, the requirements for normality in the regression model have been met.

T test is used to test whether or not the relationship between the independent variables Attitude Towards Behavior (X1), Subjective Norm (X2), Perceived Behavior Control (X3), Intention (X4) with the dependent variable Behavior (Y). The results of the t test in this study can be seen in Table 5.

Table 5. Partial Test Result (t test)

Variable	t_{count}	t_{table}
Atittude Toward Behavior	0.001	1,65
Subjective Norm	0	1,65
Precieved Behavior Control	0.004	1,65
Intention	0	1,65

b. Simultaneous Test (F Test)

Used to determine the relationship between the independent variable and the dependent variable, whether the variable Attitude Towards Behavior (X1), Subjective Norm (X2), Perceived Behavior Control (X3), Intention (X4) with Behavior (Y) (Ghozali, 2016). The results of the F test can be seen in Table 7.

Table 6. Simultaneous Test Result (F Test)

Model	*Sum of Squares*	df	*Mean Square*	F	Sig.
Regression	8,303	4	2,076	11,562	0
Residual	4,488	25	0,18		
Total	12,792	29			

Coefficient of Determination

The coefficient of determination (R^2) is carried out to see whether there is a perfect relationship or not, which is indicated by whether changes in the independent variables, namely Attitude Towards Behavior (X1), Subjective Norm (X2), Perceived Behavior Control (X3), Intention (X4) will be followed by Behavior (Y) related variables are in the same proportion. The value of Adjusted R^2 can be seen in Table 7.

Table 7. Coefficient of Determination

Model	R	R square	Adjusted R Square	Std. Error of the Estimate
1	0,806	0,649	0,593	0,42371

In Table 7, it can be seen that the Adjusted R^2 value is 0.593. This means that the independent variables (Attitude Towards Behavior, Subjective Norm, Perceived Behavior Control, Intention) can explain the dependent variable (Behavior) by 59.3%, while the rest is explained by other factors not examined.

4.4 Multiple Linear Regression Analysis

From the regression results using the SPSS program, the regression coefficients are obtained which can be seen in Table 8.

Table 8. Results of Multiple Linear Regression Processing

Variable	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
Constant	0.434	0.648		0,669	0,509		
Attitude	0.683	0.221	0,557	3,089	0,005	0,431	2,319
Norm	-0.078	0.214	-0,058	-0,364	0,719	0,552	1,812
Control	-0.051	0,156	-0,054	-0,326	0,748	0,504	1,983
Intention	0.319	0,134	0,498	2,369	0,026	0,498	2,007

4.5 One Way ANOVA

One Way ANOVA analysis aims to compare the mean values contained in the related variables in all the groups being compared. The value of each group is seen based on the independent variable with a category scale. The function of the independent variable here is actuallyto represent the group of data to be studied. The independent variables in the One-Way ANOVA analysis are also called factor variables, while the groups being compared are also called factor level variables. The results of One Way ANOVA data processing can be seen in Table 9.

Table 9. Results of One Way ANOVA Data Processing

Variabel	Mean	Std. Deviation	Std Error	T	Sig.	Remarks
Atittude (X1)	4,100	0,385	0,136			
X1.1	4,033	0.054	0.112	1.760	0.080	Significant
X1.2		0.045	-0.030	-0.459	0.647	Significant
X1.3		0.032	0.087	1.629	0.104	Significant
X1.4		0.028	0.054	0.967	0.335	Significant
X1.5		0.032	0.128	2.141	0.033	Significant
X1.6		0.050	0.194	3.810	0.000	Significant
X1.7		0.024	0.090	1.837	0.067	Significant
X1.8		0.038	0.177	3.388	0.001	Significant
Norm (X2)	3,300	0,871	0,435			
X2.1		0.046	-0.206	-3.287	0.001	Significant
X2.2		0.051	0.204	3.038	0.003	Significant
X2.3		0.032	-0.113	-2.155	0.032	Significant
X2.4		0.026	0.020	0.402	0.688	Significant
Control (X3)	3,800	0,416	0,208			
X3.1		0.038	-0.024	-0.474	0.636	Significant
X3.2		0.032	0.145	2.791	0.006	Significant
X3.3		0.028	-0.118	-2.190	0.029	Significant
X3.4		0.025	-0.074	-1.370	0.172	Significant
Intention (X4)	3,550	0,288	0,144			
X4.1		0.027	0.080	1.647	0.101	Significant
X4.2		0.033	0.099	1.818	0.070	Significant
X4.3		0.025	-0.035	-0.670	0.503	Significant
X4.4		0.026	0.371	7.333	0.000	Significant

Based on Table 9, it can be seen that the average value of Attitude Towards Behavior, Subjective Norm, Perceived Behavior Control, Intention, and Behavior with the following details: (1) The average Attitude score is 4.1 with the most significant question at number X1.2 by knowing the fuel retail in Surabaya City Attitude Towards Consumer behavior is predicted to make the behavior in buying fuel at certain retail gas stations; (2) The average Norm value is 3.3 with the most significant question on number X2.4. By knowing whether consumers feel under social pressure to fill fuel at certain retail gas stations, the consumer's Subjective Norm is predicted to make behavior in buying fuel at retail gas stations certain; (3) The average value of Control is 3.8 with the most significant question on number X3.1. By knowing whether consumers are able to determine the decision to buy independently, the consumer's Perceived Behavior Control is predicted to make Behavior in buying fuel at certain retail gas stations; and (4) The average Intention value is 3.55 with the most significant question on number X4.3 by knowing whether consumers intend to try to purchase BBM at certain retails outside the ones commonly used by consumers, Customer Intention is predicted to make behavior in buying BBM at retail. Certain gas station.

Thus, it can be concluded descriptively that the highest average of the four TPB variables that make consumer behavior possible to buy fuel at certain retail gas stations is the Attitude Towards Behavior variable with a mean value of 4.1.

5. DATA ANALYSIS AND INTEPRETATION

5.1 Analysis of Research (Multiple Regression)

The following describes the results of the study based on the four variables of Theory of Planned Behavior:

H1: Attitude Toward Behavior (X1) shows the heteroscedasticity test results of 0.812> 0.05, which means there is no heteroscedasticity disorder in the regression model. The t test resultsshow a result of 0.001 <1.65, which means that X1 there is a difference in the average results of the variables towards the Behavior (Y) variable. The Beta coefficient (β) produces a value of 0.338 which means that every change of one unit of X1 can result in a change in Y of 33.8% (Figure 4). It can be concluded that the higher the X1 value owned by consumers, the more significant the possibility of making consumers buy fuel at certain retail gas stations.

H2: Subjective Norm (X2) shows the results of the heteroscedasticity test of 0.239> 0.05, which means that there is no heteroscedasticity disorder in the regression model. The t test results show a result of 0 <1.65, which means that X2 there is a difference in the average result of the variable against the Behavior variable (Y). The Beta coefficient (β) produces a value of 0.015 which means that every change of one unit of X2 can result in a change in Y of 1.5% (Figure 4).It can be concluded that the higher the X2 value owned by consumers, will not affect the possibilityof making consumer behavior to buy fuel at certain retail gas stations.

H3: Perceived Behavior Control (X3) shows the results of the heteroscedasticity test of 0.746> 0.05, which means that there is no heteroscedasticity disorder in the regression model. The t test results show a result of 0.004 <1.65, which means that X3 there is a difference in the average results of the variables towards the Behavior variable (Y). The Beta coefficient (β) produces a value of -0.215, which means that every change of one unit of X1 can result in a change in Y of - 21.5% (Figure 4). It can be concluded that the higher the X2 value owned by consumers, will not affect the possibility of making consumer behavior to buy fuel at certain retail gas stations.

H4: Intention (X4) shows the results of the heteroscedasticity test of 0.857> 0.05, which means that there is no heteroscedasticity disorder in the regression model. The t test results show a result of 0 <1.65, which means that X4 there is a difference in the average result of the variable against the Behavior variable (Y). The Beta coefficient (β) produces a value of 0.355 which means that every change of one unit of X1 can result in a change in Y of 35.5% (Figure 4). It can be concluded that the higher the X4 value owned by consumers, the more significant the possibility of making consumer behavior to buy fuel at certain retail gas stations.

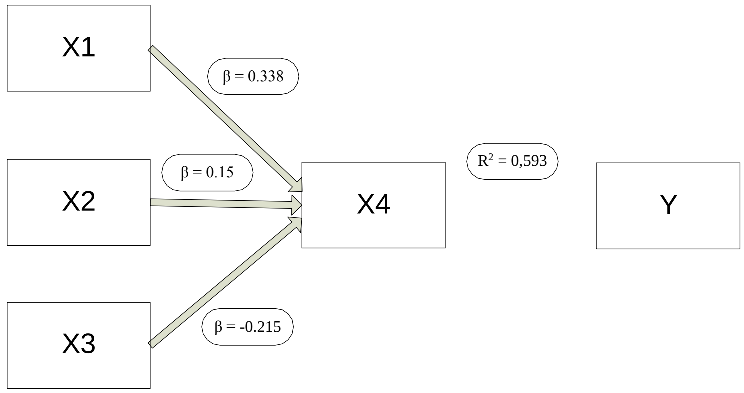

Figure 4. TPB Model Determinants of Non-Subsidized Fuel Purchase in Surabaya City

Based on the results of the research that has been done, the test results on the variables X1, X2, X3, and X4 with the kolmogorov-smirnov normality test show the Asymp results. Sig. (2 tailed) 0.2> 0.05, which means that the requirements for normality in the regression model have been met.The simultaneous significance test (Test F) has a Sig value. 0 <0.05, then by the basis for decision making in the F test it can be concluded that the hypothesis is accepted or in other words the variables X1, X2, X3, and X4 simultaneously affect Y. In testing the coefficient of determination (R2) the value Adjusted R^2 is 0.593 (Figure 4). This means that the independent variables X1, X2, X3, and X4 can explain the dependent variable Y by 59.3%, while the rest is explained by other factors that are not examined. The results of multiple regression analysis produce the formula:

$$\mathbf{Y = 0.557\, X_1 - 0.058\, X_2 - 0.054\, X_3 + 0.498\, X_4} \quad \textbf{(1)}$$

From the Attitude Toward Behavior and Intention variables, the most dominant influence on the possibility of making consumer behavior to buy fuel at certain retail gas stations where these variables have a positive and significant effect. Meanwhile, Subjective Norm and Perceived Behavior Control according to the results of this study do not have a significant positive effect on the possibility of making consumer behavior to buy fuel at retail gas stations.

5.1 Implications of Research Results

The results of interviews with actors, employees, and consumers of retail gas stations in the city of Surabaya resulted in findings and input regarding their understanding of the various types of fuel. The unequal number of retail SPBU Pertamina non Pertamina makes their understanding of non Pertamina products limited. The most important thing that influences consumers' desire to buy is the price issue and the location of gas stations. With the results of multiple linear regression which shows the value of Attitude Toward Behavior has the highest value, it can be suggested for PT. Pertamina can make a program to adjust its business strategy thatleads to the Attitude Toward Behavior variable by strengthening significant variables by prioritizing knowledge related to selling products, this is evident in the variable item questionX1.2 and consumer attitudes X1 related to PT. Pertamina is sold at retail gas stations so that the targeted products with the bestselling volume can be accepted by the public for sustainable business interests facing the rapid movement of retail retail competitors for gas stations that enter Indonesia.

5.2. Further Research (Based on Limitations)

This research is still carried out in the scope of only being carried out in the city of Surabaya, it is better if this research is developed in all major cities in Indonesia to be able to find out what consumers want so that strategies and products sold can answer consumer needs in the future.

6. CONCLUSIONS

The conclusion of this study: (1) Attitude toward behavior (cognitive, affective, andconative aspects) has a positive and significant effect on consumer behavior (target, action,context, and time aspects). The higher the attitude toward behavior of consumers, the higher the possibility of making the consumer's behavior to buy fuel at certain retail gas stations; (2) Subjective norm (aspects of normative beliefs and motivation to obey) is proven to have a significant negative effect on consumer behavior. Subjective norm does not affect, so it is not possible to make consumer behavior to buy fuel at certain retail gas stations; (3) Perceived behavior control (aspects of belief strength, power of control factor, and performance Intention) have a significant negative effect on consumer behavior. The perceived behavior control possessed by consumers does not allow the consumer behavior to buy fuel at certain retail gas stations; and (4) Intention (aspects of performance intention) are positive and significant towards consumer behavior. The higher the intention value that consumers have, the higher the possibility of making consumer behavior to buy fuel at certain retail gas stations.

Suggestions for this research: (1) consumers independently need to always improve their attitude toward behavior, this is to be able to determine consumer behavior and intention to buy fuel at certain retail gas stations more precisely in the long term; (2) Fuel producers need to always improve their attitude toward consumer behavior, so that they can more precisely determine consumer behavior in buying fuel at certain retail gas stations in order to increase the number of sales in the long term; (3) The next researcher needs to carry out further research, especially research with: (a) the same variables as the scope of the study (sample size and area) which is wider (East Java or National), and (b) the addition of research variables that affect consumer behavior in buying fuel, such as the variable quality of fuel on driving comfort and safety of motorvehicles, the amount of income with the amount of fuel purchased, and the prediction of fuel demand in terms of consumer needs, predictions of fuel preparation for the next few years.

7. REFERENCES

Ahmad, W., Kim, W. G., Anwer, Z., & Zhuang, W. (2020). Schwartz personal values, theory of planned behavior and environmental consciousness: How tourists' visiting intentions towards eco-friendly destinations are shaped?*Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2020.01.040

Ajzen, I. (1991). Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes.The theory of planned behavior. In *Organizational Behavior and Human Decision Processes*.

Ajzen, I. (2002). Constructing a TpB Questionnaire : Conceptual and Methodological Considerations. *Time*. Alzubaidi, H., Slade, E. L., & Dwivedi, Y. K. (2020). Examining antecedents of consumers' pro-environmental behaviours: TPB extended with materialism and innovativeness. *Journal of Business Research*. https://doi.org/10.1016/ j.jbusres.2020.01.017

Arikunto, S. (2006). Prosedur Penelitian Suatu Tindakan Praktik. *Jakarta: Rineka Cipta*.

BPH-MIGAS. (2019). *Pertamina (Persero) Mendominasi Penjualan BBM*. https://www.bphmigas.go.id/2019/

Gatersleben, B., Steg, L., & Vlek, C. (2002). Measurement and determinants of environmentally significant consumer behavior. *Environment and Behavior*. https://doi.org/10.1177/0013916502034003004

Ghozali, I. (2016). Aplikasi Analisis Multivariate dengan Program IBM SPSS 23. In *(Edisi 8). Semarang: Badan Penerbit Universitas Diponegoro*.

Gieure, C., Benavides-Espinosa, M. del M., & Roig-Dobón, S. (2020). The entrepreneurial process: The link between intentions and behavior. *Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2019.11.088

Hair, J. F., Anderson, R. E., and Tatham, R. L., & Black, W. C. (2010). Multivariate Data Analysis: A Global Perspective (7th Edition). In *Pearson Prentice Hall, New Jersey*.

Hoffmann, A. O. I., & Plotkina, D. (2020). Why and when does financial information affect retirement planning intentions and which consumers are more likely to act on them? *Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2020.06.023

Hsu, C. L., Chang, C. Y., & Yansritakul, C. (2017). Exploring purchase intention of green skincare products using the theory of planned behavior: Testing the moderating effects of country of origin and price sensitivity. *Journal of Retailing and Consumer Services*. https://doi.org/10.1016/j.jretconser.2016.10.006

Kuncoro, M. (2009). Metode Riset untuk Bisnis & Ekonomi. In *Metode Riset untuk Bisnis & Ekonomi*. Lo, F. Y., Yu, T. H. K., & Chen, H. H. (2020). Purchasing intention and behavior in the sharing economy:
Mediating effects of APP assessments. *Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2020.08.017

Lortie, J., & Castogiovanni, G. (2015). The theory of planned behavior in entrepreneurship research: what we know and future directions. *International Entrepreneurship and Management Journal*. https://doi.org/10.1007/s11365-015-0358-3

Mahizer Hamzah, Yusup Hashim, & Ismail Abdul Raoh. (2008). Kajian Tahap Kompetensi Pengetua/Guru Besar Sekolah Terhadap Pengurusan Teknologi Instruksional di Sekolah. *2nd International Malaysian Educational Technology Convention 2008, At Kuantan, Pahang, Malaysia*.

Mosahab, R., Mahamad, O., & Ramayah, T. (2010). Service Quality, Customer Satisfaction And Loyalty: A Test Of Mediation. *International Business Research*. https://doi.org/10.5539/ibr.v3n4p72

Noel, H. (2009). *Consumer Behaviour*. AVA Publishing (UK) Ltd.

Pristiandaru, D. L. (2020). Inspirasi Energi: Konsumsi Minyak Dunia dan Pentinya Saat ini. In *Kompas.com*. https://www.kompas.com/global/read/2020/09/14/181411970/inspirasi-energi-konsumsi-minyak-dunia-dan-pentingnya-saat-ini?page=all

Sebayang, R. (2018). OPEC: 2040, Konsumsi Minyak Dunia Capai 112 Juta Barel. *CNBC*. https://www.cnbcindonesia.com/market/20180924154250-17-34487/opec-2040-konsumsi-minyak-dunia-capai-112-juta-barel

Vanany, I., Soon, J. M., Maryani, A., & Wibawa, B. M. (2019). Determinants of halal-food consumption in Indonesia. *Journal of Islamic Marketing*. Vol. 11 No. 2, pp. 507-521. https://doi.org/10.1108/JIMA-09-2018-0177

Zhang, Y., & Li, L. (2020). Intention of Chinese college students to use carsharing: An application of the theory of planned behavior. *Transportation Research Part F: Traffic Psychology and Behavior, 75,* 106–119. https://doi.org/https://doi.org/ 10.1016/ j.trf.2020.09.021.

TOPIC

Project Management

THE EFFECT OF PROJECT MANAGEMENT KOWLEDGE IMPLEMENTATION ON NON-CORE PROJECT SUCCESS IN PT TELKOM INDONESIA

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ABSTRACT

Increasingly fierce business competition and very challenging targets in the current digital era encourage companies to always innovate in their business activities. One innovation that is often done by companies is to expand into other fields that are not its main business. In running its new business, especially in the form of projects, companies often have not implemented aspects of project management knowledge. Noting the importance of the implementation of project management knowledge on project success, the authors conducted research aimed at finding out the aspects of project management knowledge that most influenced the success of non-core projects in the company. As a case in point, the authors observe the Government & Enterprise Service unit (GES) of Telkom Surabaya telecommunications (witel) which took the initiative to take on a non-core project that is construction in the span of 2018-2019. Structural positions that function as Project Management Office (PMO) themselves are only allocated in 2019 in the unit. This research was conducted using the Partial Least Square - Structural Equation Modeling (PLS-SEM) method. The data used in this research are the implementation of the knowledge aspect of project management as the independent variable and project success as the dependent variable. The results of the PLS-SEM analysis show that the implementation of aspects of project management knowledge that has the most influence on the success of a non-core project in a company is project financial management, project claims management, project communication management, and project time management.

Keywords: project management, project success, PLS-SEM, non-core project

1. INTRODUCTION

Increasingly fierce business competition and very challenging targets in the current digital era encourage companies to always innovate in their business activities. One innovation that is often done by companies is to expand into other fields that are not its main business. In running its new business, especially in the form of projects, companies often have not implemented aspects of project management knowledge (Debowski, 2006).

The field of Project management has come a long way from what it used to be. Previously it had insufficient coverage as a research field (Davis, 2014) but has now developed into a discipline alongside other management functions which have seen growth in research literature (Mir & Pinnington, 2014). There is no doubt that companies seeking competitive advantage are utilizing project management to keep achieving business success. Companies are seeing the payoff from investing resources to developing Project management expertise as this is translating to lower cost, stakeholder satisfaction, and higher competitive advantage so much that it was instrumental in lifting companies from recession (PMI, 2010).

There is a lot of literature in relation of project management to industries especially the construction, but the literature regarding Project Management in the non-core project done by non construction company is largely scanty. This raised the curiosity as to which Project Management practices are employed by non construction company in managing their non-core projects and to what extent they are utilized and finally assessing which ones have a bearing on achieving project success. Having knowledge of the subject matter is key but is there a need for at least basic knowledge of project management practices. This research is conducted to understand their system of managing non-core projects and how much success has been achieved by doing so with a view to proposing which practices could be utilized from Project Management practices by professionals of various industries since in-depth surveys carried over the years has left no doubt as to the value that Project Management delivers to different organizations and industries.

So what Project Management practices are employed by non-construction company in order to achieve project success? The objective of identifying factors or practices that impact the success or failure of a project inspires this empirical study of the influence of Project Management Knowledge on project success. This study aims to explore how PMBOK Project Management Knowledge affects Project Success of non-core project (construction) in non-construction company. This study strives to provide imperative information as to what Project Management practices are used by non-construction company to achieve project success in their non-core business. To demonstrate the impact of PMBOK on Project success in the non-construction company, the researchers designed and carried out a survey in PT Telkom Indonesia. An analysis using Partial Least Square-Structural Equation Model analysis was carried out.

2. CONCEPTUAL FRAMEWORK

2.1 Project Management Knowledge Areas

PMBOK guide identifies 10 distinct knowledge areas: Integration, Scope, Time, Cost, Quality, Human Resource, Communication, Risk, Procurement and Stakeholder-based on 47 Project Management processes in 5 Project Management process. In addition, there are 4 extension knowledge areas specifically for construction: Safety, Environmental, Financial, and Claim (Project Management of Institute, 2013).

Chou, Irawan & Pham (2013) used eight knowledge areas to carry out a multinational study of the contribution of PMBOK to the success of construction engineering projects. Ling et al. (2008) used nine components to carry out research on the significance of Project Management knowledge to project performance. Each PM knowledge area (PMKA) has certain Project Management processes so as to produce the required outcome, it further utilizes certain tools and techniques to process certain outputs. Ling et al. (2008) and Chou et al. (2013) used the management techniques, tools and skills (TTS) as PMBOK indicators. The researchers decided to use PMKA individual processes as the indicators for this research similar to the classification made by Morteza & Kamyar (2009). This is because unlike surveys which mainly target individuals with a certain level of knowledge of Project Management practices in the construction industry, most non-construction company’s worker do not have a deep understanding of the PMBOK knowledge areas and the corresponding indicators of Project Management techniques, tools and skills (TTS) therefore using technical words would make this survey incomprehensible. The Project Management knowledge Areas investigated in this study include all fourteen components. Table 1. represents the fourteen knowledge areas and the indicators.

Table 1. Project Management Knowledge Areas and Corresponding Indicators

PMKA	Indicator	Label
Integration (X1)	Develop project documents and project management plans appropriately	X1.1
	Integrate several aspects of project management knowledge	X1.2
	Update and control the progress of project work and project documents regularly	X1.3
	Handover of project results according to the initial agreement	X1.4
Scope (X2)	Identify the scope of activities that must be carried out appropriately	X2.1
	Creating and implementing a WBS appropriately	X2.2
	Update the progress of project work and control the conformity to scope on a regular basis	X2.3
	The final result of the project scope is in accordance with the initial agreement	X2.4
Time (X3)	Appropriately define the time and resources required for each activity	X3.1
	Arrange a sequence of activities and schedules effectively	X3.2
	Update the progress of project work and control compliance with the schedule on a regular basis	X3.3
	Project completion according to the schedule that has been drawn up during the project	X3.4
Cost (X4)	Determine the cost estimate in every detail of the project activity appropriately	X4.1
	Make an appropriate project funding plan	X4.2
	Controlling cost expenditures at each stage according to initial planning	X4.3
	Project completion is in accordance with the cost and funding estimates that have been prepared during the project	X4.4
Quality (X5)	Determining standards and quality requirements appropriately	X5.1
	Meet the standards agreed at each stage of the project	X5.2
	Monitor and verify output at every stage	X5.3
	The project is completed according to the agreed quality standards	X5.4
Human Resource (X6)	Assemble the project team effectively and efficiently	X6.1
	Develop both capabilities and interpersonal skills of team members	X6.2
	Actively evaluate team performance	X6.3
	Projects are completed according to the allocation of resources that have been prepared during the project	X6.4
Communication (X7)	Collect information needed by stakeholders appropriately	X7.1
	Distribute information needed by related parties effectively	X7.2
	Control whether the information sent to stakeholders is correct and using effective methods	X7.3
	All stakeholders get the information needed until the project is completed	X7.4
Risk (X8)	Identify and analyze risks that may occur during the project	X8.1
	Develop a risk response plan and implement it properly according to the situation	X8.2
	Controlling the response for each event to fit the plan that has been prepared	X8.3
	Until the project is finished, nothing happens whose impact exceeds planning	X8.4
Procurement (X9)	Identify the goods / services that must be provided during project activities appropriately	X9.1
	Carry out the process of procuring goods / services appropriately as needed	X9.2
	Manage good relationships with all parties involved in the procurement process	X9.3
	All goods / services procurement is carried out properly in accordance with applicable regulations	X9.4
Stakeholder (X10)	Identify all stakeholders in the project and determine the right engagement strategy	X10.1
	Engaging with stakeholders according to the prepared strategy	X10.2
	Control and evaluate the results of engagement on a regular basis	X10.3
	All stakeholders are well maintained until the project is completed	X10.4
Safety (X11)	Develop a Plan for Quality, Occupational Health and Safety and the Project Environment	X11.1
	Carry out safety procedures according to the plan that has been prepared	X11.2

	Control and evaluate the implementation of safety procedures regularly	X11.3
	There were no serious safety violations until the project was completed	X11.4
Environmental (X12)	Develop a Plan for Quality, Occupational Health and Safety and the Project Environment	X12.1
	Carry out environmental management procedures according to the plan that has been prepared	X12.2
	Controlling and evaluating the implementation of environmental treatment on a regular basis	X12.3
	The environmental conditions of the project are in accordance with the standards agreed upon at the beginning	X12.4
Financial (X13)	Arrange project funding / financial planning appropriately	X13.1
	Prepare all funding processes (own capital, loans, etc.) according to initial planning	X13.2
	Update project implementation process and evaluate project funding regularly	X13.3
	Funding according to plan until the project is completed	X13.4
Claim (X14)	Prepare terms and things to do regarding claims	X14.1
	Carry out the work in accordance with the scope and standards agreed upon at the beginning	X14.2
	Evaluate performance and claim settlement if it occurs	X14.3
	Minimizing the occurrence of claims until the project is completed, but if it happens it can be resolved properly	X14.4

2.2 Project Success

Davis (2014) said that in early 1970 measures of project success was fixated on the operational side, tools and techniques (Iron triangle of time, cost and quality) and was lacking in any sort of behavioral soft skills (Munns & Bjeirmi, 1996). It was mainly dependent on the viewpoint of the project manager. Project Managers mainly focused on the technical aspects of the project without proper communication with the clients. During 1980-1990 for the first time, a list of ten success factors including project mission and top management was produced by (Pinto & Slevin, 1987, 1988) though it was critiqued, thereby bringing to light how imperative it is to evaluate a project from various perspectives. Later (Moris and Hough, 1987) established that success should rely on multiple project stakeholders and the time during which it is measured, though their framework was still based on the iron triangle. In the 21st-century project success was defined more than just the Project managers but by the stakeholder expectations. Papke-shields, Beise & Quan (2010) stated that although the iron triangle often called the traditional criteria of success has been criticized, it is considered by many as the key part of assessing project success. Different project stakeholders have different views of how project success should be interpreted, as it is improbable that a single project success criterion will be suitable for all projects, as such frameworks have been developed for measuring project success. Ultimately the aim of project management is to make sure that project success is achieved (Berssaneti & Carvalho, 2015). There is an overwhelming number of success factors from numerous researchers. Table 2. gives a summary of the project success measures selected for the purpose of this study.

Table 2. Measures of Project Success

Construct	Indicator	Supportive Literature
Project Sccess	Completed on time	(Dvir et al., 2003; Papke-shields et al., 2010)
	Completed within budget	(Dvir et al., 2003; Papke-shields et al., 2010)
	Meet quality requirement	(Dvir et al., 2003; Papke-shields et al., 2010)
	In accordance with the initial design	(Dvir et al., 2003; Muller & Turner, 2007; Papke-shields et al., 2010)
	Stakeholder satisfaction	(Dvir et al., 2003; Muller & Turner, 2007; Papke-shields et al., 2010)

2.3 Research Model

Project Management literature demonstrates that there is a positive relationship which exists between Project Management knowledge areas and Project Success (PMI, 2013). From such literature, it can be stated that the individual Project Management knowledge Areas has the potential to contribute to Project Success (Chou et al., 2013). Hence, this research model is used:

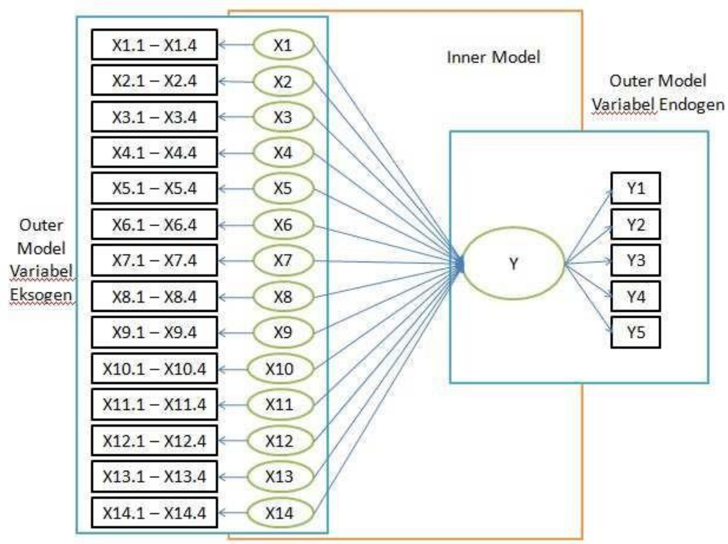

Figure 1. Research Model

3. Research Methodology

3.1 Survey Process (Questionnaire Design and Development)

This study utilized the Project Management Body of Knowledge (PMBOK) as the framework for investigating how non-construction company employer actually execute and manage projects. It analyzed data obtained from surveys of team project in PT Telkom Indonesia. The items to measure the Project management knowledge and Project success was adopted from peer-reviewed publication in the project management research area with a slight modification which is clearly stated in all cases. The survey respondents were PT Telkom Indonesia project team in five different projects.

The questionnaire was drafted in bahasa Indonesia. To collect the data required, the questionnaire was sent manually to all project team. The questionnaire comprised of 3 sections with a total of 61 questions. The questionnaire covered the 14 Project Management Knowledge Areas, questions were presented in an easy to understand manner so as to enable respondents to easily understand the questions and obtain respondents true understanding of the issue. The first section obtained regarding the respondent's background. The second section obtained data on the respondents Project Management Knowledge designed along the PMBOK Project Management

Knowledge Areas framework. Finally section three enlisted data on Project Success of accomplished projects. The Likert scale system was employed scoring from 1 to 5.

3.2 Data Collection

A structured offline questionnaire was chosen to assess Project management Knowledge of non-construction company project team and a total of 70 responses were received over an 6 week period.

Table 3. Characteristics of Survey Respondents

Attribute	Distribution	Frequency	Percentage (%)
Age	21-30	17	24,3
	31-40	31	44,3
	41-50	14	20
	>51	8	11,4
Work Experience (years)	1-5	5	7,1
	6-10	12	17,1
	11-15	18	25,7
	16-20	13	18,6
	21-25	10	14,3
	26-30	7	10
	>31	5	7,1
Education	Bachelor’s Degree	55	78,6
	Master’s Degree	8	11,4
	Others	7	10
Project	Smart Building	18	25,7
	Homestead	13	18,6
	Warehouse	14	20
	Data Center A	12	17,1
	Data Center B	13	18,6

4. Data Analysis and Result

4.1 PLS-SEM Analysis: Outer Model Evaluation

Outer model evaluation can be done using convergent validity by looking at the value of the loading factor of each indicator, AVE (Average Variance Extracted) value of each latent variable, cronbach’s-alpha and composite reliability. Here is the result of calculation:

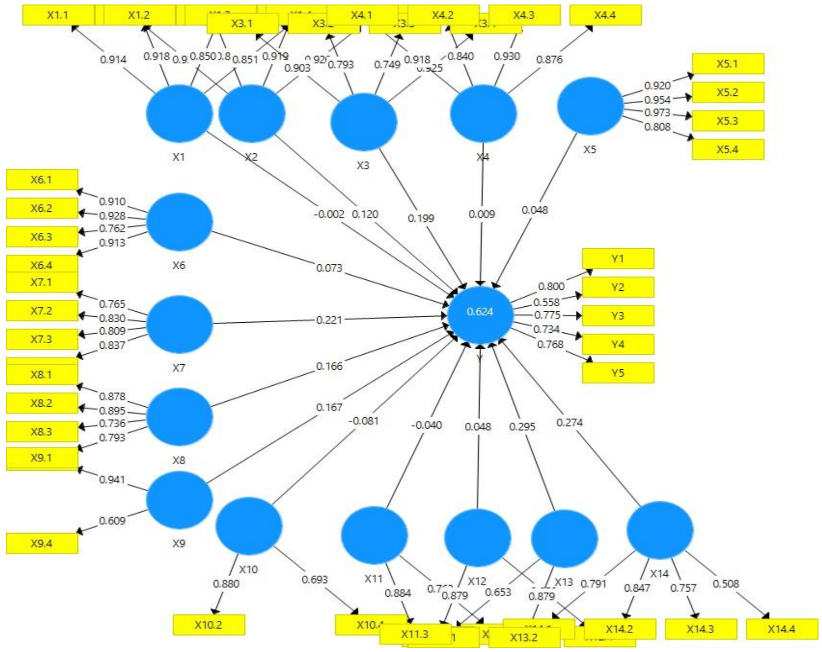

Figure 2. Loading Factor and Path Coefficient

Table 4. Cronbach's-Alpha, Composite Reliability & AVE

Construct Reliability and Validity

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
X1	0,908	0,934	0,781
X10	0,746	0,768	0,627
X11	0,684	0,810	0,681
X12	0,664	0,856	0,748
X13	0,742	0,746	0,600
X14	0,706	0,822	0,543
X2	0,937	0,955	0,841
X3	0,867	0,909	0,715
X4	0,914	0,939	0,795
X5	0,937	0,954	0,838
X6	0,902	0,932	0,776
X7	0,827	0,884	0,657
X8	0,855	0,896	0,685
X9	0,855	0,764	0,628
Y	0,782	0,851	0,536

All loading factor values from the indicator to the latent variable are > 0.5. This shows that all the indicators in the second stage path diagram are valid for measuring the latent variables. Each latent variable has Cronbach's alpha value> 0.6, composite reliability value> 0.7, and AVE value >0,5. This shows that each indicator is reliable.

4.2 PLS-SEM Analysis: Inner Model Evaluation

The R-square value (R2) shows how much the ability of the exogenous latent variable to explain the variation of the endogenous latent variable value. Based on calculations using software, in this study the R-square (R2) value of the endogenous latent variable was 62.4%. This means that

62.4% of the variation in the value of the non-core project success variables can be explained by the 14 exogenous latent variables studied, while the remaining 37.6% is influenced by other variables outside the model.

Q-Square Predictive Relevance (Q2) is a value that shows how good the observation value of the model is. Based on calculations using software, this study obtained the Q-Square Predictive Relevance (Q2) value of 0.261. The Q-square Predictive Relevance (Q2) value greater than zero indicates that exogenous latent variables have predictive relevance to the affected endogenous latent variables (Sholihin and Ratmono, 2013). This shows that the exogenous latent variables used in the research model already have predictive relevance to the project success variable.

The final step in evaluating the inner model is to test the significance of the effect of each exogenous latent variable on the endogenous latent variable. The significance test was carried out by using the bootstrapping method to measure the t-statistic value of the structural model. At the 5% significance level, the path coefficient is said to be significant if it produces a t-statistic value> 1.95 (Efron, 1979). The calculation of T Statistics of each variable is given by table 5 below:

Table 5. T-Values & P-Values

Mean, STDEV, T-Values, P-Values

	T Statistics (|O/STDEV|)	P Values
X1 -> Y	0,021	0,983
X10 -> Y	0,620	0,536
X11 -> Y	0,293	0,770
X12 -> Y	0,346	0,729
X13 -> Y	2,102	0,036
X14 -> Y	1,998	0,039
X2 -> Y	1,161	0,246
X3 -> Y	1,960	0,046
X4 -> Y	0,078	0,938
X5 -> Y	0,411	0,682
X6 -> Y	0,469	0,639
X7 -> Y	1,975	0,041
X8 -> Y	1,656	0,098
X9 -> Y	1,012	0,312

This shows that only 4 of these exogenous latent variables have a significant effect on the endogenous latent variables of the success of non-core projects. The magnitude of the influence of each variable is represented by their respective path coefficients. From the path coefficient test in the previous section, the path coefficient values for each variable are as follows: Project Financial Management (X13) of 0.295; Project Claims Management (X14) of 0.274; Project Communication Management (X7) of 0.221; and finally Project Time Management (X3) of 0.199.

$$Y = 0{,}295\ X13 + 0{,}274\ X14 + 0{,}221\ X7 + 0{,}199\ X3$$

5. CONCLUSION

Based on the results of the analysis carried out in this study, it can be concluded that the implementation of 14 aspects of project management knowledge comprehensively has a positive effect on the success of non-core projects. From a total of 14 aspects, 4 aspects of project management knowledge were obtained whose implementation had the most significant effect on the success of non-core projects, namely:

a. Project Financial Management: if the value of this variable is increased by one unit, the success value of non-core projects will increase by 0.295 units.
b. Project Claims Management: if the value of this variable increases by one unit, the success value

of non-core projects will increase by 0.274 units.

c. Project Communication Management: if the value of this variable increases by one unit, the success value of non-core projects will increase by 0.221 units.

d. Project Time Management: if the value of this variable increases by one unit, the success value of non-core projects will increase by 0.199 units.

This research can still be developed further so that the results can better represent the effect of implementing project management knowledge on the success rate of non-core projects, namely by:

1. Adding different research samples and business scopes. In this study the authors only took sample data from 5 non-core projects at PT. Telkom Indonesia so that the results are relevant only to the telecommunications industry. If you want more general results, the research sample must be larger and come from various types of industries.
2. Considering the project owner's point of view as a comparison because this research was conducted from the perspective of the contractor (executor).

REFERENCES

Ahmed Ibrahim & Dante Yong. 2019. The Influence of Project Management Knowledge of Academics on the Success of University Research Projects.

Chou, J., Irawan, N., & Pham, A. (2013). Project Management Knowledge of Construction Professionals: Cross-Country Study of Effects on Project Success, 1–15

Davis, K. (2014). Different stakeholder groups and their perceptions of project success. International Journal of Project Management, 32(2), 189–201.

Dvir, D., Raz, T., & Shenhar, A. J. (2003). An empirical analysis of the relationship between project planning and project success, 21, 89–95.

Fotwe, F. E. & McCaffer, R., 2000. Developing Project Management Competency: Perspectives From The Construction Industry. International Journal of Project Management, Volume 18, pp. 111-124.

Freeman, M. & Beale, P., 1992. Measuring Project Success. Project Management Journal, March , Volume Vol.XXIII; No.1, pp. 8-17.

Ling, F., & Low, S. (2008). Models for predicting project performance in China using project management practices adopted by foreign AEC firms. Journal of Construction, (December 2008), 983–990.

Morteza, S.-G., & Kamyar, K.-C. (2009). Generic project success and project management success criteria and factors: Literature review and survey. WSEAS Transactions on Business and Economics, 6(8), 456–468.

Papke-shields, K. E., Beise, C., & Quan, J. (2010). Do project managers practice what they preach, and does it matter to project success. International Journal of Project Management, 28(7), 650–662.

Project Management Institute, 2003. Extension to A Guide to the Project Management Body of Knowledge. 2000 Edition. Pennsylvania: Project Management Institute.

Project Management Institute, 2008. PMBOK. 4th Edition penyunt. Pennsylvania: PMI Publication.

IMPROVEMENT OF DELAYS IN THE CAMPLONG SALT FACTORY PROJECT USING LEAN SIX SIGMA FOR CONSTRUCTIONS

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ABSTRACT

The incidence of delays in completing project activities has a very detrimental impact, including late penalties, a decrease in the contractor's reputation and even the impact of business opportunity losses as a project owner. As an effort to avoid the negative impact of delays, construction companies are required to make improvements so that the company is able to compete in an increasingly dynamic and competitive market, this is also emphasized by the current financial crisis and economic recession, which requires companies to introspect, make efficiency and increase performance effectiveness through breakthroughs improvement methods. The application of lean methods, six sigma or a combination thereof, can be a solution because this method is a breakthrough management study that focuses on efforts to improve performance effectiveness and improve process efficiency. This popular concept emerged as a revolutionary manufacturing industrial management method resulting in the success stories of major companies in the world. The development of this method has also begun to be widely used in construction project management which is expected to bring the same success as its application in the manufacturing industry. In this study the lean six sigma (LSS) method was used as a paradigm refinement and an analysis tool for the implementation of the study project where delays were found in the completion of work. The input of this research is data on factors of delays and waste that occur in the project through distributing questionnaires to stakeholders involved in the project. In addition, to complement the performance measurement analysis, secondary data from the work implementation report is also used, including the progress of work and the use of costs. This research will produce the output of the lean method in the form of critical waste which is thought to be the dominant cause of delays in the Camplong salt factory construction project, which is then analyzed using root cause analysis and if then recommendation. Analysis of other proposed improvements is carried out by reviewing the value stream process which is expected to be able to minimize non-value added activity. The output of the six sigma method is in the form of an LSS-PI performance indicator which will be used to measure the performance of existing projects and the determination of threshold values as a means of controlling the performance of future performance quality improvements from the point of view of timeliness, cost, quality, process effectiveness and inventory waste.

Keywords: Critical Waste, Performance Index, Improvement, Lean Six Sigma, Constructions.

1. INTRODUCTION

A planning and scheduling is very decisive in the implementation of a construction project which aims to organize and allocate limited resources so that the project can be completed as expected. Projects always have a deadline which means they have to be completed before or on time as specified. In some studies even mention like by (Alsuliman, 2019) that about 75% of public construction projects at MOMRA In Saudi Arabia exceeded their planned time and were delayed. Likewise, what happened in the research case study was conducted on the implementation evaluation of the Madura Indonesia Camplong salt factory construction project. In addition to the cost of delays penalties for contractor, many other negative impacts will be received by the contractor and the project owner from the delay in project completion. In a study by Pinto et al (2020), mentions that related to the economic impact risks arising from delays in the completion strategic projects of power plants construction in Brazil, which increases the potential for business failure from project owners. Iyer and Kumar (2016), stated that the delay in the project completion is causing increased costs and cutting the potential revenue and profitability of the company. As an effort to avoid the negative impact of project delays, construction companies must make improvements so that the company can compete in an increasingly dynamic and competitive market, in addition to the current conditions of financial crisis and economic recession, requiring each company to make system improvements, efficiency and increasing the effectiveness of performance with continuous improvement methods.

Six Sigma as a business strategy is highly recommended in achieving superior performance in operational business processes. That is a business management strategies can be powerful and widely used by world-class companies such as General Electric (GE), Motorola, Honeywell, Bombardier, ABB, Sony and many more. The Lean concept in the constructions practice or lean construction is to adopt the lean thinking concept that was first developed by the Toyota Production System in the 1950s, where the main purpose of this concept are maximizing value, minimizing waste and pursuing perfection. Through a combination of lean and six sigma (LSS) it is hoped to produce collaboration between improving productivity and quality simultaneously.

Womack and Jones (2008) state that Lean Thinking is the antidote to waste. There are five Lean Principles, 1) Specify Value of Customers, 2) Identify the Value Stream, 3) Make the value- creating steps flow, 4) Let the customer pull the product from you. Sell one. Make one, 5) Pursue Perfection. While Six sigma is a structured methodology to improve processes that are focused on reducing process variances within tolerance limits or specifications of service performance characteristics while reducing defects (products/ services that do not meet specifications) by using statistics and intensive problem solving tools (Antony, 2006). The Lean Six Sigma (LSS) approach as a framework is the implementation of improvement planning using a defined methodology and commonly referred to as the DMAIC concept (Define, Measure, Analyze, Improve and Control) where the stages are recurrent stages or form a quality improvement cycle (Zahara, 2016).

Several research related to the application of the LSS method have also been carried out, including research by Han et al. (2008), with Six Sigma-Based Approach to Improve Performance in Construction Operations assessed from the productivity and effectiveness of the process using Critical Total Quality (CTQ) performance indicators, but in this research does not include how control so that the workflow can run well and sustainably. Al-Aomar (2012) uses lean construction in the construction industry to help industry reduce costs and waste, increase effectiveness and improve quality by developing a six sigma rating framework. Muliyanah and Setiawan (2013), in their research to find out the causes of delays in warehouse construction projects and to manage the project schedules using the DMAIC cycle approach. Banawi (2013), using a combination of developing the Lean, Green and Six Sigma (LG6) framework. The results obtained are improving project performance by increasing work efficiency and attention to existing environmental impacts. However, this study does not provide a comprehensive measurement study of the current project performance parameters and the value of the improvements made. Another study conducted by Nyata and Wiguna (2018) found the dominant factors causing delays in construction projects and formulated solutions using the DMAIC concept by applying several techniques that were able to minimize delays. Through research that has been conducted and has made many positive contributions to the study of project management development, this research was conducted to provide new ideas for the application of the LSS concept to project delay analysis and formulate process improvements through efforts to minimize waste and maximize value and use LSS-PI as a performance indicator. project to be used as a control tool in order to avoid delays.

1.2 Lean Six Sigma Combination

The lean concept used in this research is lean construction, referred to by Howell and Koskela (2000), that is focused on the production process of a project. Lean Construction is a way to design a construction management system that can minimize waste from material usage, time and effort in order to maximize value. Application of lean concepts, one of them is using value stream mapping analysis, which is a tool in lean concepts that can be used to map value streams in detail to identify wastes and find their causes and provide appropriate ways to reduce or even eliminate them, Womack and Jones (2008). The focus of Value Stream Mapping is on value adding and non-value adding processes.

Application of Six Sigma has a different framework in construction operations. The Six Sigma approach is data based for the achievement of quality products and services with a focus on increasing parameters called Lean Six Sigma- Performance Index (LSS-PI). In this study the application of the Six Sigma approach is linked to the problem of project delays, therefore the LSS-PI identification used is based on achieving timeliness and ongoing project costs, or in other words the LSS-PI approach will be linked to project performance achievement data obtained from components earned value (EV), schedule variance (SV) and cost variance (CV) as measurement indicators. As discussed in Al-Aomar (2012), The project speed and cost effectiveness are the most important aspects in lean construction. Schedule variance (SV) and cost variance (CV) are simmiliar performance measures in the earned value management system (EVMS). Variance is a deviation from planning that must be anticipated through corrective action. As discussed in Kerzner (2009), Schedule and cost variances (SV & CV) can be determined through a formulation that involves the budgeted cost components (ie planned value, PV) for work scheduled, budgeted cost for work performed (ie earned value, EV), and actual cost (AC) for work performed as follows:

$$SV = EV - PV \quad (1)$$

$$CV = EV - AC \quad (2)$$

Both SV and CV can be expressed in terms of value for money or units of time. A negative schedule variance indicates a behind schedule condition and a negative cost variance indicates a cost overrun. cost and schedule effectiveness, the physical progress of the project is measured using a schedule performance index (SPI) and a cost performance index (CPI) based on the earned value (EV) during the job evaluation compared to actual cost (AC) and planned value (PV) during the same period. The two indices are estimated as in formulas (3) & (4) where if the indices value is less than 1.0 then each indicates cost overrun and a behind schedule condition (Al-Aomar, 2012) :

$$CPI = EV/AC \quad (3)$$

$$SPI = EV/PV \quad (4)$$

2. METHOD

In this study, using the DMAIC (Define, Measure, Analyze and Control) concept approach as a process for achieving Six Sigma performance. These stages are shown in Figure 2 which are as follows the define stage contains identification activities that support the process of formulating problems related to the research object study. At the measure stage, it contains data collection and measurement activities through distributing questionnaires for the causes of delays and critical waste and also calculating performance indicators in the implementation of the study object project. At the Analyze stage, an analysis of the data collection and measurement will be carried out to determine the cause of the problem and then as the basis for the improvement process. The next stage is improvement, where efforts will be made to improve the process to overcome the problem using the lean six sigma concept tools. In the final stage is control, a simulation will be carried out based on the proposed process improvement and the determination of threshold measurement parameters as a reference for project performance control tools.

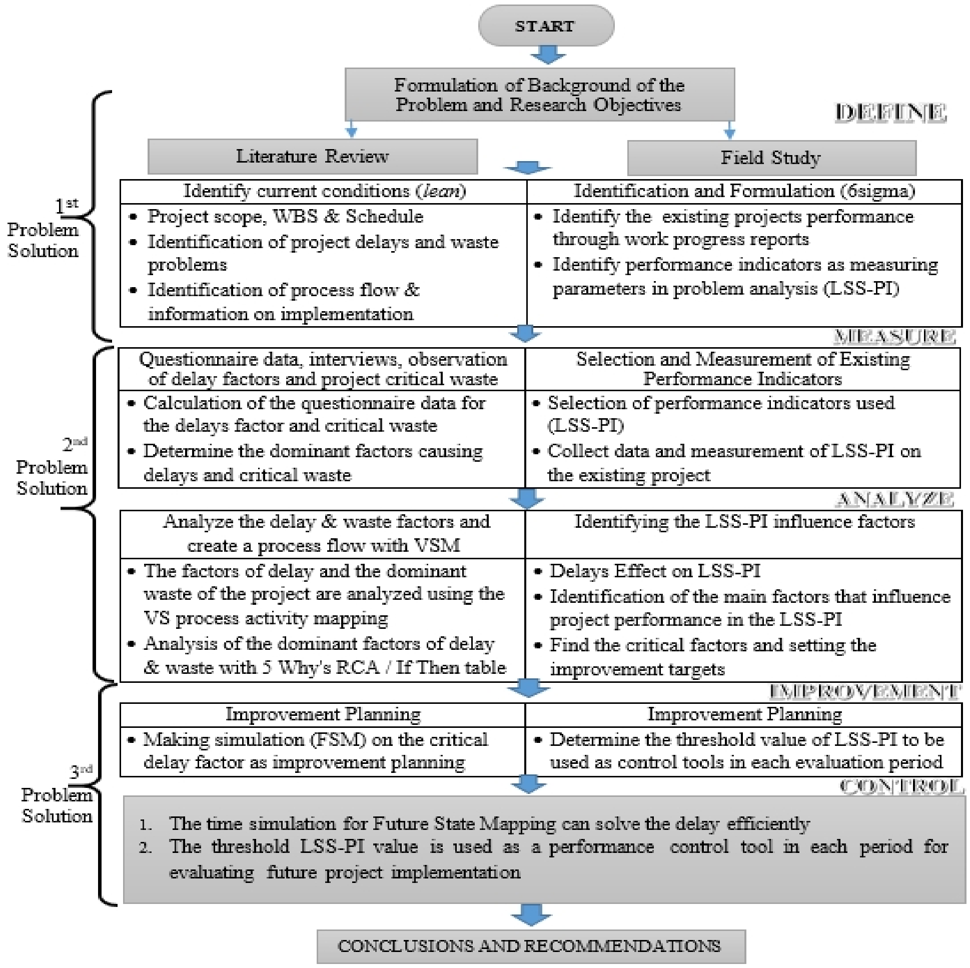

Figure 1 Research Work Step Flow

3. RESULTS AND DISCUSSION

3.1 Project Delays Factor and Critical Waste

In this research, data collection was carried out through questionnaires related to the factors causing project delays and also the incidents of waste that occurred in the implementation of the project. The project delay factors used was taken based on literature references and discussions with stakeholder experts involved and obtained 27 delay variables as shown in Table 1 below. Through the data from the questionnaire which contains an assessment of the delay factor variable, it results in an assessment of variable data as shown in figure 2 shows that the factors that cause delays that are considered dominant in project implementation are the first rank or the most dominant lies at V1 Poor contractor project scheduling planning management system (improper planning) with a significance rate 78,6% followed by the variable in the next rank is V21 Delay in approval of drawings / specs from consultants and owners with a significance rate 77,3% and the third dominant position is V5 Weak contractor's financial capacity with a significance rate 70,6%.

Table 1. Variable Causes of Project Delay.

No	Variable Causes of Delay	Code
1	Poor contractor project scheduling planning management system (improper planning)	V1
2	The readiness of the contractor's work equipment & resources is not well planned	V2
3	Poorly used project organization and communication systems	V3
4	Differences and misperceptions of contracts and agreements between Contractors and V4 Owners (weak management contracts)	
5	Weak contractor's financial capacity	V5
6	Lack of expertise and skills of the contractor workforce	V6
7	The contractor's experience with the project handled is inadequate	V7
8	The number of contractor's work that has been reworked	V8
9	A design error and failure occurred	V9
10	Weak methods of inspection and testing of products and work (QC)	V10
11	Material import constraints and fluctuations in the exchange rate of increased material prices	V11
12	Delays in delivery of goods and materials due to transportation	V12
13	Delays in procurement activities	V13
14	Work accidents during implementation	V14
15	Implementation methods and techniques are wrong	V15
16	Unpredictable conditions (uncertainty conditions)	V16
17	Bad weather and does not support project implementation	V17
18	Less disturbance and support from the population (strike and citizen demonstrations) due to the economic, educational and socio-religious conditions in the project area	
19	Owner's financial capacity is weak to the point of late payment	V19
20	Delay in handing over land from the owner and starting work permits	V20
21	Delay in approval of drawings / specifications from consultants and owners	V21
22	There were several design changes and Owner requests outside the contract	V22
23	Owner and consultants are not fast in making decisions (complicated bureaucracy)	V23
24	There is frequent change of sub-contractors	V24
25	The duration of the work contract is too strict (unrealistic)	V25
26	Lack of enriched software and design tools for designers	V26
27	Production of engineering design documents is slow; Design detail drawing is unclear	V27

The next primary data used in the analysis is a questionnaire on the factors of waste in project execution. The waste factor used in the questionnaire is taken from a studies in previous literature review of which is considered to be close to the possibility of occurring in the project. The waste variables are as shown in table 2 below. Through the data from the questionnaire which contains an assessment of the waste factor variable, it results in an assessment of variable data as shown in table 3.shows waste of Excess Processing type becomes critical waste which has the highest significance of 90%, followed by Movement Waste with a significance of 68% and in third place there is Inventory Waste with a significance of 57%.

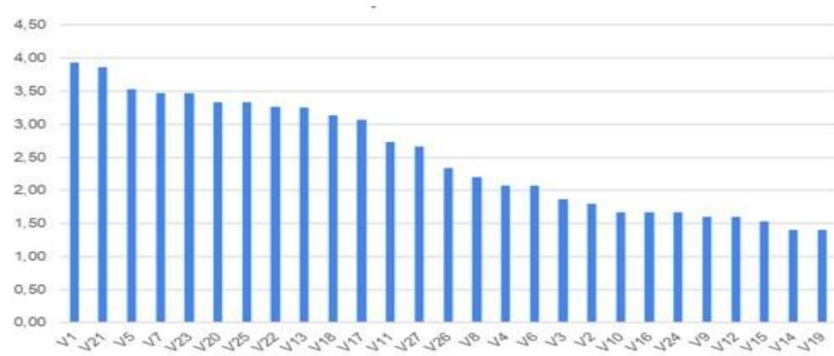

Figure 2 Graph of Measurement Variable Factors Causing Delay

Table 2. Identification of construction waste factors

No	Factors of waste in 7 wastes	Category
1	Equipment & Material delivery transportation delays	Transport (W1)
2	The process of purchasing goods & materials is far and away	
3	Limited shipping expedition	
4	Workers are not disciplined and not productive (ineffective work)	Waiting (W2)
5	Interruptions and external work stoppages	
6	Workers are waiting a lot (idler) because the work location, equipment & jobs are not ready	
7	Excessive job qualifications and specifications (Over spec)	Over Product (W3)
8	Error or excess purchase of Material	
9	Error work / rework / repair / re-testing	Deffect/ Corection (W4)
10	Design Failure	
11	Priority error for arrival of equipment / execution of its installation	
12	Excessive storage / insufficient storage of materials & equipment	Inventory (W5)
13	lost goods / equipment (theft) or because their use is not recorded	
14	Material equip is damaged, not maintained, not organized, not stored properly (material mngmnt)	
15	The movement of workers back and forth to purchase less materials	Movement (W6)
16	The bureaucracy in the execution of the purchase / job is too complicated or complicated	Excess Processing (W7)
17	Requests for changes to specifications & needs for clarification.	
18	Excessive training activities	
19	Excessive safety procedure activities	
20	Excessive supervision activities	

Table 3. Identification of construction waste factors

No	Seven Wastes	Total Value	% Significance	Rank
W1	Transportation/ Conveyance	93	48%	5
W2	Waiting/ Delays	101	52%	4
W3	Over Production	29	15%	7
W4	Defective parts / Correction	93	48%	6
W5	Inventory	111	57%	3
W6	Movement / Unnecessary motion	133	68%	2
W7	Excess Processing	175	90%	1

The results of the assessment of the delay factor and critical waste have been obtained in Figure 2 and Table 3, then further analysis is needed to find out the root causes of the problem of the delay and waste factors that occur. The root cause analysis is provided with the 5 Why's method as shown in table 4 below. In the results of the 5Why's analysis, at the final WHY level it is considered the root cause of the problem of waste and delays so that it requires special and serious attention for the contractor company.

Table 4. Identification of The Root Cause of Wastes & Delays (5 Why's)

Waste Factor	Why 1	Why 2	Why 3	Why 4	Why 5
Excess Processing (W7)	Long time Technical & Work Document approval process	Long bureaucratic approve from internal contractors - consultants - owner	The review approve process must be in the form of a physical document with delivery constraints etc.	The electronic approve review process cannot yet be agreed upon	The document validity is legally not yet regulated / guaranteed.
Movement (W6)	Movement does not need to occur much, especially for procurement of material shortages and searching for equipment and work materials	Site manager and field supervision only use a general work plan that contains work items so that the readiness of materials and equipment is unpredictable	There is no planning system for the preparation of material and work equipment preparation before the execution work is carried out	The site manager and field supervision do not make detailed planning down to man power, materials and planning tools	Selection and evaluation related to site manager and field supervisor level performance are not carried out routinely and strictly by the project manager
Inventory (W5)	Work materials and equipment on site are disorganized and there is a risk of redundancy due to difficulty in finding and loss of equipment materials	In the field there is no inventory management system and planning for controlling material and equipment warehouses	There is no dedicated person that is responsible for inventory management and there are only warehouse registrar and security officers.	Limited permits for additional man power allocation and no awareness from the project team regarding the importance of the inventory control function.	There is no special monitoring and provisioning from management regarding standards and procedures for planning and controlling inventory
Waiting (W2)	Many waiting activities occur due to unpreparedness of materials, equipment and work documents	Sub-con work often stops due to late payment from the contractor, and some delivery delays are related to invoices.	Delays in supply and realization of payments and flow of project implementation financing are due to financial control with centralized management from the head office	The contractor's financial capacity is weak and financial problems at the head office are not good enough	

From the results obtained about the root cause component based on the results of the 5Why's analysis given in table 4, then an analysis of improvement recommendations for the problem of delay is given with the if then root cause analysis method and recommendations as shown in table 5 below.

Table 5. Generate Recommendation from The Root Cause of Wastes & Delays

Waste Factor	Root Cause (IF)	Improvements Recommendation (Then)
Excess Processing (W7)	The document validation system that is reviewed and approved electronically from a legal and legal point of view has not been regulated / guaranteed in government legislation	At this time electronic transactions have begun to get priority in recognition of the legality and strength of the law by the government due to the digitalization of industry 4.0 coupled with the pressure of pandemic conditions. So in the future, the agreement must be agreed upon regarding the alternative use of the approval method and document review digitaly can be done to compensate for the risk of delays that occur, such as in the case study project.
Movement (W6)	Selection and evaluation related to site manager and field supervisor level performance are not carried out routinely and strictly by the project manager	The project team or in this case PM can involve the HC (human capital) team from the head office to assist in the selection and standardization of qualifications and performance evaluation for supervisor and site manager level personnel so that the PM can always control and evaluate the targets and performance of personnel in the field so that planning and execution for the better
Inventory (W5)	There is no special monitoring and provision from management regarding standard and procedures for planning and controlling inventory	Through the supply chain management & inventory bureau from the head office can provide quality standards as well as planning and inventory control procedures to be implemented at the project site so that inventory management can be carried out and applied better.
Waiting (W2)	The contractor's financial capacity is weak and financial problems at the head office are not good enough	Management at the head office, especially in the financial system, needs to plan expenditure priorities and budgets, especially when it comes to financing ongoing project operations. Especially in the implementation of the project, the object of study is always backed up with good progress and on time payments from the owner

3.2 Process Acivity Mapping

In this process, an analysis of the measurement of value added and non-value added activities will be carried out by creating a value stream mapping (VSM) of the existing process based on the results of the dominant delay factor data along with the critical waste found in the implementation process of the Engineering and Procurement phases.

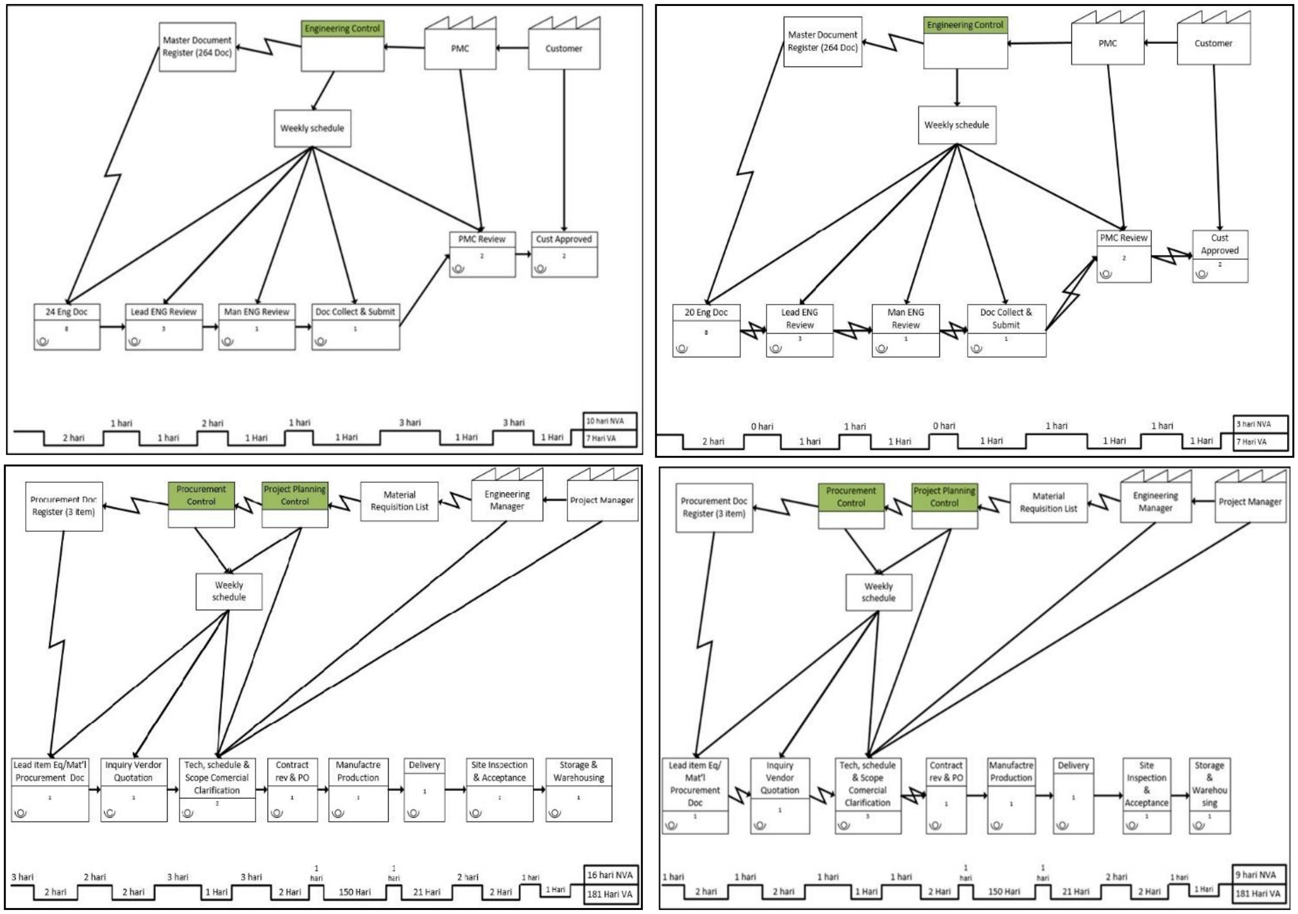

Figure 2 Current State Mapping &Future State Mapping Engineering &Procurement Phase

Through FSM planning in the engineering and procurement phases an estimate of the total NVA reduction is 77 days of engineering and 21 days of procurement so that if the implementation of the process activity mapping improvement plan can be controlled properly, it can improve the estimated time performance of 98 days.

3.3 Assessing The Lean Six Sigma-Performing Index Performance Index (LSS-PI)

LSS-PI is a quality performance appraisal approach tool of a construction project implementation as used in Al-Aomar's (2012) research where the measure of project performance quality is viewed from five aspects of achievement including aspects of work quality, cost aspects, speed aspects, value aspects of the process flow and the aspects of waste that occurs in the project. From the five indicators of the performance appraisal approach, only a few will be used, especially those most related to the incidence of project delays, namely the cost and time performance (SPI & CPI) and the effectiveness of the work flow in VI. The results of measuring the performance of the existing project at the end of the project deadline shown in the Table 5.

Table 5. Resume of Lean Six Sigma Performance Index Assessment Results

No	Indikator	Parameter			LSS-PI
1	EVMS data	PV: Rp.65 M	EV:Rp.55,2M	AC:Rp.57,8M	SV: 9,7M SPI:**0,85** CPI:**0,95**
2	Value Data	CTe:7(day) CTp:181(day)	FTe:10(day) FTp:16(day)	PeriodsE:17(day) PeriodsP:197(day)	VIe:**0,4118** Vip:**0,91**

In the improvement phase, the LSS-PI threshold value reference will be proposed as a means of controlling project performance according to the company's capabilities, and the results of interview discussions with experts. The threshold values are generated as shown in the Table 6.

Table 6. Resume of Proposed Reference Value of LSS-PI and Relationship to 7 Wastes

No	Seven Wastes	LSS-PI	LSS-PI (Threshold)	Keterangan
1	Defective parts / Correction	SR: **- (*)**	SR ≥ 3,0	93% of work must be accomplished according to plan, without defects and no rework occurs
2	Waiting / Delays	SPI:**0,85**	SPI ≥ 1,10	a minimum of more than 10% of the time performance is planned as a buffer when there is a delay
3	Over Production	CPI:**0,95**	CPI ≥ 1,10	a minimum of more than 10% cost performance is planned as a buffer for delays in costs
4	Excess Processing	VIe:**0,4118** Vip:**0,91**	VI ≥ **0,75**	The NVA that is allowed in the process is 25% of the total process completion time.
5	Transportation/ Conveyance			
6	Movement / Unnecessary motion			
7	Inventory	WI: **(*)**	WI ≤ **15%**	Waste inventory that is allowed is a maximum of 15%, planning for material and service procurement must be in accordance with what is needed (just in time).

4.CONCLUSIONS

Based on data processing and analysis in this research, a conclusion can be drawn that

1. The factors that cause delays that are considered dominant in project implementation are the first rank or the most dominant lies at V1 Poor contractor project scheduling planning management system (improper planning) with a significance rate 78,6% followed by the variable in the next rank is V21 Delay in approval of drawings / specs from consultants and owners with a significance rate 77,3% and the third dominant position is V5 Weak contractor's financial capacity with a significance rate 70,6%.
2. Wastes of Excess Processing type becomes critical waste which has the highest significance of 90%, followed by Movement Waste with a significance of 68% and in third place there is Inventory Waste with a significance of 57%.
3. The results of measuring the performance of the project object of study at the deadline for implementation using the LSS-PI obtained SV = (-) 9.7M & SPI = 0.85; CV = (-) 2,6M & CPI = 0,95 so it can be interpreted that the quality performance of scheduling until the end of project implementation is still poor and there are delays and cost overrun; and VI = 0.4118 were found from the VSM manufacturing process, where this value still shows the amount of NVA value that occurred during the project implementation process.
4. From the improvement planning in FSM it is estimated that it will improve processing time and reduce NVA activities which will be able to compensate for previous delays so that it is expected that a

improvement process can be implemented in the next project because it is estimated that it can have an impact on avoiding potential fines, saving operational costs due to can be done more quickly as well as the increased reputation of the contractor company which is an intangible benefit.

5. The proposal for determining the minimum threshold reference value of LSS-PI needs to be determined based on the company's ability and commitment which will be used as evaluation performance control, namely SR ”≥ 3.0; SPI ”≥1,10; CPI ”≥1,10; VI ”≥0.75; WI ”≤0.15. This can be used as a tool for measuring future project performance which is able to see from 5 aspects of performance, namely the quality of work, scheduling performance, cost performance, inventory performance and process effectiveness, so that it can be monitored early on the position of performance deviations and conducted immediately for improvement evaluation

5. REFERENCES

Al-Aomar, R. (2012). A lean construction framework with six sigma rating, *International Journal of Lean Six Sigma*, 3(4), pp. 299–314. doi: 10.1108/20401461211284761.

Antony, J. (2006). Six Sigma for Service Processes, *Business Process Management Journal*, 6(4), pp. 20–27.

Banawi, A. A. (2013). *Improving Construction Processes By Integrating Lean, Green, And Six- Sigma*, University of Pittsburgh.

Han, S. H. et al. (2008). Six Sigma-Based Approach to Improve Performance in Construction Operations, *ASCE*, 24(January), pp. 21–31. doi: 10.1061/(ASCE)0742-597X(2008)24.

Howell, G. and Koskela, L. (2000). Reforming project management: the role of lean construction, *Journal of Management*. Available at: http://usir.salford.ac.uk/9428/.

Iyer, K. C. and Kumar, R. (2016). Impact of Delay and Escalation on Cash Flow and Profitability in a Real Estate Project, *Procedia Engineering*. Elsevier B.V., 145, pp. 388–395. doi: 10.1016/j.proeng.2016.04.097.

Koskela, L. J. (2015). Lean production in construction Lean production in construction, *Elsevier Science Pub*, (March).

Messah, Y. A., Widodo, T. and Adoe, M. (2013). Kajian Penyebab Keterlambatan Pelaksanaan Proyek Konstuksi Gedung Di Kota Kupang, *Jurnal Teknik Sipil*, 2(2), pp. 157-168– 168.

Muliyanah, D. and Setiawan, H. (2013). *Analisa Pengendalian Ulang Penjadwalan Proyek Pembangunan Gudang X dan Y Menggunakan Siklus DMAIC*, 1(4), pp. 295–303.

Nyata, D. S. and Wiguna, I. P. A. (2018). Analisis Keterlambatan pada Proyek PT Jatim Taman Steel di Gresik dengan Menggunakan Lean Six Sigma Framework, *Jurnal Aplikasi Teknik Sipil*, 16(1), p. 15. doi: 10.12962/j2579-891x.v16i1.2866.

Pasqualini, F. and Zawislak, P. A. (2005). *Value Stream Mapping In Construction : A Case Study In A Brazilian Construction Company*, IGLC, 13, pp. 117–125.

Pinto, L., Guardia, E. C. and Carvalho, D. B. (2020). Economic impact of anticipations or delays in the completion of power generation projects in the Brazilian energy market, *Renewable Energy International journal*, 147, pp. 1312–1320. doi: 10.1016/j.renene.2019.09.074.

Saini, U. and Sujata (2013). Lean Six Sigma – Process Improvement Techniques, *International Journal of Recent Research and Review*, VI(3), pp. 11–16.

Sambasivan, M. and Soon, Y. W. (2007). Causes and effects of delays in Malaysian construction industry, *Elsevier Ltd and IPMA*, 25, pp. 517–526. doi: 10.1016/j.ijproman.2006.11.007.

Thomas, H.R., Horman, M.J., de Souza, U.E.L. and Zavrski, I., (2002). Reducing variability to improve performance as a lean construction principle, *Journal of Construction Engineering & Management*, Vol. 128 No. 2, pp. 144-52.

Womack, J. P. and Jones, D. T. (2008). *Lean Thinking Banish Waste and Create Wealth in Your Corporation*, Free Press, Simon & Schuster, Inc, 2(April), pp. 1–8.

Zahara, F. (2016). Pengendalian Kualitas Part Trim Rear Quarter Right APV Arena dengan Menggunakan Metode Six Sigma di PT. Suzuki Indomobil Motor, *Jurnal Optimasi Sistem Industri*, 13(1), p. 486. doi: 10.25077/josi.v13.n1.p486-502.2014.

PATTERN MAPPING OF PROJECT MANAGEMENT MATURITY TO NUMBER OF PROJECTS UNDERTAKE BY CONTRACTOR

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ABSTRACT

Organizations strive to complete projects effectively and successfully due to the fact that project management has become the dominant way to carry out projects. But projects do not always progress as planned. Project problems that arise as a result of project management. Therefore it is important that organizations should continue to evaluate the results of their projects to find improvements in improving Project Management Maturity (PMM). The number of projects undertaken is often considered a measure of a company's experience. Many assume that the more these companies are working on projects, indicating that the company has a good project management maturity (PMM) level. For this reason, this study aims to analyze the pattern of values for the Project Management Maturity (PMM) phase of the number of projects the company undertakes. In this study, the PMM model used was adopted from Kerzner's PMM model, which measures the level of maturity through various stages of an organization's project management cycle. The method used in this research is a survey method with the tools used are questionnaires. In the questionnaire used, the respondents of this study are the owners of the contracting company or managers who can represent the company. The results of this study indicate that most construction companies that have Large (B1 and B2) and Medium 2 qualifications in Surabaya have reached level 5 (maturity). From the analysis, it can be seen that the number of projects and the PMM value form a pattern that tends to be positive or has a positive relationship (positive correlation), which means that the more projects the company undertakes, the higher the company's project management maturity level.

Keywords: Maturity, Project Management, Contractor

1. INTRODUCTION

Construction services business in line with its development is increasingly paying attention to other aspects in addition to the technical aspects that used to be the main key, aspects of project management is one aspect that today is increasingly understood the importance of construction service actors (Kaming, 2009).Grant and Pennypacker (2006) report that in the last 10 years more businesses have used project management as a way to develop a competitive advantage. Thus making project management in a construction company is a very basic activity because construction is a type of project-based company. In complex project work, efforts to achieve the goals and qualities expected to demand that the company must carefully account for and control the use of all resources.

There have been many previous studies that make assessment models for project management maturity. According to Mateen (2015), models developed include Capability Maturity Model Integrated from Carnegie Mellon University's Software Engineering Institute, Organizational Project Management Maturity Model from Project Management Institute, Project Portfolio Management Maturity Model from PM solutions, Project Management Maturity Model from PM solutions, Project Management Maturity Model from KRL consulting, Kerzner Project Management Maturity Model from International Institute for Learning (IIL) H. Kerzner, Project, Program, Portfolio Management Maturity Model from Office of Government Commerce (OGC), Project & Program Management for Enterprise Innovation from Project Management Association of Japan (PMAJ), dan Maturity Increments IN Controlled Environments from MINCE2 Foundation. Behind the rapid development of research on pmm assessment model, not many have done research related to the relationship and influence of Project Management Maturnity value on the characteristics of construction projects. In addition, there are problems in construction companies in Surabaya that can not detect or see the maturity level is a problem that makes it difficult for the company to develop. The unknown about maturity condition results in very likely problems such as highly qualified companies but not mature in the management of project management. This makes the problem of project management maturity very important to know the condition of the company.

So from the background of the problem, this research will adopt one of the assessment models, namely kezner project management maturnity model that is considered suitable to be applied to identify the level of maturity of the project. Which is where the assessment results will be used to see how the level of maturity of the project to the number of projects obtained in one year .

2. K-PMMM PHASE STAGE

At this level there is already documentation as the basic process of project management but no consistency to understand, interact or adopt for the whole project. Key to this level is the absence of standards in the project and estimated schedules based solely on personnel knowledge. Nevertheless, there has been support and encouragement from management despite the focus largely on the project.

Measurement of maturity level at this level is done by filling out a questionnaire with middle/upper layer management respondents that produces the organization's position of existence (level of recognition) to the project management maturity cycle. Questionnaire consists of 20 questions with a scale fill (strongly agree - strongly disagree) At this level, there are five phases of the project management maturity cycle. Which organization is judged on its existence in such a cycle. The five project management cycles in question are:

• Embryonic Phase

In this first cycle, it is assessed the application and benefits of implementing project management by the management. In this phase only middle level management is considered to be able to see the benefits of implementing project management, while for senior management is still new to the concept of project management.

• Executive Management Acceptance Phase

In this next cycle the executive management level already recognizes the benefits of project management. As for some characteristics when the organization steps up this phase is:

- Executive management has understood project management.
- Management supports the implementation of project management.
- Support is provided one of them by sponsoring the project.
- After the support, there will be management's ability to improve and change the course of the business that is being operated.

• Line Management Acceptance Phase

In this cycle project management has reached up to line management. The characteristics when the organization reaches this phase are:

- Line management has committed to project management.
- Line management has supported project management.
- Line management has an understanding and education about project management.
- Functional employees have received project management training.

• Growth Phase

In the fourth cycle has begun to be seen that there is already a project management methodology in the organization. The following are some characteristics of this phase are as follows:

- The organization has developed a project management methodology.
- The scope of change can be minimized.
- Methodology is dictated with project management software.
- Management has a committee for effective planning.

• Maturity Phase

This is the last phase of project management maturity cycle. In this last cycle can be seen some characteristics, among others:

- Integration of schedule and cost.
- Control of cost and schedule is carried out development with the system.
- improving individual skills by developing an educational curriculum that is in harmony with the development of project management.

3. METHOD

Broadly speaking, this study aims to analyze the pattern of PMM value in contractor companies against the profile of the company. Whichever company profile is reviewed is, the age of the company, the company's profit, the organization of the company, and the experience of the project that has been worked on. Logical and systematic thought flow is expected to achieve the research objectives set. The use of methods in this research is by surveying using questionnaires. As well as for data processing used descriptive analysis of two variables to see the pattern between the value of the contractor's project management maturity and the company profile.

Selected using the Kezner Project Management Maturity model because it meets the needs in research. This model refers to the PMBOK standard, can consider the weaknesses and strengths of the organization, has a detailed scope of processes, is simple and easy to research but provides high results details, as well as lower costs than other models.

The population referred to in this study is a large and middle class private construction company (M2, B1, and B2) in Surabaya. Meanwhile, the sample is several middle and large class private construction companies that will be represented by one questionnaire conducted on one project reviewed at each sample company. In this study, samples were taken by 19 companies.

Several data collection methods have been considered, including conducting interviews in person, telephone interviews, sending questionnaires by mail, facsimile, and electronically (email).In general, each of these methods has its advantages and disadvantages. Combining the various available methods is expected to increase the rate of return of the questionnaires shared. In particular, the determination of the method needs to be adjusted to the situation and conditions including Indonesian culture so that researchers can optimize the data that can be collected.

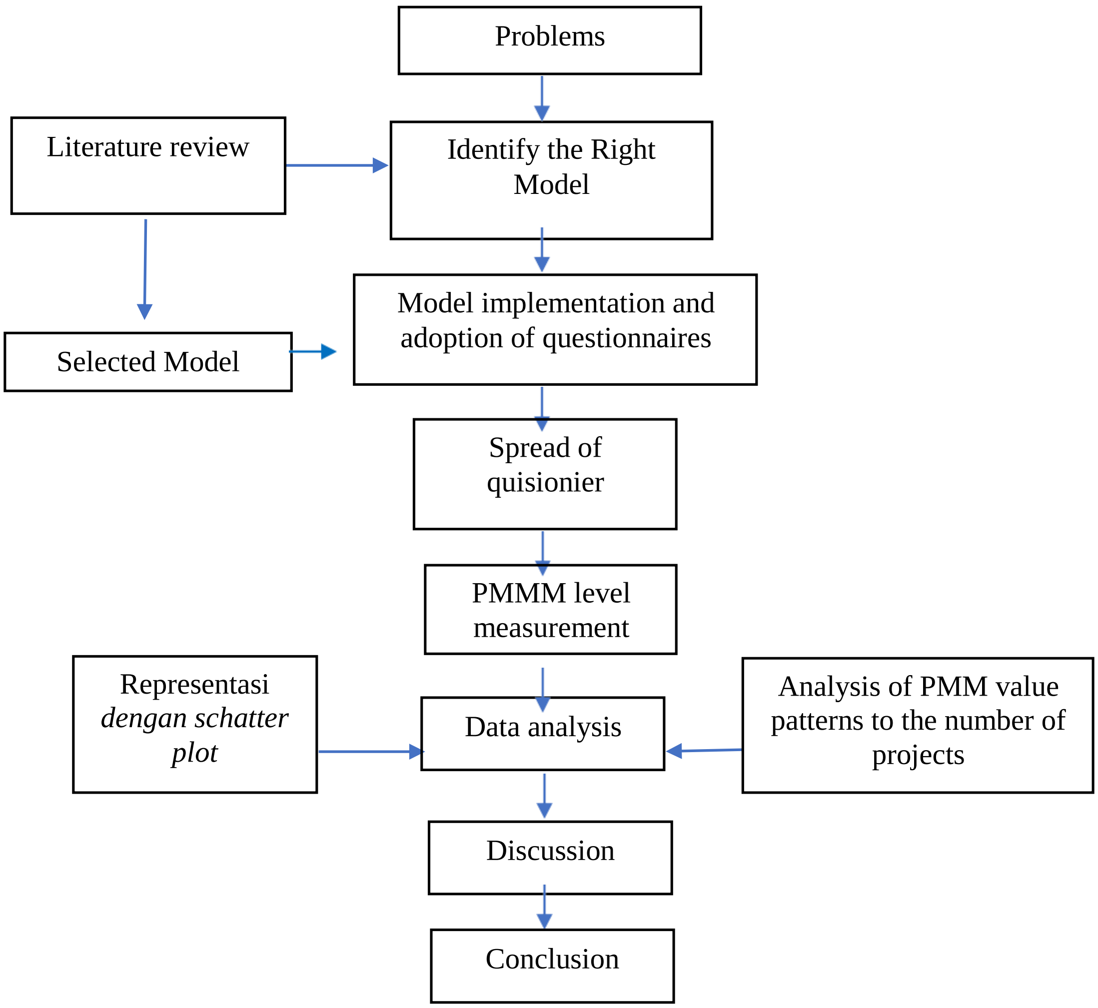

Figure 1. Research flow diagram

4. RESULT AND DISCUSSION

Of the 34 questionnaires that have been distributed to 34 respondent companies, 19 returned questionnaires. The rest of the questionnaires are 2 companies that are not willing, 1 company that is in trouble (Problem corporate), 2 companies that are not active and 10 companies that do not respond. The contractor companies that are respondents amount to 19 consisting of large (B1 and B2) and intermediate qualifications (M2), with the distribution as in Figure 2 of the Contractor Company's Qualification. The number of projects obtained in one year is characteristic of the company that can show the experience of the project done. More and more project experience is considered the company has a lot of experience carrying out construction projects.

This is seen from the number of projects undertaken in one year. In characteristic, the number of projects obtained in one year is divided into 5 groups, namely companies that get less than 5 projects, 5-9 projects, 10-14 projects, 15-20 projects, and more than 20 projects. As many as 7 companies on average per year get 10-14 projects, while 6 companies get 5-9 projects, 4 companies get 15-20 projects. In the group of less than 5 projects and more than 20 projects there is one company each. All data about the respondent's company can be seen in the attachment.

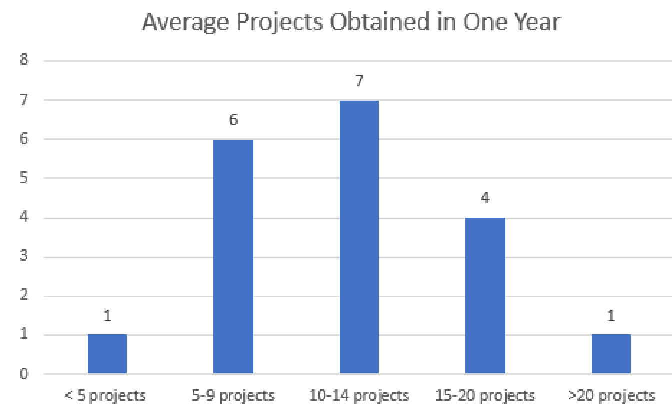

Figure 2. Average Projects Obtained in One Year
Source : Author (2021)

4.1 PMM Assessment with Kezner-PMM Method

Twenty questions are contained in this section which is divided into five categories, namely embryo stage (question number 1, 3, 14, and 17), executive management acceptance stages (questions number 5, 10, 13, and 20), middle and lower management support stages (questions number 7, 9, 12, and 19), development stages (questions number 4, 6, 8, and 11) and maturity stages (questions number 2, 15, 16, and 18).Measurements based on seven Likert scales that range from strongly disagreeing (-3) to strongly agreeing (3).

Table 1. Respondents' Answer Grouping Table

Question Number	Level				
	Embryonic	**Executive**	**Line managmnt**	**Growth**	**Maturnity**
1	-2				
3	3				
14	3				
17	2				
5		2			
10		3			
13		3			
20		3			
7			3		
9			3		
12			-2		
19			0		
4				2	
6				3	

8				3	
11				-3	
2					-2
15					-2
16					-3
18					3
total	6	11	4	5	-4

Source : Author (2021)

Table 1 shows the grouping of respondents' answers, that in question no. 5 is a question about the real support of the organization's executive management for example, through presentations, correspondence or sometimes attending field project team meetings.On that question respondents gave an assessment of 2 which means agree with the statement. The assessment given by the respondent is the respondent's response from the state of the organization of the company. The next step after all the columns are filled with assessments from respondents is sums to find out the total value in each phase. Summing is done based on the four scores of each question representing the phases of the PMM level After summing each column of the category the next step is to change the order of the total score in table 2 below by placing a color mark on the block in the appropriate area.

Table 2. Score Recapitulation in Each Company's PMM Phase Category

Points													
Life Cycle Phase	**-12**	**-10**	**-8**	**-6**	**-4**	**-2**	**0**	**2**	**4**	**6**	**8**	**10**	**12**
Maturity													
Growth													
Line Management													
Excutive													
Embryonic													

Source : Author (2021)

Seen in the table above is the result of PMM assessment from company respondents II. Kerzner explained that when an organization has earned a score of 6 or more it means that the organization is already at that level. The data above shows that in the embryonic phase the company II gets a value of 6 which according to K-PMMM when an organization gets a value of 6 or more, it indicates that the organization has passed or at least is in that phase. In the PMM performance of the company II can be seen the results that in the first phase and both companies get a value of 6 and more than 6 which indicates that the company has passed that phase or is in that phase. From table 2 regarding the recapitulation of respondents' assessment score II, it can be seen that the organization has been in phase 2, namely executive phase and still has not passed the line management, growth, and maturity phase. Being in the executive phase means that the company has recognized that project management has the benefits and recognition of the benefits of such project management has reached the level of executive management.

4.2 Mapping PMM to the Number of Projects Undertaken

In characteristic the number of projects undertaken is considered to be able to see the company's experience in working on how many projects. The more projects done, the more experience the company has. Mapping the PMM Value to the average number of projects undertaken can be seen in Figure 3

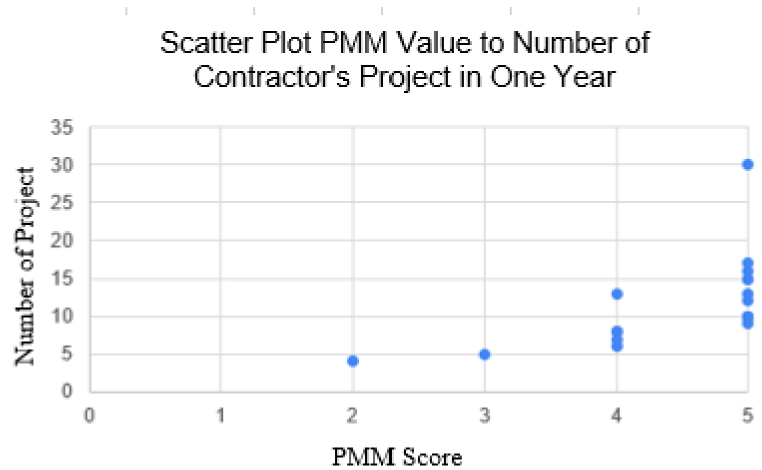

Figure 3. Scatter Plot PMM Score to Number of Contracto's Project
Source : Author (2021)

From the scatterplot image above, it can be seen that the number of projects and pmm values form a pattern that tends to have a positive relationship (positive correlation) which means that the more projects carried out by the company, the higher the project management maturity level of the company. Seen at level 5 (maturity) the company at maturity level has at least more than 8 projects carried out for one year, while for companies working on the same large projects such as 13 projects occupy a lower PMM level or occupy level 4. This allows for extreme data outliners or data that are likely to result from abnormal situations.

The relationship between the maturity of project management and work experience cannot be seen significantly, it can be explained that the more work that has been handled does not guarantee the level of maturity of the company's project management the better (Kaming et al ,2009). But in the research conducted by Tomaluweng et al (2017) stated that the influence of the company's experience on mp maturity level on medium qualified contractors in Ambon City (CV) has no significant effect and on large companies (PT) have a significant effect.

4. CONCLUCION

The results of this study showed that most construction companies that have a large qualification of B1, B2 and M2 in Surabaya have reached level 5 (maturity). From the analysis can be seen that the number of projects and the value of PMM form a pattern that tends to be positive or have a Positive relationship (Positive correlation) which means that the more projects carried out by the company, the higher the company's project management maturity level.

5. REFERENCES

Grant,K.P. dan Pennypacker,J.S. (2006), "Project Management Maturity : An Assessment of Project Management Capabilities Among and Between Selected Industries", IEEE Transactions on Engineering Management, Vol.53 No.1, page 59–68.

Hillson, D. (2003), "Assessing Organizational Project Management Capability", Journal of Facilities Management, Vol.2 No.3, p. 298–311.

Husein, Umar. (2000), Marketing Research and Consumer Assessment, PT Gramedia Pustaka, Jakarta.

Ibbs, C.W. and Kwak, Y.H. (2000), "Assessing Project Management Maturity", Project Management Journal, Vol. 31 No.1, p. 32.

Ivancevich, J.M (2007), Organizational Behavior and Management, Erlangga, Jakarta.

Jamaluddin, Chin, C.M.M., And Lee, C.W. (2010), "Understanding the Requirements for Project Management Maturity Models: Awareness of The ICT Industry in Malaysia", IEEE International Conference on Industrial Engineering and Engineering Management.

Kaming,P.F., Eko,S., dan Hugeng,S.N. (2009), "Study on Project Management Maturity in Contractors", Proceedings of the National Conference on Civil Engineering 3, UPH dan UAJY, page M123-M131.

Kerzner, H. (2001), Strategic Planning for Project Management Using Project Management Maturity Models, John Wiley & Sons, Canada.

Kerzner,H. (2009), Project Management : A Systems Approach to Planning, Scheduling, and Controlling, New Jersey: John Wiley & Sons, page 1094.

Mateen,M (2015), Measuring Project Management Maturity - a framework for better and efficient Projects delivery, Master of Science Thesis in the Master's Programme International Project Management, Chalmers University of Technology, Göteborg – Sweden.

PMI : Project Management Institute (2003), Organizational Project Management Maturity Model : OPM3 Knowledge Foundation, Project Management Institute (PMI), Inc, Newtown Square, Pennsylvania.

PMI : Project Management Institute (2013a), A Guide to the Project Management Body of Knowledge (PMBOK), Edition 5, Project Management Institute (PMI),Inc, Newtown Square, Pennsylvania.

PMI : Project Management Institute (2013b), Organizational Project Management Maturity Model : OPM3 Knowledge Foundation, Edition 3, Project Management Institute (PMI), Inc, Newtown Square, Pennsylvania.

Tomaluweng, D.E., Zaika, Yulvi., dan Wijatmiko, Indradi.(2017) Project Management Maturity Level Study at Contractor Company in Maluku Province, Jurnal Spectra.

COMPARISON OF ULTRASONIC LEVEL TRANSMITTER AND 3D SOLID SCANNER IN SILO LEVEL MEASUREMENT FROM THE PERSPECTIVE OF CONTRACTOR

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ABSTRACT

Cement silos are storage containers that store and distribute various types of cement manufacturing materials, such as limestone, clay, iron sand, and raw materials from cement. Cement silos are a vital part of the cement manufacturing process because they are the key to the distribution terminal. The entire silo requires a level measurement to monitor the production process so that the level measurement accuracy is needed. However, the process material in the silo is bulk solid. The bulk material level measurement requires multiple point measurement caused by the material's surface, which tends to be uneven. Therefore, the current level measurement system uses four single-point measurements, but only relying on four points results in low accuracy because it cannot represent the bulk surface shape. One alternative replacement is by using a 3D solid scanner. Analysis of using a 3D solid scanner was carried out by comparing it with an ultrasonic level transmitter with a 3D scanner and analyzing the cost, quality, and time of the two types of level transmitters. Based on the comparison of advantages and disadvantages, 3D scanner technology is better than ultrasonic technology because the 3D scanner has better accuracy in scanning the silo's bulk material's surface, 3.5 times faster installation time, and cheaper installation costs 18.72%.

Keywords: Silo, Level, Measurement, 3D Scanner, Ultrasonic, Accuracy.

1. INTRODUCTION

PT X intends to build and operate a cement production facility in Indonesia. Cement production facilities must have quality cement products and have reliable storage processes to continue production activities. They will build one clinker silo unit, two cement silo units, and four process bath units to complete the project work package.

The three silos and bins above must have high reliability so that the production process runs smoothly, thus requiring instruments to monitor them. The instrument used is the transmitter level for monitoring the material's height and the pressure transmitter for monitoring the pressure. Appenzeller (2011). Capacitance, ultrasonic, and radar level transmitter has a weakness, namely the measurement is only based on one point on the surface of the material. Liptak (2003). while the cement silo and bins facilities above accommodate solid bulk material, this type of material is different from the water. The surface is always flat, and solid bulk material has surface characteristics that tend to be uneven, so that level measurement is not as easy as measuring water. Besides, solid bulk material can generate dust, which can interfere with Instrument reading.

One alternative to the level transmitter for measuring the bulk solid's height in a silo is a 3D solid scanner. It has the advantage of displaying the entire surface of the material in the silo and bins along with the average height and volume of the actual material, with this facility making it easier for operators to monitor the material. This tool uses low-frequency acoustic waves, which can eliminate the interference reading from dust, and the tool does not touch the material. Legg (2014), Brooks (2006) will make it easier to install and repair.

2. PROJECT OVERVIEW

2.1 General Project Information

The cement production facility at PT X consists of one clinker silo unit with 35,000 tons, 33 m high, and 30 m in diameter. This clinker silo functions to accommodate clinker material. They will build two cement silos with a capacity of 15,000 tons, 57 m high and 20 m in diameter, which functions to store cement production. And four units of bins with a capacity of 6000 tons, 7 m high and 5 m in diameter, which serve as temporary storage for clinker, gypsum, and limestone materials for the cement manufacturing process.

2.2 3D Solid Scanner

The 3D solid scanner is an instrument that accurately measures the height and volume of bulk solids and powder materials in storage devices such as silos, bins, etc. This tool uses point measurement technology with low-frequency acoustic wave sensors. This tool can use for vast diameter silos by integrating several 3D solid scanners in one silo. Emerson (2015).

The working principle of a 3D level scanner is to use acoustic waves. This tool works by capturing acoustic waves that are reflected from the material being measured. When the sound source is emitted, the sound will bounce off the surface of the material. The sensor will receive the reflected sound, and the sensor will read the height by measuring the time the sound has run. The 3D level scanner uses three antennas to transmit and receive three different frequencies. This tool has the advantage of measuring time/distance and measuring the direction of the sound received to measure the XYZ coordinates of each material surface point being measured. The many points measurement results will be processed in the microprocessor to obtain the material's height and volume. In processing the data, dimensional data from the silo is needed.

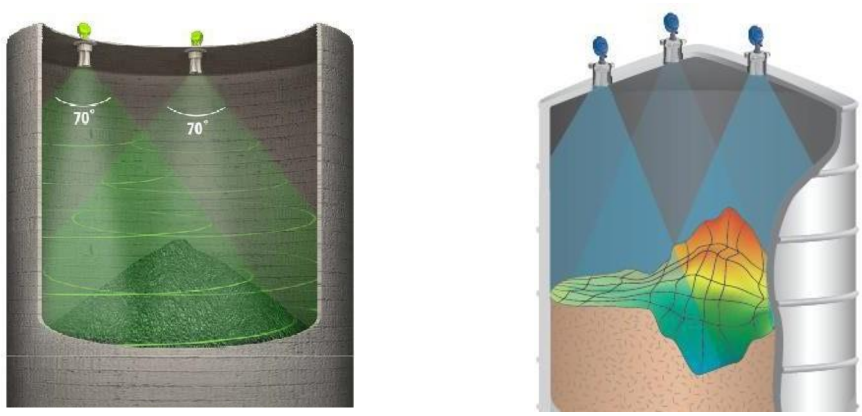

Figure 1. Working Principle of a 3D Solid Scanner

The 3D solid scanner uses a beam angle of 700 to emit the source of its acoustic waves, so the more comprehensive the silo, the greater the number of tools installed. 3D scanner vendors use a particular application by providing silo dimension data to obtain the number of 3D solid scanners installed in the silo, the position of 3D level scanner placement, and the accuracy obtained. This tool has a unique built-in logic that functions to interpolate unscanned surfaces due to the small beam angle. This tool is also equipped with directional false echo filtering, which functions to filter incoming acoustic waves so that noise waves cannot interfere with the reading.

3. RESULTS AND DISCUSSION

3.1 Level Sensor Type Selection

Cement silo is an essential part of the cement manufacturing process because it is the key to the distribution terminal. This cement silo allows cement production to continue even though the shipping section stops operating. Appenzeller (2011). cement silos require high efficiency in filling and emptying. In the PT X cement production facility project, the number of silos to be installed is seven units. The following is the silo number and its description.

Table 1. Silo List

No	Silo No	Material	Diameter	Capacity (ton)	Distance to Control Room	Silo Filling Speed
1.	Clinker Silo	Clinker	30 m	35000	97 m	0.16 mm/s
2.	Cement Silo-01	Cement	20 m	15000	107 m	0.21 mm/s
3.	Cement Silo-02	Cement	20 m	15000	117 m	0.21 mm/s
4.	Bin Clinker-01	Clinker	5 m	6000	214 m	0.14 mm/s
5.	Bin Clinker-02	Clinker	5 m	6000	214 m	0.14 mm/s
6.	Bin Gypsum-01	Gypsum	5 m	6000	214 m	0.14 mm/s
7.	Bin Limestone-01	Limestone	5 m	10000	214 m	0.23 mm/s

Then from the characteristics of the material in each silo after further analysis based on considerations in selecting the type of sensor level:

1. General Requirements:
   a) Ability to measure height and volume
   b) Consistent material output feed rate capability
   c) Reliable system
   d) Compatible with other systems
   e) Easy to operate
   f) Free maintenance / low price maintenance
   g) Easily developed with other systems
   h) Compatible with International Standard (API, ASTM, ISO)
   i) Software support
   j) Service & spare part support
   k) Vendor quality assurance procedures (ISO 9001)

2. Types of Level Sensor
   Selection of the sensor level according to the condition/type of material and the process requirements of the silo. In order to meet the process requirements and cover some of the flaws in the silo, a 3D solid scanner can be used as an alternative as a level sensor.

Table 2. Feature of the Level Sensor

Feature	Level Switch	Ultrasonic Level Transmitter	Radar Level Transmitter	3D Solid Scanner
Maximum temperature(C)	275	1100	260	185
Inaccuracy - % of Span	0.25-3	0.5-3	0.1-1	0.5-3

Non-Contact Measurement	-	√	√	√
Unaffected by Dust Generation	-	-	-	√
Solid Measurement	√	√	√	√
Volume Measurement	-	-	-	√
Reliable and Accurate in Wide Silo	-	-	-	√
3D visualization	-	-	-	√

3.2 Quality Comparison

Quality comparison considers the advantages and disadvantages of using ultrasonic level transmitter technology with the 3D solid scanner in certain functions.

Table 3. Level Sensor Feature Comparison

No	Function	Ultrasonic	3D Solid Scanner
1	Ability as a monitoring system	It can be used as a monitoring system without any time limit as long as power continues to flow	It can be used as a monitoring system without any time limit as long as power continues to flow
2	Ability to measure bulk solid material level	It can be used as a level measuring tool with the ability to measure one point on the surface of the material	It can be used as a level measuring tool with the ability to measure multiple points on the surface of the material
3	Ability to measure live volume	It can be used in volume measurement but requires many tools installed with estimated volume values	It can be used in measuring volume accurately and real time live measurement
4	Ability to display 3D contours of material surfaces	It cannot be used to display 3D contours of material surfaces	It can be used to display a 3D contour of a material surface
5	Ease of maintenance	Plug and play device replacement which makes maintenance easier	Plug and play device replacement to make maintenance easier. Besides that, there are additional self-cleaning features to extend maintenance time

3.3 Construction Time Comparison

Construction time comparison is needed to determine the processing time between ultrasonic level transmitter technology and 3D solid scanner. The basis for calculating the construction time is obtained from best practices carried out in similar projects. The comparisons were made using the number of silos (Table 1) which will install with the ultrasonic level transmitter and the 3D scanner.

Table 4. Comparison of Construction Time

No	Item	Time (hour)	
		Ultrasonic	3D Scanner
1.	**Clinker Silo (1 Ea)**		
	Installation (Labour Only)		
	Field Instrument	37.6	18.8
	Instrument Accessories	4.3	2.1
	Total	**41.9**	**20.9**
2.	**Cement Silo (2 Ea)**		
	Installation (Labour Only)		
	Field Instrument	75.2	18.8
	Instrument Accessories	9.9	2.5
	Total	**85.1**	**21.3**
3.	**Bins Process (4 Ea)**		
	Installation (Labour Only)		
	Field Instrument	150.4	37.6
	Instrument Accessories	37.7	9.4
	Total	188.1	47.0
4.	**Grand Total**		
	Clinker Silo	41.9	20.9
	Cement Silo (2 Ea)	85.1	21.3
	Bins Process (4 Ea)	188.1	47.0
	Total	**315.1**	**89.2**
	Deviation	**225.9**	

Refer to the above comparison, and it is found that using 3D scanner technology is obtained from a time of 225.9 hours or about 3.5 times faster. The construction time of the 3d scanner is faster because the number of equipment required for each silo is less than the ultrasonic level transmitter. If the ultrasonic level transmitter requires four pieces to be able to detect the height of the silo level more accurately, then one or two is sufficient when using a 3D scanner.

3.4 Construction Cost Comparison

Comparison of construction costs is used to compare the costs required when using ultrasonic level transmitter technology and 3D solid scanner. The equipment price assumption presented is obtained from vendors' offers and best practices from similar projects that contractors have undertaken.

Table 5. Comparison of Construction Cost

No	Item	Price	
		Ultrasonic	3D Scanner
1.	**Clinker Silo**		
	Instrument		
	Price per Instrument	$2,500	$7,822
	Number of Instrument	4	2
	Total	**$10,000**	**$15,644**

	Installation Material		
	Instrument Cable and Accessories	$98.94	$98.94
	Number of Instrument	4	2
	Total	**$395.76**	**$197.88**
	Installation Cost (Labour Only)		
	Field Instrument	$230.88	$115.44
	Instrument Cable and Accessories	$337.56	$168.78
	Total	**$568.44**	**$284.22**
	Total	**$10,964.2**	**$16,126.1**
2.	**Cement Silo (2 Ea)**		
	Instrument		
	Price per Instrument	$2,500	$7,822
	Number of Instrument	8	2
	Total	**$20,000**	**$15,644**
	Installation Material		
	Instrument Cable and Accessories	$114.24	$114.24
	Number of Instrument	8	2
	Total	**$913.92**	**$228.48**
	Installation Cost (Labour Only)		
	Field Instrument	$461.76	$115.44
	Instrument Cable and Accessories	$779.52	$194.88
	Total	**$1,241.28**	**$310.32**
	Total	**$22,155.2**	**$16,182.8**
3.	**Bins Process (4 Ea)**		
	Instrument		
	Price per Instrument	$2,500	$7,822
	Number of Instrument	16	4
	Total	**$40,000**	**$31,288**
	Installation Material		
	Instrument Cable and Accessories	$218.28	$218.28
	Number of Instrument	16	4
	Total	**$3,492.28**	**$873.12**

	Installation Cost (Labour Only)		
	Field Instrument	$923.52	$230.88
	Instrument Cable and Accessories	$2,978.88	$744.72
	Total	**$3,902.4**	**$975.6**
	Total	**$47,394.88**	**$33,136.72**
4.	**Grand Total**		
	Clinker Silo	$10,964.2	$16,126.1
	Cement Silo (2 Ea)	$22,155.2	$16,182.8
	Bins Process (4 Ea)	$47,394.88	$33,136.72
	Total	**$80,514.28**	**$65,445.62**
	Deviation	**$15,068.66**	
	Percentage of Savings	**18.72%**	

Refer to the comparison above, it can be concluded that in terms of cost, the use of 3D solid scanner technology can save $ 15,068.66 or about 18.72%.

4. CONCLUSION

Based on the comparison of the advantages and disadvantages of level measurement technology, the 3D solid scanner is better than the ultrasonic because the 3D solid scanner has a better level of accuracy in scanning the surface of the silo's bulk material. Based on the comparison of construction costs, using a 3D level scanner is $ 15,068.66 or 18.72% cheaper than the ultrasonic level transmitter. The 3D level scanner can save a construction time of 225.9 hours or 3.5 times faster than the ultrasonic level transmitter.

ACKNOWLEDGEMENT

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6. REFERENCES

Appenzeller, R. (2011) Central cone silos for cement, *Proceedings of IEEE-IAS/PCA 53rd Cement Industry Technical Conference*, St. Louis, MO, USA, 1-8.

Brooks, T.F and Humphreys, W.M., (2006). A Deconvolution approach for the mapping of acoustic sources (DAMAS) determined from phased microphone array. *Science Direct.* Sound and Vibration 294, 856 – 879.

Emerson, (2015). *Level and Volume Measurement of Bulk Solid*, Emerson, USA.

Legg, M and Bradley, S., (2014). Automatic 3D scanning surface generation for microphone array acoustic imaging. *Science Direct.* Applied Acoustics 76, 230 – 237.

Liptak, B.G, (2003). *Process Measurement and Analysis*, 4th Edition, CRC Press, London. Schwedes, J and Schulze, D., (1990). Measurement of flow properties of bulk solids. *Science Direct.* Powder Technology 61 (1), 59 – 68

CONSTRUCTION RISK EVALUATION WITH FUZZY WEIGHTED ANALYSIS

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ABSTRACT

Risk evaluation is a process of comparing the level of risk found during the implementation process with the risk criteria previously established. Risk evaluation is important to do, but most projects never carry out a risk evaluation after completing project implementation. By knowing the risk level of a project, we also explain that the risk response and risk plans must be studied and controlled to divert or mitigate the impact of these factors in order to optimize the use of contingent costs provided for risk management. So it is important for the project to conduct a risk evaluation as information and reference that can be used in future. In this research, the risk is carried out based on the risk of the project construction implementation. The use of fuzzy logic with the weight risk analysis method is considered to be a very appropriate method considering the many advantages of fuzzy logic analysis. Fuzzy can help make risk evaluations of past projects more objective. The combination of weighted values will be carried out using pairwise comparison of all risk variables and sub- variables in order to obtain the weighted value of the risk importance. The results of this study indicate that the results of the risk evaluation on the six research object projects are grouped into Low risk projects. Project 1 has a value of $\mu VL = 0.0113$ with $\mu L = 0.983$, Project 2 has a value of $\mu L = 0.9764$ with $\mu M = 0.0238$, project 3 has a value of $\mu L = 0.993$ with $\mu M = 0.0708$, Project 4 has a value of $\mu L = 0.969$ with $\mu M = 0.0307$, Project 5 has a value of $\mu L = 0.9802$ with $\mu M = 0.02$, and Project 6 has a value of $\mu VL = 0.002$ with $\mu L = 0.997$.

Keywords: Risk, Fuzzy Logic, Weighted, Evaluation

1. INTRODUCTION

The success of a construction project is strongly influenced by the ability to control risks due to the uncertain conditions that occur during the project. For this reason, it is necessary to implement comprehensive risk management in activities that affect time performance, cost and project quality.

Risk management plans are playing an increasingly important role in the success of each project. An adequate risk management plan allows the project to face risks (threats / opportunities) and can create a precise and timely response that minimizes loss or increase the benefits associated with these risks. Therefore Risk management has become an area of interest for researchers, who are in focus on risk identification, evaluation, response, monitoring and control.

Risk evaluation is an important part of the risk management stage. Risk evaluation is a process of comparing the level of risk found during the implementation process with the risk criteria previously established. Risk evaluation is important to do, but most projects never carry out a risk evaluation after completing project implementation. By knowing the risk level of a project, we also explain that the risk response and risk plans must be studied and controlled to divert or mitigate the impact of these factors in order to optimize the use of contingent costs provided for risk management. So it is important for the project to conduct a risk evaluation as information and reference that can be used in subsequent work.

In this study, 6 research object projects were taken to be carried out by evaluating the risks that have occurred in the project. This is done with the initial step, namely making a weighting based on the level of importance of risk and sub risk that occurs at the project implementation stage. The weighting results can show which parts of the risk have a large weight that must be considered so that appropriate responses and decisions can be made to these risks.

2. RISK MANAGEMENT

There is some definition of risk management including that project risk management is the process of evaluating identified risks or opportunities to discover the size of the risk, whether it is worth a response, and how that response should be a priority given the limited resources (Loosemore at al.2006). In addition, Al Bahar (1988) defines risk as a process that combines quantitative uncertainty, using probability theory, to evaluate potential risk impacts. A study conducted by Labombang (2011) stated that risk management is an approach that is done to risk with stages starting from understanding, identifying and evaluating the risks of a project. More specifically explained that project risk management includes the process of risk management planning, identification, analysis, response planning, and project monitoring and control. Risk management also aims to increase the likelihood and impact of positive events and reduce the probability and impact of negative events in the project.(PMI,2017)

2.1 Fuzzy Logic for Risk Assessment

When dealing with things that have uncertain or incorrect values, usually the assessment is done using linguistic values such as "high", "low", "good", "medium", etc., to describe it (Gupta and Nukala, 2005).Fuzzy logic is a logic that has a fuzzyness between two values (Anshori, 2012).The first fuzzy theory was put forward by Lotfi A.Zadeh in 1965.A fuzzy number has a membership function that is devoluted by three real numbers expressed as (l,m,u) called Triangular Fuzzy Numbers (TFN). Figure 1 Displays the Triangular Fuzzy Number (TFN) structure.

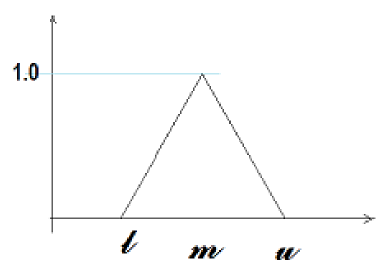

Figure 1. Triangle Membership Function
(Source : Chaterjee, et. Al, 2010)

Fuzzy Logic (Fuzzy Logic) or also known as Faint Logic is an appropriate way to map an input space into an output space based on the concept of fuzzy sets. In real conditions, some aspects of the real world are always or usually outside the mathematical model and are inexact. The concept of uncertainty is the basic concept for the emergence of fuzzy logic concepts. The starting point of the modern concept of uncertainty is a paper by Lofti A Zadeh (1965), in which Zadeh introduced a theory that has objects from fuzzy sets that have imprecise boundaries and membership in fuzzy sets, and are not in true logic form (true) or false (false), but expressed in degrees. As described in Figure 2 regarding the use of fuzzy logic in risk assessment.

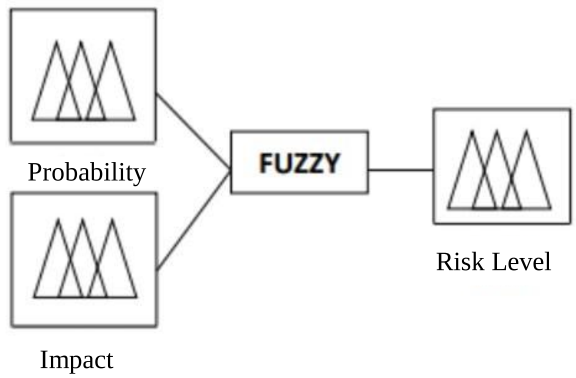

Figure 2. Fuzzy Method Scheme for Risk

(Source : Latief, et. Al, 2015)

3. METHOD

The weighting analysis of the risk variables for the implementation of high rise building construction uses the fuzzy-pairwise comparison method. Data analysis starts from compiling the pairwise comparison matrix according to the questionnaire content of the respondents to calculating the weight of each variable, consistency test and continued with fuzzy calculations.

The risk variable as an attribute in weighting using the Fuzzy - Pairwise method is taken based on the results of the literature study conducted by the author. So that the criteria used are in accordance with the conditions of the project being the object of research, it is necessary to screen the results of literature studies. The preliminary survey was conducted on three people who are practitioners in the construction sector, namely technical directors, operational directors, and Project Managers who have worked for more than 25 years from a contracting company. This survey was conducted by conducting interviews with experts to screen the risk variables obtained from the literature.

Furthermore, researchers used sampling techniques with Quota Sampling method. This sampling technique takes the number of samples as much as the number that has been determined by the researcher. In this study, the research population is a project in 2014-2020 totaling 55 projects, which are 36 tiered buildings. The rest are warehouses, factories, bridges and buildings other than highrise buildings. So that for the sample taken 6 sample projects.

The respondents of this research are all project managers and site managers who work at a contracting company, who are involved in highrise building construction projects. The characteristics of the respondents in this study were their level of education and experience working in the construction sector. Weighting questionnaires and risk assessments were distributed to 9 respondents represented by 1 respondent for each research object project. Respondents are expected to be able to weight the risks that have occurred in the research object project and provide an assessment of the risk variables and sub-variables.

Analysis is the research steps used to solve research problems and achieve research objectives. In answering the research objectives, a research stage was formed as depicted in Figure 3. Each step consists of input, the process and method carried out, and the output.

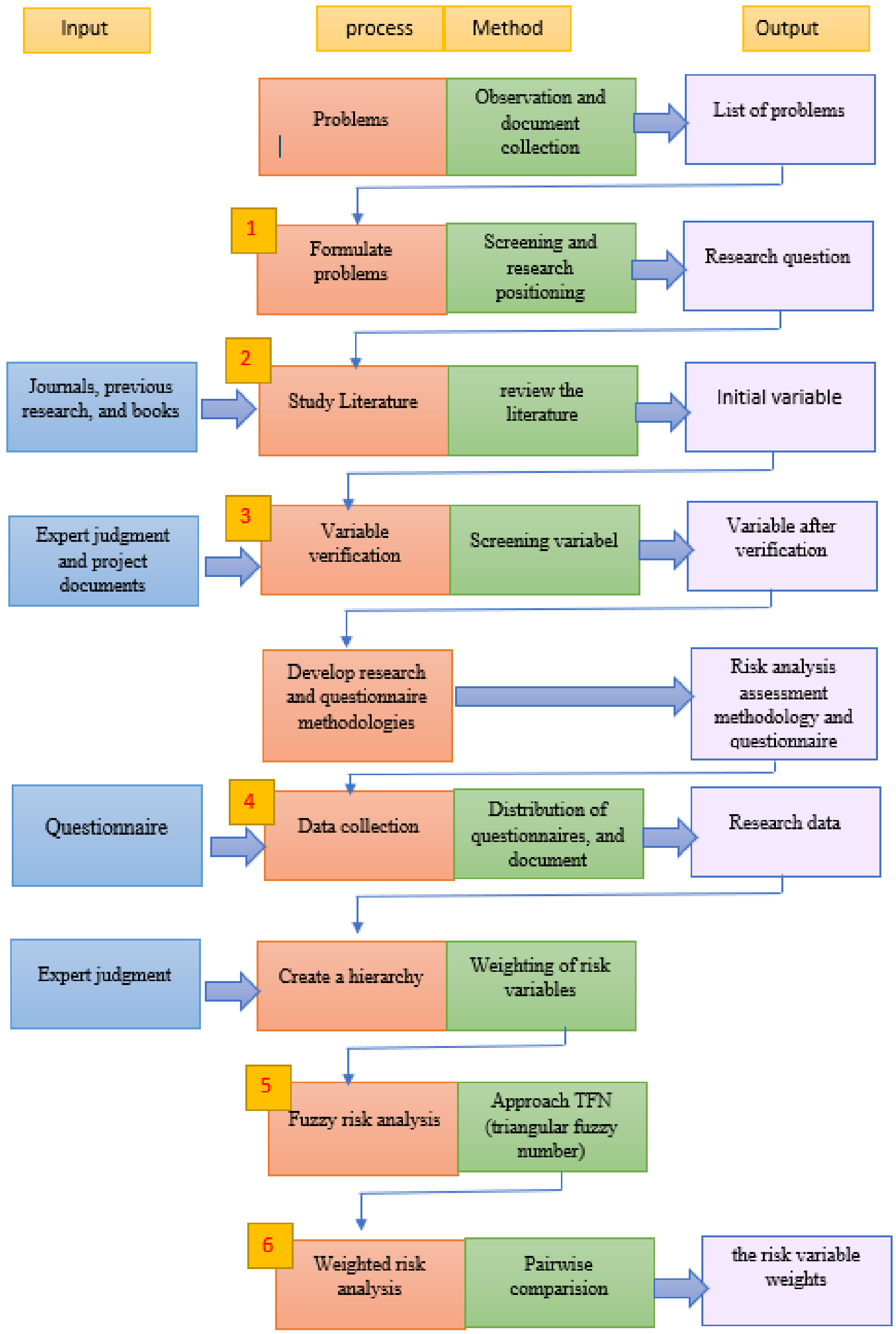

Figure 3. Research flow diagram

4. RESULT AND DISCUSSION

To find out whether a questionnaire can be used as a consideration, it is necessary to check whether the results of the answers are consistent or not. According to Saaty (1994), if CR ≤ 10%, the pairwise comparison matrix is consistent. Consistent means that all elements have been grouped homogeneously and the relationships between the criteria are logically justifying each other. After the matrix is declared consistent, the next step is to change the comparison matrix into fuzzy numbers.

So that from the results of the questionnaire comparisons are compiled and from the pairwise comparison matrix we convert it to a fuzzy comparison matrix by converting the scale to a TFN (triangular fuzzy number). From the pairwise comparison matrix, the fuzzy synthetic extent for each main criterion is calculated. Comparison of the likelihood level between the fuzzy synthetic extents and the minimum value. Calculating the value of the Fuzzy vector (V) If the value of Si has been obtained, it can be defined as the value of the vector (V). After determining the vector value and comparing the possible level between the fuzzy synthetic extent and its minimum value (ordinate value). Furthermore, from each vector, the minimum value for each criterion is found. Then do the weight calculation and normalization of the weight vector so that we know the weight value of the main variable. The calculation of each ordinate value of each risk criterion is added up. Normalization of the vector weight value is done by dividing each criterion ordinate by the total criteria ordinate. Weight ranking of the personnel risk sub-variables of the respondents. Ranking or sorting is done by sorting the weight of the risk sub-variable according to the amount of weight from the largest to the smallest. This is done for all respondents who give weighted risks to the research object project.

4.1 Analysis of the Fuzzy Pairwise

To find one final result from the assessment of the nine respondents, it is necessary to find the geometric mean of the assessment of the respondents using the following methods:

$$a_w = \sqrt[n]{a1.a2.\dots an}$$

Where :

aw = Combined assessment (end)

ai = Respondent's assessment i

n = Many respondents

After aw is obtained for each cell, a comparison matrix is formed and then the priority weight is searched.

The following is an example of the process and the results of the pairwise comparison average matrix between the risk variables, for the process and the geometric mean matrix result of pairwise comparison can be seen in the attachment. The average pairwise comparison matrix assessment between risk variables is obtained from calculating the average pairwise comparison assessment results between these variables. The following is the fuzzy pairwise comparison matrix of each respondent (in the attachment)

The Fuzzy pairwise comparison assessment matrix between the variables of the assessment results on the questionnaire according to weighting respondents I-IX can be seen in the attachment. From the nine comparison matrices, the average assessment of risk variables can be obtained, an example of calculating the average pairwise comparison between the criteria of all respondents

In the personnel column design technology line l:

Respondent 1 gave rating: 0.14

Respondent 2 gave rating: 0.11

Respondent 3 gave rating: 0.11

Respondent 4 gave rating: 4.00

Respondent 5 gave rating: 1.00

Respondent 6 gave rating: 3.00

Respondent 7 gave rating: 0.13

Respondent 8 gave rating: 0.25

Respondent 9 gave rating: 0.20

$a_w = \sqrt[n]{a1.a2.\dots an}$

$$a_{21} = \sqrt[69]{0.14\ x\ 0.11x0.11x4x1x3x0.13x0.25x0.20}$$
$$a_{21} = 0.371$$

So that from the above calculations, the pairwise comparison matrix between the overall risk variables is obtained as follows:

	Personnel			design tech			quipment n material			safety			const. Technology			naturally			social		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
Personnel	1.00	1.00	1.00	1.01	1.66	2.70	0.61	1.22	2.37	0.50	0.83	1.47	0.92	1.91	3.32	1.22	2.62	4.39	1.95	3.95	6.05
design tech	0.37	0.60	0.99	1.00	1.00	1.00	0.27	0.43	0.81	0.33	0.67	1.20	0.70	1.33	2.66	0.48	0.87	1.62	1.35	2.66	4.48
equipment n materials	0.42	0.82	1.65	1.24	2.31	3.74	1.00	1.00	1.00	0.14	0.20	0.33	1.00	2.62	4.64	1.88	4.02	6.01	1.19	2.09	3.63
safety	0.68	1.20	2.01	0.83	1.50	3.02	3.00	5.00	7.00	1.00	1.00	1.00	0.76	1.44	2.62	0.94	1.88	3.20	1.02	2.08	3.71
const. Technology	0.30	0.52	1.09	0.38	0.75	1.43	0.22	0.38	1.00	0.38	0.69	1.31	1.00	1.00	1.00	0.52	0.98	1.85	0.49	1.00	2.10
naturally	0.23	0.38	0.82	0.62	1.15	2.09	0.17	0.25	0.53	0.31	0.53	1.07	0.54	1.03	1.91	1.00	1.00	1.00	0.97	1.99	3.44
social	0.17	0.25	0.51	0.22	0.38	0.74	0.28	0.48	0.84	0.27	0.48	0.98	0.48	1.00	2.04	0.29	0.50	1.03	1.00	1.00	1.00

Figure 4. Pairwise Comparison Matrix

Source : Author (2021)

From the matrix above, the average geometric value of the pairwise comparison assessment criteria can be made. This is done with equations :

$$\tilde{r}_i = \left(\prod_{j=1}^{n} d_{ij} \right)^{1/n} \quad , \quad i = 1, 2, \dots \dots, n$$

Table 1. Geometric Average of Respondents' Combined Variables

	geometric average		
	ṛ		
Personnel	0.94	1.65	2.61
design tech	0.55	0.91	1.52
equipment n materials	0.77	1.35	2.14
safety	1.03	1.75	2.79
const. Technology	0.42	0.72	1.35
naturally	0.45	0.74	1.30
social	0.32	0.53	0.94
total	4.49	7.66	12.66
reserve (pow of-1)	0.22	0.13	0.08
increasing order	0.08	0.13	0.22

Source : Author (2021)

The next step is to find the total value of each column with the fuzzy geometric mean by adding up all the vector values ṛ. The next step is to calculate the reserve (pow of-1) with the power of the vector addition and then convert it to a triangular number. After obtaining the reserve result (pow of-1), do the fuzzy weighting of the criteria i (multiply each sum ṛ by the inverse vector. So that the table below is obtained:

Table 2. The ranking of weights between the risk variables of the respondents combined

	fuzzy weighted			Mi	Ni	rank
	ẇ					
Personnel	0.07	0.216	0.5812	0.3	0.209	2
design tech	0.04	0.119	0.3381	0.2	0.120	4
equipment n materials	0.06	0.177	0.4771	0.2	0.171	3
safety	0.08	0.229	0.6213	0.3	0.223	1
const. Technology	0.03	0.094	0.2993	0.1	0.102	5
naturally	0.04	0.096	0.2901	0.1	0.101	6
social	0.03	0.069	0.2096	0.1	0.073	7

Source : Author (2021)

Mi is a non fuzzy number so normalization is needed (Ni) .This step is also carried out on the value of each alternative against each criterion from the group assessment of all respondents. So that after obtaining the weights for the criteria in groups using the fuzzy pairwise method, analysis of the risk sub-variable method based on group assessment should also be carried out.

4.2 Risk and Sub Risk Weight Recapitulation

To find out how much the weight of the sub-risk to the overall risk weight, a multiplication is carried out between each sub-variable weight for the risk variable. So that we get a risk weighting recapitulation and sub risk that will be used in the risk evaluation assessment with the weighted fuzzy analysis method, which is shown by the table regarding the recapitulation of risk weighting and sub risk.

Table 3. Risk Weighting and Sub Risk Recapitulation.

Code	Risk	Weight	Global weight
	Internal (Personnel Risk)	0.210	
s1	Quality of technical personnel (including psychological, moral integrity, operating techniques and efficiency).	0.290	0.061
s2	Quality of management personnel (including psychological diathesis, moral integrity and management level).	0.290	0.061
s3	Immature consideration of field conditions.	0.260	0.055
s4	Internal technology system failure	0.160	0.034
	Design Technology Risks	0.120	
s5	Design deviation from construction	0.430	0.052
s6	Lack of understanding of structural characteristics and design theory	0.570	0.068
	Equipment and Material Risks	0.171	
s7	Wrong type and quantity of raw materials, finished products, and semi-manufacturing.	0.120	0.021
s8	Local transportation restrictions	0.060	0.010
s9	Delays in supplying and loading construction equipment	0.220	0.038
s10	Insufficient production capacity of construction equipment	0.100	0.017
s11	Lack of accessories and fuel for construction equipment	0.110	0.019
s12	Construction machinery malfunction and electrical faults	0.030	0.005
s13	Disadvantages of equipment maintenance and overloading of construction equipment	0.040	0.007
s14	Equipment damage due to natural factors	0.050	0.009
s15	Equipment that has not been used for a long time	0.040	0.007
s16	Unavailability or shortage of materials	0.200	0.034
s17	Equipment and material theft on site	0.030	0.005
	Safety Risk	0.223	
s18	Accident on site	0.820	0.183

s19	Injury at site	0.180	0.040
	Construction technology risks	0.102	
s20	Death by accident	0.102	0.102
	External Risk (Natural Risk)	0.101	
s21	Poor weather and environmental conditions	0.280	0.028
s22	Unwanted field conditions (instability of water supply, electricity, etc.)	0.390	0.038
s23	Adverse geographic location	0.220	0.022
s24	Depletion of natural resources	0.120	0.012
	Social Risks	0.073	
s25	Problems created by society	0.073	0.073

Source : Author (2021)

4.3 Risk Evaluation Assessment

At this stage the authors use software tools to carry out risk analysis. The first step is to make a risk modeling by determining the inputs and outputs. In this study, the input variables are probability and Impact, while the output variable is the level of risk.

Fuzzy Membership Function is done by changing linguistic terms into fuzzy numbers. In a fuzzy set has set elements and membership levels. If in the concept of a crisp set which can only be expressed in numbers 0 or 1, the concept of fuzzy sets can allow an element to have a membership value between 0 to 1. This, if depicted in the form of a curve, can form overlapping or intersections between one member and another. So it is possible to get confused between one term and another. The Fuzzy Membership Function values used in this study are as shown by figure 5. The occurrence (Probability) when the respondent gives an assessment of 2 will be converted into a fuzzy membership number (0.5, 2, 2.5). Same as the impact when given a value of 3 it will be changed to (0.15, 3, 3.5).

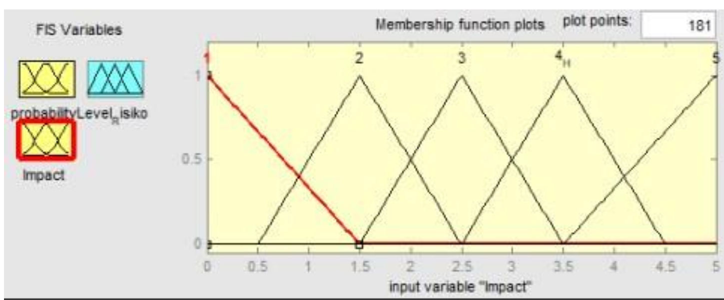

Figure 5. Imput Fuzzy Membership Function

Source : Author with software tools (2021)

After creating a Membership Function for fuzzy membership, the next step is to input if then rules which will become the basis for processing to produce the Output. Making if then rules in this risk calculation follows the following rules:

Table 4. Fuzzy Risk Rules

	Impact				
Probability	1	2	3	4	5
1	VL	VL	L	L	M
2	VL	L	L	M	M
3	L	L	M	M	H
4	L	M	M	H	VH
5	M	M	H	VH	VH

Source : Tah et al (2000)

Note :

VL = Very Low, L = Low, M = Medium, H = High ,VH = Very High.

The results of the assessment of the probability and impact from each project will be included in the previously made fuzzy modeling, for example in the risk sub-variable number 5. Regarding the design deviation from the construction, the respondent gives an assessment that the risk is 3 which means it is likely to occur (30-50%). This risk has an impact 3 which means that it disrupts the administration of the work program and has a significant financial loss impact. So that the input probability is inputted with a value of 3 and the input value is inputted with a value of 3. As in the picture below:

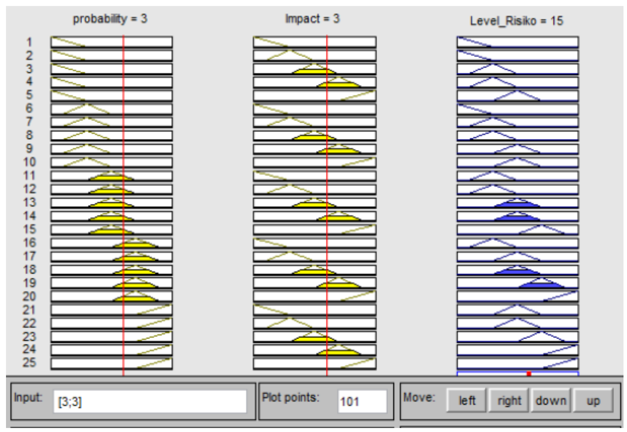

Figure 6. Imput Fuzzy Membership Function

Source : Author with software tools (2021)

The weighting results obtained in the previous stage will be multiplied by the processed results of the risk assessment of each respondent using fuzzy. After multiplying each sub-risk variable in each project, the total value is added. The total value can be seen in the table 5.

Table 5. Recapitulation of Risk Level Results

Proyek	1	Rank	2	Rank	3	Rank	4	Rank	5	Rank	6	Rank
s1	0.639	4	0.914	2	0.914	2	0.889	2	0.609	5	0.993	2
s2	0.373	7	0.373	9	0.373	8	0.373	9	0.373	7	0.373	9
s3	0.334	8	0.546	5	0.334	10	0.546	5	0.334	8	0.546	4
s4	0.206	15	0.206	13	0.206	14	0.206	14	0.206	15	0.206	14
s5	0.774	2	0.516	6	0.516	5	0.516	6	0.774	2	0.516	5
s6	0.684	3	0.419	8	0.684	3	0.684	3	0.419	6	0.419	7
s7	0.215	13	0.126	17	0.126	16	0.126	16	0.300	9	0.126	17
s8	0.063	23	0.063	21	0.063	20	0.063	20	0.103	19	0.063	21
s9	0.230	12	0.549	4	0.376	7	0.376	8	0.230	13	0.376	8
s10	0.105	18	0.171	15	0.105	18	0.105	18	0.105	18	0.257	10
s11	0.115	17	0.115	18	0.115	17	0.115	17	0.115	17	0.115	18
s12	0.077	20	0.031	24	0.051	22	0.051	22	0.077	21	0.031	25
s13	0.042	24	0.068	20	0.042	23	0.042	23	0.042	25	0.068	20
s14	0.086	19	0.052	22	0.052	21	0.052	21	0.086	20	0.052	22
s15	0.068	22	0.042	23	0.042	23	0.042	23	0.068	23	0.042	24
s16	0.209	14	0.342	10	0.342	9	0.342	10	0.209	14	0.209	13
s17	0.031	25	0.031	24	0.031	25	0.031	25	0.051	24	0.051	23
s18	1.119	1	1.119	1	1.119	1	1.119	1	1.119	1	1.119	1
s19	0.246	10	0.246	11	0.246	12	0.246	11	0.246	11	0.246	11
s20	0.624	5	0.624	3	0.624	4	0.624	4	0.624	4	0.624	3
s21	0.283	9	0.173	14	0.283	11	0.212	13	0.283	10	0.173	15
s22	0.235	11	0.235	12	0.235	13	0.235	12	0.235	12	0.235	12
s23	0.136	16	0.136	16	0.136	15	0.136	15	0.136	16	0.136	16
s24	0.074	21	0.074	19	0.074	19	0.074	19	0.074	22	0.074	19
s25	0.447	6	0.447	7	0.447	6	0.447	7	0.730	3	0.447	6
Total	7.415		7.618		7.535		7.652		7.599		7.496	

Source : Author (2021)

Project 1 is a hotel and apartment development project with 2 towers with a building height of 18 floors with 3 basements. In the risk analysis carried out on this project, it is clear that the implementation risk that occurs in the hotel and apartment development project occupies the lowest risk level among the other 6 projects. This project has a risk level after a risk analysis evaluation of the project is 7,415. The risk that has the greatest weight is the risk of safety, namely the risk of accidents on the site. This risk has the greatest weight among other risks even though the probability and impact from the results of the risk evaluation of the six projects has a low level, namely with a probability of below 10% and the impact that can still be handled at the stage of routine activities such as less material losses and does not affect stakeholders.

In the second project, the construction of an apartment with 2 towers, each tower has a floor height of 15 floors with 2 basements. The construction work was carried out for two years, from 2014 - 2015. In the implementation stage, it was seen from the results of the evaluation of risks other than safety which did have a large weight from the weighting results in the following sequence, namely the risk of quality of technical personnel, the risk of delays in supplying and entering construction equipment, and Risk immature consideration of field conditions.

Project 3 is a hospital construction project which has an 8-story building, the construction of this hospital will take place in 2017-2018. In the results of the risk evaluation analysis that has an impact other than safety risk which has a large weight is the personnel risk which is part of the sub-risk for the quality of technical personnel (including psychological, moral integrity, operational techniques and efficiency) The next major risk is a lack of understanding of structural characteristics and design theory, lack of understanding of structural characteristics and design theory which affects the contingency costs of the construction of this project.

The construction of this hotel is a research subject project number 4 which runs from 2019-November 2020. The risk factors that have a large probability and impact on the construction of this project are risks caused by the quality of technical personnel (including psychological, moral integrity). , operational techniques and efficiency). Apart from technical personnel problems, the next risk factor is the delay in supplying and loading construction equipment. From the results of interviews with Project Manager Project 4, it was found that during construction there were many problems caused by the risk of design deviation from construction, this happened because of changes at any time by the owner who had given design changes regarding the addition of the number of floors by 2 times. when adjusted to the fieldwork method it changes back to the original design. There are a number of things caused by this risk that can be stated in the contract addendum, but there are also things that are a domino effect that interferes with the project implementation process which affects the use of contingency costs.

In the construction of fifth project, the risk with the greatest probability and impact is the risk of damage to construction machinery and electrical faults that have occurred in the field which has caused work delays within a few days. This has happened in a project regarding the use of tower cranes where there was damage to several parts, thus hampering the use of the tower crane. Apart from that, another risk factor is the design deviation from construction errors. There have also been problems related to restrictions on local transportation at the beginning of the Covid-19 pandemic around April-May 2020 regarding the mobilization of field workers which has an effect on the progress of work in the field.

In this sixth project, the results of the risk evaluation analysis show that the biggest risk is the risk caused by the quality of technical personnel (including psychological, moral integrity, operational techniques and efficiency). The next risks that have an impact on contingency costs are the risk of insufficient production capacity of construction equipment, and the risk due to site theft. In this project, based on the results of interviews with the Project Manager, it was found that there had been material theft in the field which had an impact on the contingency costs provided.

Walke (2004) and Li et al (2013) in their research on implementation risk said that the risk of the quality of technical personnel (including psychological, moral integrity, operating techniques and efficiency) was a risk factor that was ranked first. The same thing as the research results on the six projects reviewed, the risk of the quality of technical personnel is always in the three biggest orders of risks that have the greatest weight. In the research conducted by Handoyo et al (2016) also stated that the most dominant factor that can cause the risk of cost overruns at the building construction implementation stage is the Planning and Professionalism Factor of 35.21%, then Environmental Factors and Estimates of 21.47% then the Material of 10.04%. Research conducted by El-Karim et al (2015) also states that the risk that has the greatest impact on the problem of cost overrun is the engineering criteria and design criteria. This shows that the risk of design and planning and worker professionalism are among the dominant factors affecting cost overruns. so as to minimize the use of contingency costs, it is necessary to prepare preventive steps to reduce the impact and the possibility of these risks. This can be done with risk retention or risk transfer such as the use of insurance mechanisms and sub-contactors. In the research conducted by El-Karim et al. (2015) it also explains that risk responses and risk plans must be studied and controlled to transfer or mitigate the impact of these factors to other parties such as insurance companies, sub-contractors or clients themselves, which increases use of contingency costs effective and tend to be less.

4. CONCLUCION

The results of this study indicate that the results of the risk evaluation on the six research object projects are grouped into Low risk projects. Project 1 has a value of $\mu VL = 0.0113$ with $\mu L = 0.983$, Project 2 has a value of $\mu L = 0.9764$ with $\mu M = 0.0238$, project 3 has a value of $\mu L = 0.993$ with $\mu M = 0.0708$, Project 4 has a value of $\mu L = 0.969$ with $\mu M = 0.0307$, Project 5 has a value of $\mu L = 0.9802$ with $\mu M = 0.02$, and Project 6 has a value of $\mu VL = 0.002$ with $\mu L = 0.997$.

5. REFERENCES

Al-Bahar, J. F. (1988), Risk management in construction project: A systematic analytical approach for contractors, Phd Thesis, University of California, Berkeley.

Al-Bahar, J.F. dan Crandall, K.C. (1990), “Systematic risk management approach for construction projects”, Journal of Management and Engineering ASCE, vol 3, page 533-546.

Anshori, Yusuf. (2012), “Triangular Fuzzy Number Approach in Analytic Hierarchy Process Method”, Foristek Scientific Journal,Vol. 2 No. 1, page 126-132.

Chatterjee ,J., Sheet ,D., Garud, H., Suveer, A., and Mahadevappa, M. (2010, "Brightness preserving dynamic fuzzy histogram equalization", *IEEE Transactions on Consumer Electronics*, vol. 56, no. 4, hal 2475-2480.

El-Karim, Mohamed Sayed Bassiony Ahmed Abd., Nawawy, Omar Aly Mosa El and Alim, Ahmed Mohamed. (2015), “ Identification and assessment of risk factors affecting construction”. HBRC Journal.

Fu Li, Q., Zhang, P. & Chao Fu, Y., (2013), Risk Identification for the Construction Phases of the Large Bridge Based on WBS-RBS, *Research Journal of Applied Sciences, Engineering and Technology*.

Handoyo, Suryo, and Susila, Herman (2016), Analysis of Dominant Cost Risk Factors in the Implementation of Building Construction Projects in Surakarta, Journal of Civil Engineering and Architecture, Vol. 18 No 22.

Latief, R.U., Abdurrahman, M.A, and Setiawan, Reza (2015). Fuzzy Risk Assessment In Tello Bridge Construction Project, Universitas Hasanudin.

Labombang, Mastura. (2011), Manajemen Risiko dalam proyek Konstruksi. *Jurnal SMARTek*. Vol. 9 No. 1.

Loosemore, Raftery, Reilly, Higgon. (2006), Risk Management in Projects, Second edition, Routledge, London.

Nukala, S. and Gupta, S.M. (2007), "A fuzzy mathematical programing approach for supplier selection in a closed-loop supply chainnetwork", In Proceedings of the 2007 POMS- Dallas Meeting.

PMI. (2017), A Guide To The Project Management Body Of Knowledge (PMBOK GUIDE) sixth Edition, Project Management Institut.Inc, Newtown Square.

Saaty, T. (1993), Decision Making for Leaders: Analytical Hierarchy Process for Decision Making in Complex Situations, 2nd Printing, PT. Pustaka Binaman Pressindo, Jakarta.

Saaty, T. L. (1993), Decision Making for Leaders: Analytical Hierarchical Process for Decision Making in Complex Situations (Vol. II). PT Pustaka Binaman Pressindo, Jakarta.

Zadeh, L. A. (1965) ,Fuzzy Sets,Information and control 8,page 338-353.

Walke ,R. C. , (2004), An Approach to risk quantification in construction projects using EMV analysis, Thesis Phd, Veerm

ANALYSIS OF DELAY FISCAL METERING SYSTEM DEVELOPMENT PROJECT USING FAULT TREE ANALYSIS METHOD

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ABSTRACT

In connection with the sustainability refinery operation excellent (SROE) program that was inaugurated by the processing directorate, one of the barometers of its success is the focus on the development of the Fiscal metering system project, the development of this fiscal metering system is planned to take 1 year 2 months, where the activity starts at the end of the month. March 2017 until it ends in May 2018, there is a delay of 6 months from the initial planning, there is a change in schedule to March 2017 ending in November 2018.

This study aims to analyze the factors that cause and impact delays in the development of a fiscal metering system project at PT XYZ using the fault tree analysis (FTA) and event tree analysis (ETA) methods. From the two analyzes, it is used to identify the causes of failure, analyze delays in the development of a fiscal metering system project, identify the sources that most influence the delay in the development of a fiscal metering system project and determine prevention on the project and analyze what impacts can be reduced by making project mitigation. The method of constructing a failure tree or logic tree using focus group discussion (FGD) and event tree analysis (ETA) and determining the probability value of the cause of the delay or basic event is carried out using secondary data and field observations.

The probability value of the overall delay in the development of a fiscal metering system project is 0.0944. From the results of the event tree analysis (ETA) diagram, it was found that the development of this fiscal metering system project was delayed due to various factors and the daily delay penalty was 1 0/00 of the contract value of IDR 194,229,168,693.12, then the fines caused by a delay of 1 month amounting to IDR 4,467,270,880 while for a maximum 6 month fine of IDR 26,803,625,280, it is necessary to have a mitigation plan and prepare a list of risks to project delays in fiscal metering system.

Keywords: Fault Tree Analysis (FTA), Event Tree Analysis (ETA), fiscal metering, risk of bridging oil and gas projects.

1. INTRODUCTION

The ideal condition is if, at the time of project implementation, the activities run according to the planned schedule. However, if a problem arises that causes the implementation to be not following the schedule, then this can have an impact, one of which is the delay in the project time.

Problems that arise causing delays in a project are usually caused by several factors. Some of these factors may be caused by service users/contractors / supervisory consultants, and/or other factors.

Project delays need to be analyzed to know what factors affect the delay in project implementation. Besides that, it also knows what jobs are experiencing delays so that these jobs can hinder the implementation of other jobs.

1.1 Fault Tree Analysis (FTA)

Fault tree analysis was first introduced at Bell Laboratories and is one of the most widely used methods in system reliability, maintenance, and safety analysis. FTA is a deductive procedure used to determine various combinations of hardware and software and human failures (called top events) as levels in the FTA system (Kocecioglu, 1991). According to Rosyid (2007), fault tree analysis is a method for identifying all possible causes (component failure or other failure events that occur alone or together) causing system failure and providing a basis for calculation.

The chance of the failure occurring. FTA can be used for cases with a combination of component failures, so FTA is suitable for systems with redundancy.

Meanwhile, according to Kocecioglu (1991), FTA is a simple fault tree analysis that can be described as an analytical technique. The fault tree is a graphical model involving various parallels and various combinations of pilot errors which will result in the occurrence of undesirable events that have been previously defined or can also be interpreted as a logical reciprocal description of the basic events that lead to the unwanted event become the top events of the fault tree.
Fault tree analysis has an important value in solving the following (Kocecioglu, 1991):

i. Analyse system failures.
ii. Look for the aspects of the system that were involved in major failures.
iii. Help management know changes in the system.
iv. Help allocate the analysers to concentrate on part failure in the system.
v. Help provide qualitative choices, as well as quantitative, in the reliability system analysis.
vi. Helping the analysers use his knowledge to enter into system behaviour.

According to Brown (1976), several basic definitions must be known in the discussion of fault tree analysis, including:

- Event is something that happens in the system. Has two modes, namely occurs or not.
- Fault event is an event where one of the two modes is an abnormal occurrence, resulting in failure or error.
- Normal event is an event in which both modes are expected and tend to occur at a certain time.
- Basic event is an event in which both modes are expected and tend to occur at a certain time.
- Primary event is an event caused by the properties in the component itself.
- Secondary events are events caused by external sources.
- Head event is an event at the top of the fault tree being analysed, failing.

1.2 Fault Tree Symbol

In describing the fault tree, standard symbols are used to simplify analysis. The symbols used can be seen at **Table 1**.

Table 1. Fault Tree Symbol

Event Symbol	Description
	*Top Event*
	Logic Event Or
	Logic Event AND

	*Transferred Event*
	*Basic Event*

1.3 Minimal Cut Set

To determine the minimum cut set used to provide answers to FTA problems using MOCUS (Method Obtain Cut Set). MOCUS (method for obtaining cut set) is an algorithm that is used to obtain a minimum cut set. According to Clemens (2002), a cut set is a fault tree-forming combination which if everything happens will cause the peak event to occur. Cut sets are used to evaluate fault tree diagrams and are obtained by drawing lines through the blocks in the system to show the minimum number of failed blocks that caused the entire system to fail.

However, it is not the smallest combination of events that causes a peak event. To find out, a minimum cut set is required. This minimal cut set is a combination of the smallest events that lead to unwanted events (Billinton et al, 1992). If one of the events in the minimum cut set does not occur, no culmination event or unwanted event will occur. In other words, the minimum cut set is the smallest root cause that has the potential to cause disability (peak event).

The fault tree quantitative evaluation is carried out using a direct numerical approach which is a bottom-up approach. This numerical approach starting at the lowest level of the hierarchy and combining all probabilities of events at this level using the appropriate logic gate to which these events are associated. This probability combination will give the probability value of the intermediate event at the hierarchical level above it until the top event is reached. Logic Gate in the fault tree analysis has OR and AND gates. Where the OR gate is a gate that describes a combination of events. The OR gate is equivalent to the “+” symbol.

For n input events represented on the OR gate the equivalent of the formula T = C1 + C2 + ... + Cn for T are the output events (Probability) and C1, C2, ..., Cn are input events (Vesely et al. 2009). Meanwhile, the AND gate is a gate that describes an intersection of events. AND gate is equivalent to the symbol "." For n input events at the AND gate equivalent to the formula T = C1 + C2 + ... + Cn for T is the output event (Probability) and C1, C2, ..., Cn is input events.

In the fault tree "0" is defined as a failure event that did not occur and "1" is defined as a failure event that occurred.

1.4 Event Tree Analysis (ETA)

Event tree analysis is a method used to analyze the various impacts caused by an event being studied. This method is used to estimate and assess the probability of each consequence that may arise from an event. So that the method as a reference in anticipating the various consequences. The first step in the analysis process using the event tree analysis method is to draw as much detail as possible the part of the system that is related to the main event being studied. This step is taken to obtain an estimate of the events that may occur after the main event occurs. This process is very dependent on the part of the system that is described, the more detail, the more events are predicted. The results are likely to be more predictable consequences or scenarios valid.

The second step is to draw the event tree diagram according to all the events that have been predicted. Each event in each diagram is in the form of a question that can be answered with a "yes" or "no". Each response initiates another related event and continues until the final consequence of each predicted event is known. The third step is the stage of finding the probability value for the answers to each of the estimated events listed on the diagram. The total likelihood value for each event is then multiplied by the possible answer value for the other event following the intended flow of consequences so that the probability value of each consequence on the diagram is obtained. The total likelihood of all consequences on the diagram must add up to 1 or 100%. If the total probability value is not equal to 1 or 100% then the diagram needs to be double-checked to look for possible errors in the addition process or errors in the process of entering the likelihood value for each event.

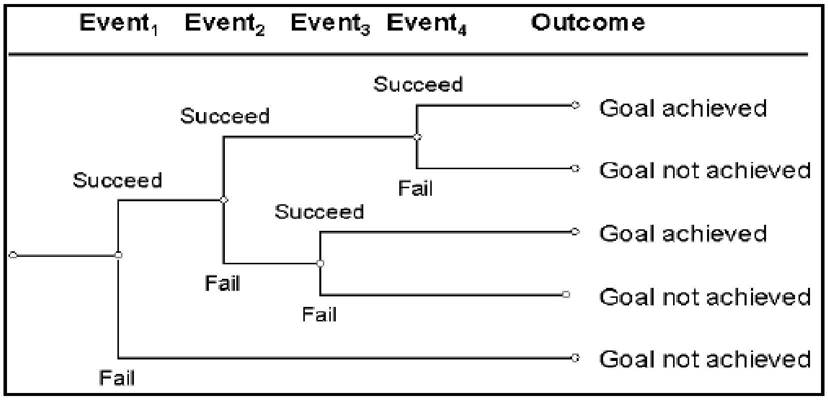


Figure 1. E*vent tree analysis (ETA)* Diagram (Clifton, 2005)

The following are various terms in the event tree analysis, as shown in the table (**Table 2**) Below:

Table 2. Fault Tree Symbol

No	Event	Description
1	Accident Scenario	The final event is a consequence. Suite an event that starts from the initiating event and is usually followed by one or more pivotal events with an undesired event at its peak
2	Initiating Event	System failure or undesired event that caused the consequences. IE results in consequences it depends on the success or failure of the prevention method designed in the system
3	Pivotal Events	Intermediary events are sub-systems lies between IE and its consequences. This sub-system is a success or failure sub-system that is built for the consequence mitigation process
4	Probabilistic Risk Assessment (PRA)	The analytical method used for the identification process and risk evaluation using quantitative analysis

This paper offers a settlement method by looking for the factors of project delays that have been undertaken using the Fault Tree Analysis (FTA) method and a method for analysing the impact scenario of project delays using the event tree analysis (ETA) approach. The flow chart of the various stages of the proposed FTA and ETA is depicted in **Figure 2**.

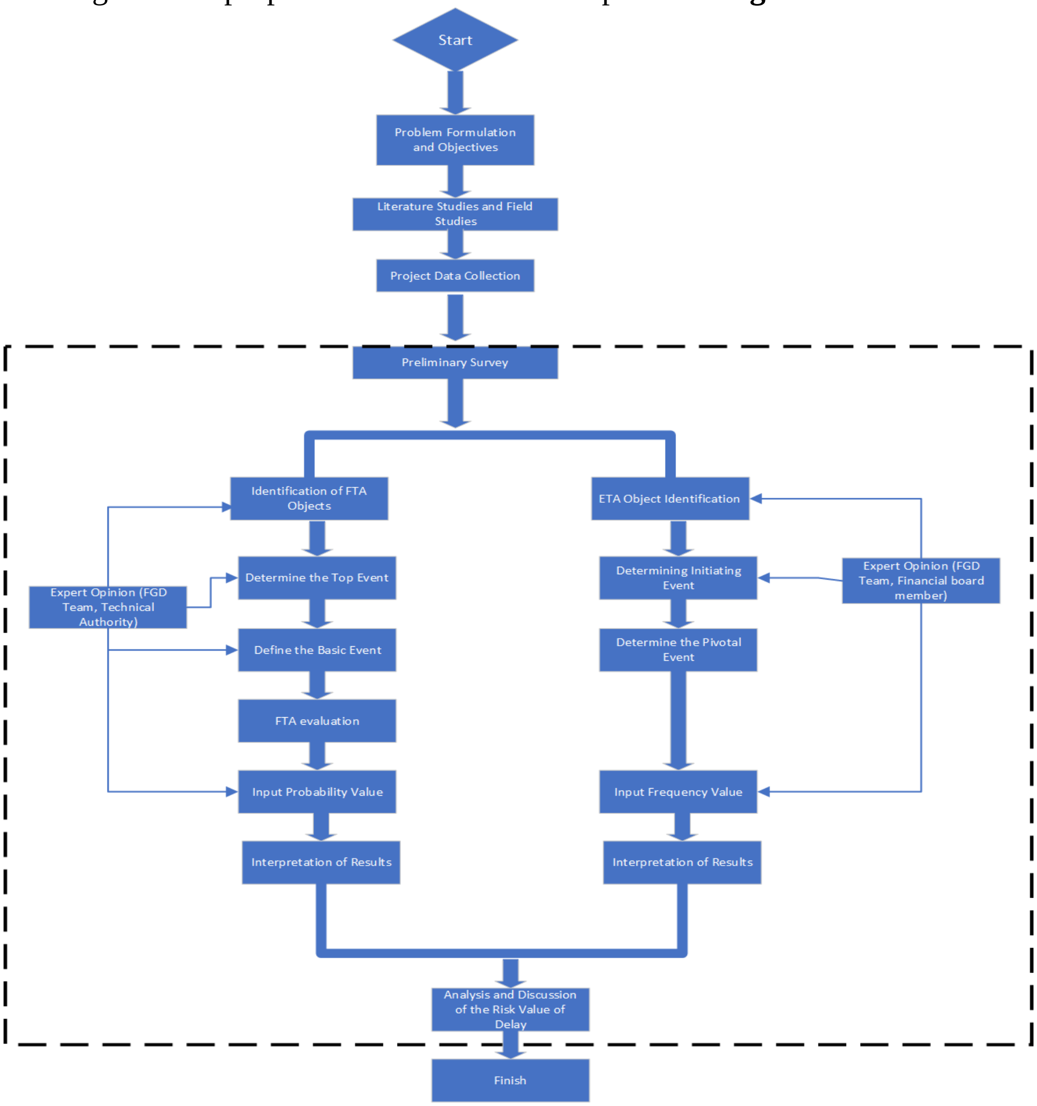


Figure 2. Flow Diagram

Table 2. Frequency Index

FI	Frequency	Definition	F (event per year)
5	Frequent	Likely Occur once per year in a fleet of 10 events	10^{-1}
4	Reasonably probable	Likely Occur once per year in a fleet of 100 events	10^{-2}

3	Remote	Likely Occur once per year in a fleet of 100 events	10^{-3}
2	Extremely Remote	Likely Occur once in 10 year in a fleet of 1000 events	10^{-4}
1	Extremely Remote	Likely Occur once in 100 year in a fleet of 1000 events	10^{-5}

In evaluating the possibility of failure of project delays, it must be emphasized that the failure rate of a basic event must be known. In this study, the expert judgment that is included in the FGD (Forum Group Discussion) is used to determine the probability of basic events. Experts provide their assessment to describe the real-world situation, experience, and knowledge based on the actual conditions of the project, shown in this is reviewed in **Table 2**.

Table 3. Severity Index for the Risk Matrix

SI	Rating	Qualitative	Quantitative
1	Minor	Fiscal metering system development projects that are not subject to fines and on time	< 0,01
2	Moderate	The new fiscal metering system development project is subject to 10-100 Mill and the project is 1-12 months late	0,001-0,1
3	Serious	New fiscal metering system development projects are subject to 100-200 million and projects> 1 year late	0,1-1
4	Catastrophic	The new fiscal metering system development project failed to be implemented	1-10

Table 4. Risk Matrix

FI	Rating	Severity (SI)			
		1	2	3	4
		Minor	Moderate	Serious	Catastrophic
5	Frequent	6	7	8	9
4	Reasonably Probable	5	6	7	8
3	Remote	4	5	6	7
2	Extremely Remote	3	4	5	6
1	Extremely Improbable	2	3	4	5

2. RESULT AND DISCUSSION

This paper analyses project delays by looking for the factors that cause delays in the Fiscal Metering System Project. The data used in this paper were obtained through field observations using interview techniques and project document analysis. The results of discussions with the FGD team, the objective of this fault tree analysis (FTA) was determined in order to find out or get the source of the problem in the delay in the Fiscal Metering System development project by referring to the respondent's results, then from the existing problems in accordance with the information from the respondent, the data was constructed. The data uses the Reliability Workbench V.13.0 software where the results of the construction are expected to be able to determine which parts or components of the system have been improved to minimize delays.

2.1 Determining the Top Event

In determining the top event, the members of the FGD first conducted a brainstorming by looking at the overall fiscal metering system development project activities. This is in order to reach an agreement that the top events are selected based on mutual agreement related to the development of a fiscal metering system. In **Table 5** below, is the Top Event of the fiscal metering system development project work. The FGD team analysed the results of the interviews into several groups.

Table 5. Top Event

No	Type Problem
1	**Production process is hampered**
	a. Long duration of material procurement
	b. Inadequate equipment facilities
	c. Unfavorable environmental conditions
	d. Worker Limitations
	e. The design underwent changes
	f. Poor worker productivity

	g. Project Handover
2	**Poor management system**
	a. Management control is less effective
	b. Lack of field communication
	c. Initial project plan schedule

2.2 Evaluation of the Factors Causing Delays in the Development of a fiscal metering system using the Fault Tree Analysis (FTA) method

After a discussion with the FGD team, several conditions can be determined as in **Figure 3** below, it is explained where the delay in the fiscal metering system development project is divided into 2 (two) main groups where this is "The production process is hampered" and "The management system is lacking. good".

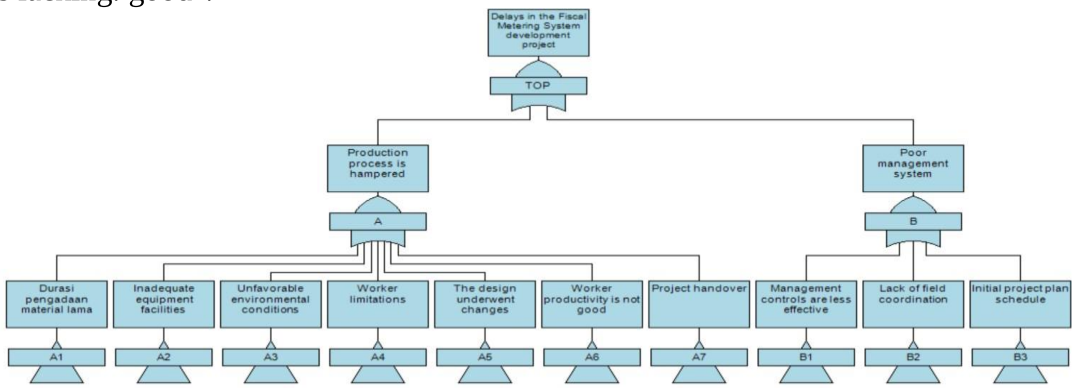
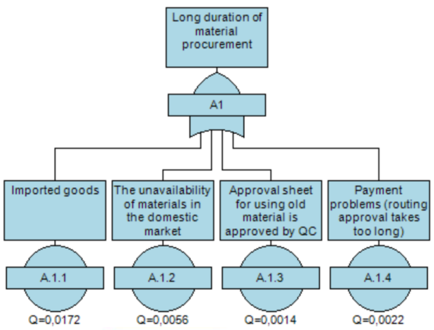
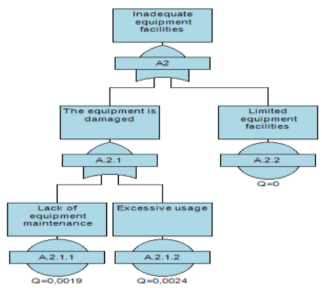
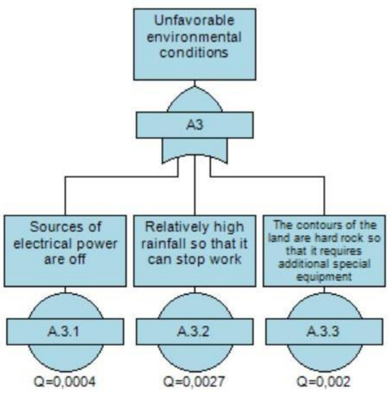


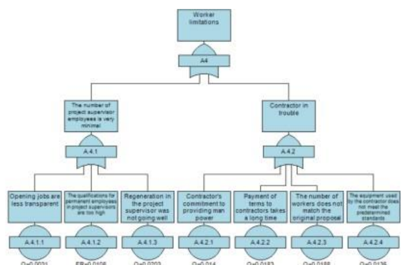
Figure 3. FTA Diagram

2.2.1 Delay Factor Using Fault Tree Analysis









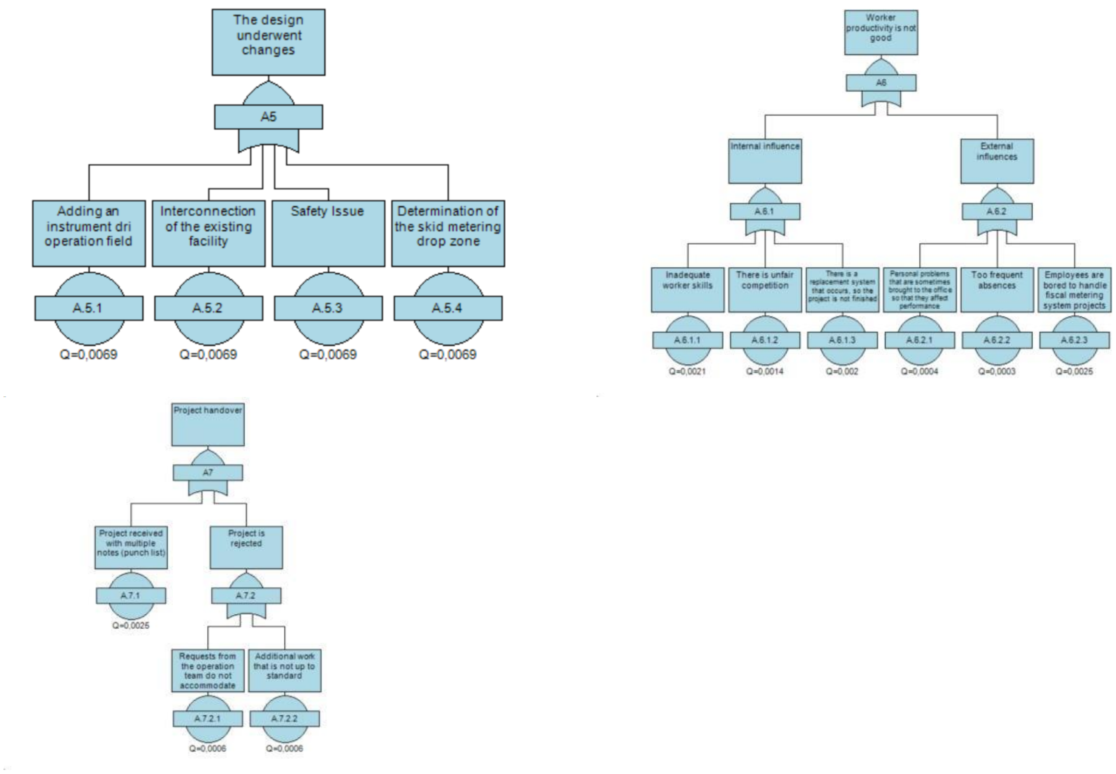


Figure 4. Fault Tree (FTA) Instructions for delayed production processes and Poor Management System

For each, the minimum cut set of the FTA for "disrupted production process" is a probability of 0.0718 while for "Poor management system" has a probability of 0.0226. So that the total number of minimum cut set probability for the top event is

$$T = C1 + C2 + \cdots Cn$$

$$T = C1 + C2 + C3$$

$$T = 0{,}0718 + 0{,}0226$$
$$T = 0{,}0944$$

So that the Top Event probability of poor production and management processes is 0.0944.

2.3 Evaluation of Factors Due to Delays in the Fiscal Metering System Development Project using the Event Tree Analysis (ETA) Method

The Event Tree Analysis (ETA) method is an analysis technique that will be used to evaluate processes and events that lead to possible failures, ETA diagram due to the late Fiscal Metering System Development Project, Figure 5. Event Tree (ETA) Instructions for delayed production processes.

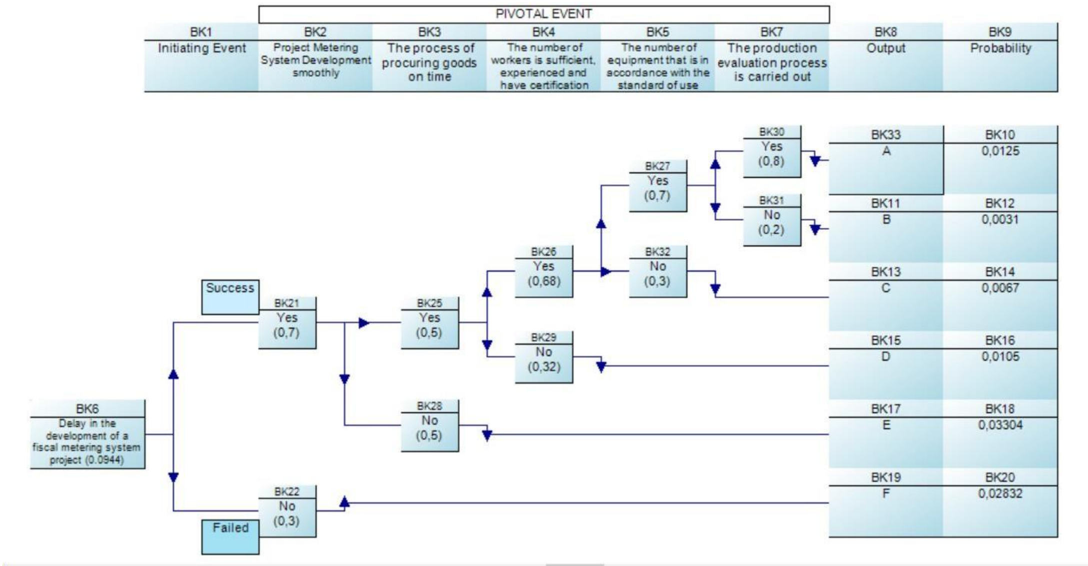


Figure 6. ETA diagram due to the Fiscal Metering System development project

Table 6. Output Risk Matrix Results

FI	Rating	Severity (SI)			
		1	2	3	4
		Minor	Moderate	Serious	Catastrophic
5	Frequent	6	7	8	9
4	Reasonably Probable	5	6	7	8
3	Remote	4	5	6	7
2	Extremely Remote	3	4	5	6
1	Extremely Improbable	2	3	4	5

A　B, C　D　E　F

3. CONCLUSION

From the results of the research conducted, several things can be concluded, namely:

1. Based on the fault tree analysis (FTA), there are 36 (thirty-six) basic events that are the main factors of delays in the work of the fiscal metering system development project.
2. From the results of the calculation of the minimum cut set of each of the main problems are as follows:
   - The production process has a probability of 0.0718 which means the level of possibility for the occurrence of delays in the work of the fiscal metering system project in this production process is in the medium category.
   - A bad management system has a probability of 0.0226, which means the level of possibility for delays in fiscal metering system project work in this bad management system is in the medium category.
   - The probability of the overall delay in the development of a fiscal metering system project is 0.0944, which means the level of possibility for delays in fiscal metering system project work in this bad management system is in the medium category.
3. The impacts of delays in a fiscal metering system project development project using the event tree analysis (ETA) method are:
   a. After a more in-depth analysis was carried out, that the delay in the development of the fiscal metering system was delayed for 6 months from the period or from the contract that was mutually agreed, this made PT XYZ impose a fine of 1 0/00 of the contract value of IDR 194,229,168,693 12, then the value of the fine imposed is IDR 71,476,334,079
   b. The reputation of the contractor as a construction service provider is subject to a score reduction of 2 stars, meaning that joining a similar project will be considered.
   c. The executing contractor is given a "yellow traffic light" which means the contractor is not allowed to participate in a similar project for the next 3 years.

4. REFERENCE

Kocecioglu, D. (1991). *Reliability Engineering Handbook*. Englewood Cliffs: Prentice-Hall. Volume 2.

Silvianita., Mahendeka D S., dan Rosyid D M., (2015), Fault tree analysis for investigation on the causes of project problems, *International Journal of Construction*, Vol. 23 No. 3, P. 89-113.

Silvianita, Khamidi M F, Kurian F J. (2005). Decision making for safety assessment of mobile ericson

A. Clifton. *Hazard Analysis Techniques for System Safety*. John Wiley & Sons, Inc. Hobeken. New Jersey.

Mooring System (2013). *Journal Technology*, 61, 2013. P l 41 – 52.

RISK ANALYSIS IN WAREHOUSE DEVELOPMENT FOR A DETONATOR ASSEMBLY: CASE STUDY IN A MINING COMPANY

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ABSTRACT

This study is to identify and assess significant risks in the industrial building construction process. From the results of this research, it is used to assess and analyze the risks of building a warehouse and operational detonator assembly buildings (BWODAB) in a mining company. This research is expected to provide input to investors, so that investors can consider the risks that arise in the warehouse and operation of the explosives detonator assembly. Risk identification uses Work Breakdown Structure and Risk analysis uses Failure Mode Effect Analysis (FMEA). Data was collected through a questionnaire distributed via WhatsApp social media to construction experts working in similar project fields. Whatsapp social media is an option because this pandemic season people limit their interactions with each other. Risk mitigation is carried out using the House of Risk (HOR) Phase 2. Delay in payment is the biggest risk agent in several construction projects, where this is within the scope of investors. Followed by the agency scope of the job definition that is not precise, the risk of changing the scope of work, the risk is the same as changes in standards and regulations, incomplete design risk. On the Contractor's side, the most dominant risk agent is labor disputes being the first risk agent. This is followed by theft or robbery of materials on site, risk of availability of labor, materials and equipment, risk of inadequate technology, poor subcontractor performance, and shortages or delays in material supply. From the priority risk agent, the results of risk analysis, a prevention plan is prepared so that the risks that occur can be minimized, these steps include; make a financial plan that refers to a detailed schedule, selection of competent contractors, proportional distribution of local workers and migrants, an adequate security system.

Keywords: *Risk agent*, FMEA, *and* HOR *phase 2.*

I. INTRODUCTION

The BWODAB construction project is quite complex due to the involvement of various parties who are project managers, planners, service providers, supervisors, and production machine suppliers. Projects often experience many incomplete design problems, revision of drawings, design errors, drawings that cannot be executed, late start, delivery of imported machines, geological problems with installation errors, lack of coordination between stakeholders, incompetent contractors, contractor financing. Risk management in running a business is important to protect the company from risks that hinder the achievement of goals and various things that could potentially cause harm to the company. Therefore, this study is to identify and assess the significant risks in the industrial building construction process. From the results of this research, it is used to assess and analyze the risks of building a warehouse and operational detonator assembly buildings (BWODAB) in a mining company. This research is expected to provide input to investors, so that investors can consider the risks that arise in the warehouse and operation of the explosives detonator assembly.

II. LITERATURE REVIEW

Project Risk Management

Risk management is the process of defining the sources of uncertainty (risk identification), estimating the consequences of uncertain events or conditions (risk analysis), producing a response strategy taking into account the expected results and ultimately, based on the proposed feedback. Accepts actual results and emerging risks, identifies, analyzes, and generates repeated steps throughout the life cycle of an object to ensure that project objectives are met. Risk management in construction is a tedious task as objective functions tend to change during the life cycle of objects, presenting an ontology based risk management framework study of a construction project through project life cycle variance - covariance in Zavadskas et al. (2010).

Risk Identification

Risk identification is an iterative process, because new risks may only be recognized when the project is ongoing during the project cycle. The frequency of repetition and who are involved in each cycle will vary greatly from case to case. Identification must include all risks, whether present or not in the organization, the goal is to produce a comprehensive list of risks from an event that can affect each structure element. Construction developments, technology, and management conditions differ. In addition, certain buildings, projects and establishments face very different levels of risk. Variables that have been identified to contribute to the level of risk can be categorized into these groups (Tamosaitene, 2013).

Risk Mitigation

The House of Risk is a renewable method of analyzing risk. Its application uses the principles of FMEA (Failure Mode Effect Analysis) to quantitatively measure risk combined with the House of Quality (HOQ) model to prioritize risk agents which must be prioritized first and then choose the most effective action to reduce potential risks posed by agents risk. The HOR method only establishes the probability for the risk agent and the severity of the risk event. Since it is possible for one risk agent to cause more than one risk event, it is necessary to quantify the aggregate risk potential of the risk agent. Adapting the House of Quality (HOQ) model to determine risk agents should be given priority as a precautionary measure. A rating is given for each risk agent based on the amount of the ARPj value for each risk agent j. Therefore, if there are many risk agents, the company can first select an agent with a high potential for risk events. This two-spread model is called the House of Risk (HOR) which is a modification of the HOQ model (Pujawan & Geraldin, 2009).

- HOR 1 is used to determine the priority level of risk agents that should be given as a preventive measure.
- HOR 2 is a priority in taking actions that are considered effective.

The testing in this study includes:

Validity test

In testing the validity of the statements on the questionnaire, the Product Moment Correlation Technique (r) can be used. The statement is considered valid if the correlation value of the calculation results is greater than the critical number (r ≥ r critical) in the table (α; 1% or 5%). The r count can use the equation below:

$$\frac{\sum \sum \sum}{\sqrt{[\sum \sum][\sum \sum]}} \qquad (1)$$

Figure 1. *Validity Test Calculation Formulas*

Where :

N : Number of Test Respondents
X : Score Answers to Questions
Y : Total Score

If a statement is found that has r count less than r table, then maybe the statement is not well structured and can make another interpretation. After testing the validity and variables and the results are valid, the research is continued with the reliability test.

Reliability Test

The reliability test used internal consistency techniques with the Cronbach alpha stability method using the reliability coefficient r. The test results are considered reliable if r count> r table. Furthermore, it is done by calculating the impact value and probability using the Mean or Severity Index value.

III. RESEARCH METHODS

Method of Collecting Data

From processing primary data and secondary data, data collection methods will be obtained in this study. From PT XX as an investor and a similar project development actor, primary data will be obtained with the aim of obtaining a description and identification of problems during project implementation. Data obtained from distributing questionnaires. The questionnaire is to collect data from research respondents, the questionnaire itself contains questions or statements related to the research objectives. Questionnaire data will be used as a measuring tool whether it is reliable. The measuring instrument is said to be reliable if the measuring instrument produces the same data on several tests carried out on the same object. Reliability shows the consistency and stability of a score (on a measurement scale) (Kuncoro, 2009). Therefore, the questionnaire data received will be tested for reliability. The reliability test in this study used the internal consistency technique with the Cronbach alpha stability method using the reliability coefficient r.

Population and Sample

In this study, the population studied was those who had done industrial building works. The population for respondents, there are several positions from parties related to similar projects, including Technical Director, Director of Contractor Companies, Project Manager, Site Engineer.

The object of this research is the construction project of a warehouse building and an operational detonator assembly building in East Kalimantan. The limited population size causes the number of population as well as the number of samples to be studied.

Sample Technique

In this study, the sample technique used is Non-Probability Sampling. The Non-Probability Sampling technique used is purposive sampling in which the sampling is done with certain considerations.

Data analysis

For data analysis, Failure Mode Effect and Analysis will be used in section 2.3 in this study, which aims to determine the risks that have a major influence on the implementation of this project.

Measurement Scale

Measurement of research variables using a scale which will represent in measuring respondents' perceptions of the effect of risk. The scale uses a range of numbers 1 to 5, namely:

1. Effect of risk severity (severity) in a development project. The severity that appears can be measured using a measurement scale, namely:
   Very small (VS) = given a score of 1
   Small (S) = given a score of 2
   Medium (M) = given a score of 3
   Large (L) = given a score of 4
   Very large (VL) = given a score of 5
2. The effect of Occurance in the development project. Occurrence (Occurance) that appears can be measured using a measurement scale, namely:
   Very small (VS) = given a score of 1
   Small (S) = given a score of 2
   Medium (M) = given a score of 3
   Large (L) = given a score of 4
   Very large (VL) = given a score of 5
3. Meanwhile, to seek detection / detection (D) risk can be represented by using a range of numbers 1 to 5. The frequency of occurrence of risk items is measured to determine the impact arising from risk by using a measurement scale, namely:
   Very rarely (VR) = given a score of 1
   Rarely (R) = given a score of 2
   Enough (E) = given a score of 3
   Often (O) = given a score of 4
   Very often (VO) = given a score of 5

Research Variable

Variable is something that will be observed in research. The risk variables in this study were obtained from several previous research journals. Meanwhile, according to the nature of the work and the type of project, risks can be classified into several types using the same task segmentation called Risk Breakdown Structures in Figure 3.1 PMBOK @ Guide (2008).

Risk identification uses Risk Breakdown Structures (RBSs) in conjunction with Work Breakdown Structures (WBSs) to help the management team identify and ultimately analyze risks. Figure 3.1 provides a typical RBS example. The use of RBS reduces the chance that a risk event will be missed. On large projects, multiple risk teams are organized based on specific outcomes and submit their risk management reports to the project manager. The initial focus should be on the risks that can affect the entire project as opposed to a specific part of the project or network. Once macro risks are identified, specific areas can be examined. An effective tool for identifying specific risks is root breakdown structures (RBSs). In this study, Root Breakdown Structures (RBSs) used references by Sameh Monir (2008) and Shahid Iqbal (2015) as follows:

Table 1. Research Variables

No.	Research Variabel	Sameh Monir	Shahid Iqbal	This Research
	Internal	**2008**	**2015**	**2020**
1	Owners' delayed payment to contractors	X	x	x
2	Owners' unreasonably imposed tight schedule	X		x
3	Owners' improper intervention	X		x
4	Change of design required by owners	X	x	x
5	Lack of scope of work definition by owner	X		x
6	Delays in obtaining site access and right of way	X	x	x
7	Owners' breach of contracts and disputes	X	x	x
8	Owners' sudden bankruptcy	X	x	x
9	Defective design	X	x	x
10	Deficiencies in drawings and specifications	X	x	x
11	Frequent changes of design by designers	X	x	x
12	Drawings and documents are not issued on time	X		
13	Accidents during construction	X	x	x
14	Poor quality of work	X	x	x
15	Low productivity of labor and equipment	X	x	x
16	Unpredicted technical problems in construction	X		x
17	Contractors' incompetence	X	x	x
18	Lack or departure of qualified staff	X	x	x
19	Subcontractors' poor performance	X	x	x
20	Subcontractors' breach of contracts and disputes	X		x
21	Delay of material supply by suppliers	X	x	x
22	Quality problems of supplier material	X	x	x
	External			
23	War threats and political instability	X		x
24	Labor strikes and disputes	X	x	x
25	Changes in laws and regulations	X	x	x
26	Corruption and bribes	X	x	x
27	Delays in approvals	X	x	x
28	Criminal acts	X	x	x

No.	Research Variabel	Sameh Monir	Shahid Iqbal	This Research
	External	2008	2015	2020
29	Substance abuse	X		x
30	Conflicts due to differences in culture	X		x
31	Inflation and sudden changes in prices	X		x
32	Currency fluctuation	X		x
33	Shortage in material supply and availability	X	X	x
34	Shortage in manpower supply and availability	X	X	x
35	Shortage in equipment availability	X	X	x
36	Unexpected inclement weather	x	x	x
37	Unforeseen site conditions	x		X
38	Delays in resolving contractual issues	x		X
39	Delays in resolving disputes	x		X
40	Unfairness in tendering	x		X
41	Local protectionism	x		X
42	Difficulty in claiming insurance compensation	x		X

The next research process can be seen in the research flow diagram in Figure 2.

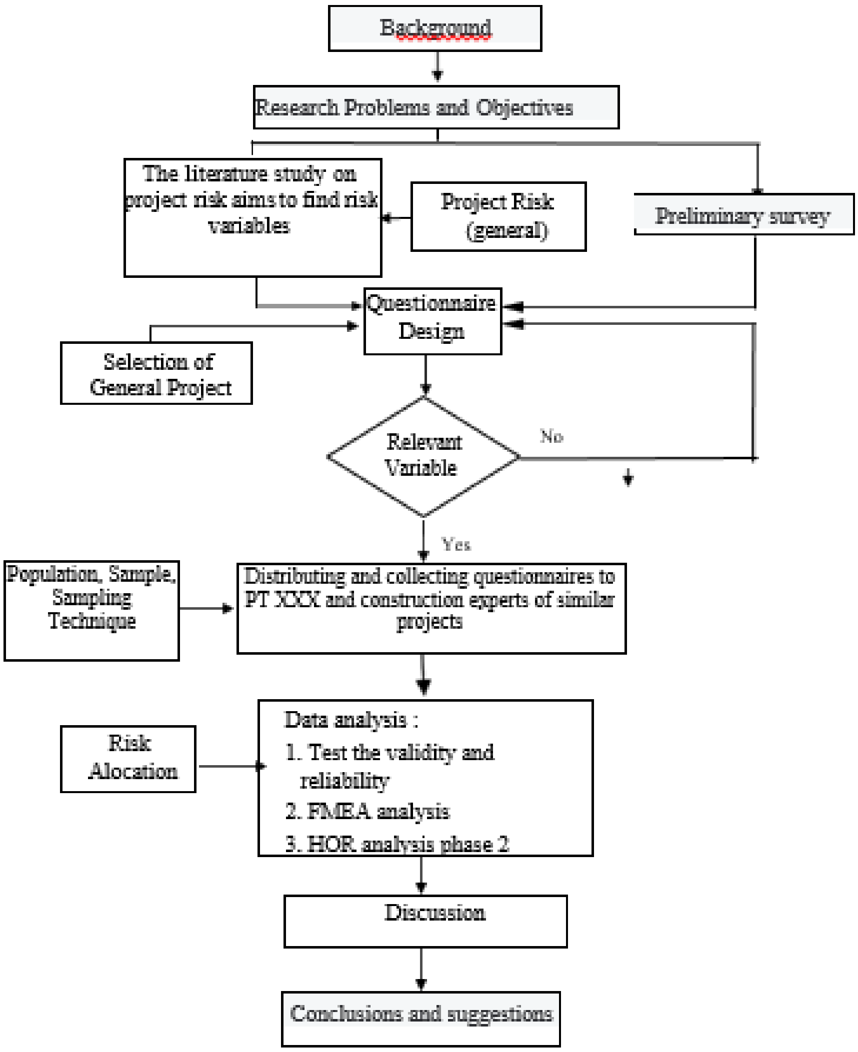

Figure 2. Research Flowchart

Research Stages

Risk identification (Stage I)

The initial stage of Risk management is Risk identification. This process describes conditions of competitiveness and identifies risk factors and uncertainties (Rutkauskas 2008 dalam Zayed et al. 2008).

Determination of the value of Severity (S), Occurrence (O) and Detection (D) by the FMEA method (Phase II)

After obtaining the risk items, the next step is to determine the level of severity (S), the likelihood of occurrence / Occurrence (O) and detection / Detection (D). Determination of rating is obtained through a brainstorming process with parties who are considered experienced in the project under study. The determination of the three ratings will greatly determine the process of prioritizing the risk list / critical risk determination. This critical risk will be analyzed further to calculate the Risk Priority Number (RPN) value of each risk.

Severity (S) indicates the level of seriousness of the result. The scale / ranking used in this study is based on the standard incident severity scale. This standard gives an impact on risks, regarding injuries, disease, social and psychological hazards as well as hazards to machines or equipment. This research looks at the impacts that arise from the risks of BWODAB development.

Questionnaires were used to determine the values of S, O, D. Then the values of S, O, D are obtained for each potential risk. Calculation of the Risk Priority Number (RPN) is an important part of FMEA because the RPN value will know the priority risks which are considered critical risks. The RPN value is calculated by multiplying the Severity (S), Occurrence (O) and Detection (D) values.

Risk Mitigation with the Phase 2 HOR Model (Phase III)

In preparing the risk management for the warehouse building construction project and the detonator assembly operational building, risk mitigation is described. Risk mitigation in this study uses the House of Risk (HOR) phase 2 model. HOR2 is used to determine which action should be taken first if a risk occurs. The steps are as follows:

1. Preparation of mitigation or preventive action (□□□) based on priority □□. See Table 3.6 HOR2 Model. Correlation relationship □□ and □□□ with the provisions 0, 1, 3 and 9. provided, 0: no correlation, 1: weak correlation, 3: moderate correlation and 9: strong correlation.
2. Calculate the total effectiveness of each preventive action (□□□) as follows:

$$\sum \square \; \square$$

3. Measurement of the degree of application difficulty □□□ with a scale of application difficulty 3: low, 4: medium and 5: high.
4. Effectiveness to difficulty ratio calculation with the formula:

$$\frac{\quad}{\quad}$$

5. Priority ranking □□□ based on value nilai □

IV. DISCUSSION RESULT

Data Tabulation

From the survey, the results obtained from the category of occurrence, detection, severity where the results of the questionnaire can be seen in Table 4.1. The results of this research can be seen in table 4.1 above, the numbers in each row show the number of respondents who chose the option according to the column listed above. For example, question no.1 is "Did design flaws in the project affect the project?" for the detection table as much as 1 respondent answered strongly agree, 6 respondents answered frequently, 5 respondents answered fairly, 13 respondents answered rarely, and the remaining 16 respondents answered very rarely, applicable to the occurance and severity table.

From these data, the greatest values are taken as the values of O, D, S, for further analysis.

Validity test

The questionnaire variable is said to be valid, meaning the measuring instrument used to measure the data is valid. The summary of research data is in Table 4.2, Table 4.3, and Table 4.4 in full can be seen in Appendices 4, 5, and 6.

Reliability Test

Reliability testing was carried out with the help of the SPSS 25.0 program by setting the error level (α) of 5%. With the help of the SPSS 25.0 program, the value of r count occurance is 0.975, the value of r count for the detection category is 0.975 and the r count for the category of severity is 0.94.According to Sugiyono (2006) the variable can be said to be reliable if r count> r table where r the specified table is 0, 6. So it can be concluded that the variables in this study can be said to be reliable and can be analyzed further. The results of the reliability test data can be seen in Appendix 7, Appendix 8 and Appendix 9.

FMEA Analysis

The FMEA analysis in this paper, as described in the previous chapter focuses on classical FMEA and the following separate steps are used to run FMEA (SANKAR and PRABHU, 2001 dalam Santos, 2008). The standard FMEA process evaluates failure modes for severity, incidence, and detection. The multiplication of these values leads to what is known as the RPN - Risk Priority Number. Based on that FMEA is the right method to do because the FMEA method measures the level of risk of project delivery conventionally based on three parameters, namely severity (S), Occurrence (O) and detection / Detection (D), as shown in Table 2 as follows:

Table 2. FMEA Analysis

No	Research Variable	QN	Model O	Model D	Model S	O x D xS	Rank
	Tabel 1. Owner's Responsibility						
1	Incomplete Design Risks	Q_011	4	1	4	**16**	8
2	Risk of Change of Standards and Regulations	Q_021	3	1	4	12	13
3	Delays in Obtaining Permission	Q_031	3	1	4	12	13
4	Delay in Drawing Availability	Q_041	3	1	4	12	13
5	Risk of Change of Standards and Regulations	Q_051	2	2	4	**16**	8
6	Risk of Change in Scope of Work	Q_061	2	3	3	**18**	5
7	Improper Scope of Job Definition in Contract	Q_071	3	2	4	**24**	4
8	Delay of payment	Q_081	3	5	3	**45**	1
	Tabel 2. Contractor's Responsibilities						
9	Accidents / Safety During Construction	Q_091	3	1	4	12	13
10	Risk of Poor Quality Material / Equipment	Q_101	4	1	4	16	8
11	Inaccurate Implementation Plan / Schedule	Q_111	3	1	3	9	24

No	Research Variable	QN	Model O	Model D	Model S	O x D xS	Rank
	Tabel 2. Contractor's Responsibilities						
12	Inadequate Technology Risk	Q_121	3	2	3	**18**	5
13	Theft / Robbery of Material on Site	Q_131	3	3	3	**27**	3
14	Third Party Delays	Q_141	1	1	3	3	31
15	Risk of Labor, Material and Equipment Availability	Q_151	3	3	2	**18**	5
16	Risk of Labor Disputes and Strikes	Q_161	3	3	4	**36**	2
17	Poor Subcontractor Performance	Q_171	4	1	4	**16**	8
18	Poor Coordination with Subcontractors	Q_181	3	1	4	12	13
19	Risk of Defective Materials from Suppliers	Q_191	3	1	4	12	13
20	Lack of Factory and Equipment	Q_201	2	1	4	8	27
21	Poor Plant and Equipment Productivity	Q_211	3	1	4	12	13
22	Shortage / Delay of Material Supply	Q_221	4	1	4	**16**	8
22	Shortage / Delay of Material Supply	Q_221	4	1	4	**16**	8
23	Lack of Qualified Staff	Q_231	3	1	4	12	13
24	Poor Labor Competence and Productivity	Q_241	3	1	3	9	24
	Tabel 3. Shared Responsibilities						
25	Natural Disaster Risk	Q_251	3	1	4	12	13
26	Delay Due to Disputes with Contractors	Q_261	2	1	4	8	27
27	Inappropriate Risk Allocation in Contract	Q_271	2	1	3	6	29
28	Exchange Rate Fluctuation and Inflation Risk	Q_281	3	1	3	9	24
29	Terrorism / Threats of War	Q_291	3	1	4	12	13
30	Bad Weather Conditions	Q_301	1	1	4	4	30
31	Political Instability	Q_311	3	1	4	12	13

Source: Processed Sources, 2020

Information :

High Risk: RPN Value> = 80% (36)

Moderate Risk: RPN values between 30% and 80%

Low Risk: RPN value <30%

From the results of the FMEA analysis, it was found that a significant RPN value (RPN> = 16) so that research variables can be selected which are included in the risk of events which are then analyzed in the HOR2 Model. Following this the selected variables can be seen in Table 4.6. as follows:

Table 3. Results of Research Variable RPN Value

No	Risk Agent	QN	F x D xS
	Tabel 1. Owner's Responsibility		
1	Incomplete Design Risks	Q_011	**16**
5	Risk of Change of Standards and Regulations	Q_051	**16**
6	Risk of Change in Scope of Work	Q_061	**18**
7	Improper Scope of Job Definition in Contract	Q_071	**24**
8	Delay of payment	Q_081	**45**
	Tabel 2. Contractor's Responsibilities		
12	Inadequate Technology Risk	Q_121	**18**
13	Theft / Robbery of Material on Site	Q_131	**27**
15	Risk of Labor, Material and Equipment Availability	Q_151	**18**
16	Risk of Labor Disputes and Strikes	Q_161	**36**
17	Poor Subcontractor Performance	Q_171	**16**
22	Shortage / Delay of Material Supply	Q_221	16

Source: Processed Sources, 2020

Analysis of the HOR2 Model

HOR2 is used to determine which action should be taken first if a risk occurs. The steps have been described in the previous chapter. See Table 4. Results of the HOR2 Model as follows:

Table 4. Results of the HOR2 Model

Risk Agent		PA_0111	PA_0112	PA_0113	PA_0511	PA_0611	PA_0711	PA_0811	PA_0812	PA_1211	PA_1311	PA_1312	PA_1511	PA_1512	PA_1611	PA_1612	PA_1711	PA_2211	PA_2212	PA_2213	PA_2214	ARP
Owner's Responsibility																						
Incomplete Design Risks	A_ 011	4	3	4																		16
Risk of Change of Standards and Regulations	A_ 051				4																	16
Risk of Change in Scope of Work	A_ 061					4																18
Improper Scope of Job Definition in Contract	A_ 071						4															24
Delay of payment	A_ 081							4	5													45
Contractor's Responsibilities																						
Inadequate Technology Risk	A_ 121									5												18
Theft / Robbery of Material on Site	A_ 131										4	5										27
Risk of Labor, Material and Equipment Availability	A_ 151												4	3								18
Risk of Labor Disputes and Strikes	A_ 161														4	3						36

Risk Agent		**PA_0111**	**PA_0112**	**PA_0113**	**PA_0511**	**PA_0611**	**PA_0711**	**PA_0811**	**PA_0812**	**PA_1211**	**PA_1311**	**PA_1312**	**PA_1511**	**PA_1512**	**PA_1611**	**PA_1612**	**PA_1711**	**PA_2211**	**PA_2212**	**PA_2213**	**PA_2214**	**ARP**
Contractor's Responsibilities																						
Poor Subcontractor Performance	A_171																4					16
Shortage / Delay of Material Supply	A_221																	4	5	5	3	16
$TE_k = \Sigma(ARP_j{*}E_{jk})$		64	48	64	64	72	96	180	225	90	108	135	72	54	144	108	64	64	80	80	48	
(D_k)		4	3	4	4	4	4	4	5	5	4	5	4	3	4	3	4	4	5	5	3	
$ETD_k = TE_k/D_k$.		16	16	16	16	18	24	45	45	18	27	27	18	18	36	36	16	16	16	16	16	
R_k		6	6	6	6	5	4	1	1	5	3	3	5	5	2	2	6	6	6	6	6	

Source: Processed Sources, 2020

The next step is to rank the results which can be seen in table 5. as follows:

Table 5. PA Rank (Preventive Action)

Code	**Strategy to Be Designed**	**Ranking**
PA_0811	Making a cash flow plan must refer to the work schedule	1
PA_0812	Make the billing document requirements clear	1
PA_1611	Avoid gaps in local and migrant workers	2
PA_1612	Prepare adequate living facilities	2
PA_1311	Prioritizing surrounding communities in recruitment.	3
PA_1312	Create an adequate security system	3
PA_0711	Prepare a clear planner's terms of reference for the contract	4
PA_0611	The smallest possible scope change	5
PA_1511	Make a good Resource execution plan	5
PA_1512	Prepare an adequate stock of materials	5
PA_0111	Prepare a clear planner's terms of reference for the contract	6
PA_0112	The planning consultant's price must be logical.	6
PA_0113	Planning time must be supported by tool capacity analysis.	6
PA_0511	Anticipate changing political conditions	6
PA_1711	Prevent material theft / robbery at the location	6
PA_2211	Make logical unit prices	6
PA_2212	Prepare a less detailed resource implementation plan	6
PA_2213	Make accurate cash flow	6
PA_2214	Prepare alternative materials	6

Managerial Implications

From table 5, the managerial implications are obtained, as follows: Preventive Action (PA) rank 1, there are 2 items originating from the risk agent for payment delay, steps that must be taken are: Make a cash flow plan must be based on a work schedule and create clear billing document requirements. Cash flow planning must refer to a detailed work plan so that the possibility of meeting targets due to limited resources can be avoided. Billing documents must be detailed and complete and must have been sent to the assignor at the specified time. Preventive Action rank 2, there are 2 items originating from the risk agency for labor disputes and strikes, steps that must be taken are: Avoid gaps in local and migrant workers and prepare adequate living facilities. Next, Preventive Action rank 3, there are 2 items originating from the risk agent for theft / robbery of material in the field, steps that must be taken are: Prioritizing surrounding communities in recruitment and creating an adequate security system.

Preventive Action rank 4, there is 1 item that comes from a risk agent whose scope of work definition is not appropriate in the field, steps that must be taken are: Prepare a clear planner's terms of reference for the contract. Preventive Action rank 5, there are 3 items that come from: change the scope of work, steps that must be taken are: As small as possible the scope change: availability of raw materials, labor, and equipment, steps that must be taken are: and make a good implementation plan. Resources: prepare an adequate stock of materials. Next, Preventive Action rank 6, there are 9 items that come from: The design risk is incomplete, steps that must be taken are: Prepare a clear planner's terms of reference for the contract, the planning consultant's price must be logical, planning time must be supported by tool capacity analysis, risk of changing regulatory standards, steps that must be taken are: Anticipate changing political conditions, poor subcontractor performance. Steps to take are: Select a qualified subcontractor, shortage / delay in supply of material. Steps to be taken are: Make logical unit prices. Prepare less detailed resource implementation planning. Creating accurate cash flow and Preparing alternative materials.

V. CONCLUSION

Based on the results of data analysis in the previous chapter, the conclusions that can be drawn from this study are as follows:

- From the results of the FMEA analysis, obtained 11 priority risk agents from 31 existing risk agents.
- 5 Risk agents are the scope of investors and 6 are risk agents for contractors.
- Followed by the agency's scope of inappropriate job definition, risk of changing the scope of work, risk of changing standards and regulations, risk of incomplete design.
- On the Contractor's side, the most dominant risk agent is labor disputes being the first risk agent.
- Of the 11 risk agents, a prevention plan was prepared using the HOR 2 Model several prevention steps, namely: Delay in payment has been the biggest risk agent in several construction projects.
- The risk of labor disputes and strikes is anticipated by minimizing gaps in local and migrant workers.
- From the risk agent priority results of the risk analysis, a prevention plan is prepared so that the risks that occur can be minimized, these steps include; make a financial plan that refers to a detailed schedule, selection of competent contractors, proportional distribution of local workers and migrants, an adequate security system.

VI. REFERENCES

El-Sayegh, Sameh Monir. (2008), "*Penilaian Risiko dan Alokasi dalam Industri Konstruksi UEA*," *Jurnal Internasional Manajemen Proyek*, Vol. 26 Hlm. 431–438.

Keshk, Ahmed Mohamed, Ibrahim Maarouf & Ysory Annany. (2018), "Studi khusus dalam Manajemen Risiko Proyek Konstruksi, Konsep Risiko, Rencana Pembangunan, Analisis Risiko Kuantitatif dan Kualitatif, Strategi Respons Risiko", *Jurnal Teknik Alexandria,* Vol. 57 Iss 4 Hlm. 3179–3187.

Kuncoro, Mudrajad. (2009). *Metode Riset untuk Bisnis & Ekonomi*, Edisi Ketiga. Jakarta: Erlangga.

Project Management Institute. (2004), *A Guide to the Project Management Body of Knowledge (PMBOK Guide) Third Edition*, Project Management Institute, Pennsylvania.

Project Management Institute. (2008), *A Guide to the Project Management Body of Knowledge (PMBOK Guide) Fourth Edition*, Project Management Institute, Pennsylvania.

Pujawan, I. Nyoman & Laudine H. Geraldin. (2009), "House of Risk: Model for Proactive Supply Chain Risk Management*". Emerald Group Publishing Limited*. Vol. 15, No. 6, Hlm. 953-967.

Santos, Flávio Roberto Souza Dos. (2008). "FMEA dan PMBOK Berlaku untuk Manajemen Risiko Proyek",
Jurnal Sistem Informasi Dan Manajemen Teknologi, Vol. 5, No. 2, 2008, Hlm. 347-364.

Shahid Iqbal, Rafiq M. Choudhry, Klaus Holschemacher, Ahsan Ali & Jolanta Tamošaitienė. (2015). "Risk Management in Construction Projects", *Technological and Economic Development of Economy Journal*, Vol. 21:1, Hlm. 65 – 78.

Sugiyono. (2006). *Metode Penelitian Kuantitatif, Kualitatif dan R & D.* Bandung: Alfabeta.

Tamosaitene, Jolanta, Edmundas Kazimieras Zavadskas, & Zenonas Turskis. (2013), "Penilaian Risiko Multi- Kriteria Proyek Konstruksi", *Jurnal Ilmu Komputer Procedia,* Vol. 17 Hlm. 129–133.

Zavadskas, Edmundas Kazimieras, Zenonas Turskis & Jolanta Tamošaitiene. (2010), "Risk Assessment of Construction Projects"*, Journal of Civil Engineering and Management*, Vol. 16:1, Hlm. 33–46 .

Zayed, T.; Amer, M.; Pan, J. (2008). "Assessing Risk and Uncer- Tainty Inherent in Chinese Highway Projects Using AHP"*, International Journal of Project Management,* Vol. 26:4 Hlm. 408– 419.

TOPIC

Risk Management and Analysis

RISK ANALYSIS IN ENGINEERING PHASE OF FUEL OIL TERMINAL REACTIVATION PROJECT IN ORDER TO MINIMIZE REWORK

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ABSTRACT

The risk is a measurable part of uncertainty, for which we can estimate the occurrence probability and the size of damage. Engineering phase is an important stage in project life cycle. An error or misunderstanding in engineering phase may lead to project construction failure, rework and delay. The main purpose of this study is to perform risk assessment and risk analysis to identify the potential risks on Fuel Oil Terminal Reactivation Project owned by Company X in engineering phase. In execution of terminal reactivation projects undertaken by Company Y as EPC, according to existing data frequent incidence of rework and several qualities of work did not meet with the requirement. There have been project delays on terminal facilities operations due to lack of performance in engineering department. Risk variables of this study obtained from literature and data on site and validated by senior engineers with experience more than 15 years in large construction project. The respondents of this study are contractor and client who are involved in this project, especially in engineering phase. The sampling method using questioner distribution and variables of risk have been analyzed using probability-impact matrix. It also used a qualitative descriptive analysis of the risk impacts, risk responses and responsibility party. The result from this study is the identification of high-risk category in the engineering phase. From the analysis obtained 6 from 31 variables most dominant factors which categorized as technical factors, managerial factors and external factors. The three dominant factors including late in design submission, poor management system of contractor and insufficient number of engineers. The risk response used is preventive strategies and curative strategies.

Keywords: Risk Analysis, Oil Terminal, Engineering Phase, EPC Project

1. INTRODUCTION

The downstream industry comprises oil & gas operations that take place after the production phase until the point of sale. This involves refining, processing, transportation and sale of petroleum products. Fuel oil terminal is one of the downstream facilities, for storing oil or hydrocarbon and their derivatives, including loading, unloading, blending and transfer activities. Fuel oil terminal equipped with storage tanks, pipeline facilities for transferring hydrocarbon, loading gantry facilities, pump house, marine loading arm, fire fighting system, marine loading arm etc. Hydrocarbon from oil tanker at jetty area was transferred by marine loading and cargo pipeline then stored at storage tank. The product of petroleum at oil terminal will be distributed to the oil station for sale.

Company X is the Oil & Gas company which has a fuel oil terminal to store and distribute fuel petroleum in Indonesia and located in Gresik, East Java province. The terminal was established in 2008 and was shut down to stop operating in 2014 to 2017. The terminal was activated and re-operated in 2018 after three years of inactivity (mothballed). In terms of reactivation of the terminal, an inspection of all existing facilities is carried out to determine the level of damage during the mothballed period. The inspection results show that it is necessary to repair, construct new facilities, and replace some of the damaged equipment. The percentage of damage to terminal facilities is obtained from reports on the results of inspections by the inspector with notes on recommendations for repairs. Based on the result of the damage that occurred at the terminal facilities, company X then appointed company Y as a contractor to perform engineering, procurement & construction (EPC) work on the terminal activation project in terms of repairing damaged facilities.

At the time of its implementation, it was found that the quality of the work did not meet with the requirement. There is a lot of rework due to lack of performance in engineering department. From the project data, it was found design and fabrication errors at the several times. Rework is defined as the unnecessary effort of redoing an activity that was inaccurately done the first time (Love, 2002). Rework is one of the main contributors resulting in cost overruns and schedule delays in construction projects. From the delays in the project, company X as a client runs the risk of delays in terms of business permits (MIGAS certification) and operational approval letters. This causes the terminal to experience operating delays and disrupt the downstream process where oil cannot be delivered to gas stations and oil sales cannot be carried out. Based on its current conditions, it is important to learn and perform risk management related project in engineering phase. The main objective is minimizing case of rework, therefore it will help in the success of project, complete the project as per project quality, cost and schedule.

2. METHODOLOGY

This research focuses on risk analysis in the fuel oil terminal reactivation project in engineering phase. This study analyzes the risk of rework which has an impact on the project schedule. There are several steps of this study. A risk analysis was carried out starting with the identification of variables, performing a first-stage questionnaire to experts for variable validation, and performing a second-stage questionnaire to obtain high category variables. The variables that have been tested by experts are followed by a second stage survey of the project personnel involved, both from the client and the contractor. The risk variable will be measured using a Likert scale. Severity Index method was used to determine the probability of risk and the impact on the project continuity. The dominant factor which have been identified will be validated by the expert and at the same time the risk responses is discussed against these risk factors.

3. RESULT AND DISCUSSION

Risk Identification

The risk variable in engineering phase obtained from several references of literature studies, data collection in the field and interviews with senior engineers.

Table 1. Risk Variables

No	Code	Risk Factors	References
1	R/T/01	Design error and omission	Farhan, 2017; Fandopa, 2012
2	R/T/02	Late design submission / revision submission	Karim 2006; Dedy, 2017
3	R/T/03	Lack of control on shop drawing	Mahirudin, 2010
4	R/T/04	Miss understanding of specification by Contractor	Lopez, 2010
5	R/T/05	Low quality of design	Lopez, 2010
6	R/T/06	Improper field survey	Aminah, 2003; COAA

7	R/T/07	Ineffective coordination and poor integration of the engineering team	Mahirudin, 2010; Love et al, 2008
8	R/T/08	Lesson learn was not implemented	Dedy, 2017; WBS Company X
9	R/T/09	High level of the scope of work which can't handle by engineer.	Mahirudin, 2010
10	R/T/10	Schedule pressure	Ogunsola, 2018; Love et al, 2008
11	R/T/11	Software or tools is not compatible	Mahirudin, 2010
12	R/T/12	Scope of work was not well identified in engineering phase	Mahirudin, 2010
13	R/T/13	Low competencies of Project Team from Client, lack of knowledge and experiences on the engineering/design stage	Interview Senior Engineer
14	R/M/01	Unclear work specification by Client	Interview Senior Engineer
15	R/M/02	Inadequate coordination between engineer and supervisor	Karim 2006
16	R/M/03	Supervisor was not referring the latest construction drawing	Karim 2006; WBS Company X
17	R/M/04	Inconsistency of organization chart, rules & responsibilities was not well identified	Karim 2006; WBS Company X
18	R/M/05	Lack of quality assurance commitment	Karim 2006; COAA
19	R/M/06	Invalid information from engineer to purchasing personnel.	Interview Senior Engineer
20	R/M/07	Poor management system of contractor / ineffective management	Dey, 2011; Interview Senior Engineer
21	R/M/08	Insufficient of engineer	Aminah, 2003; COAA
22	R/M/09	Poor of document control	Fandopa, 2012; COAA
23	R/M/10	Poor strategy on leadership of Contractor Project Manager	Love et al, 2008
24	R/M/11	Poor of teamwork and communication	Walker, 2009
25	R/M/12	Lack of stakeholder engagement in engineering phase	Interview Senior Engineer
26	R/E/1	Organization chart change	WBS Company X
27	R/E/2	Design change / scope change by Client	Mahirudin, 2010
28	R/E/3	Inadequate of skill engineer	Wellington, 2012; Aminah, 2003; COAA
29	R/E/4	Inadequate of skill supervisor to do design cross-checking	Aminah, 2003; COAA
30	R/E/5	Workers cannot be briefed, poor workers behavior	Walker, 2009; Dedy, 2017
31	R/E/6	Resistance from any advice to contractor	Walker, 2009; Dedy, 2017
32	R/E/7	Longer procurement of material (long lead item)	Aminah, 2003; COAA
33	R/E/8	Material and equipment are out of stock	WBS Company X
34	R/E/9	Unpredicted facilities or equipment damage during work execution	WBS Company X
35	R/E/10	Insufficient of existing data sheet and drawing	WBS Company X

The type of data used in this study is secondary data which used for the initial research variables and the primary data obtained from the results of questionnaires and interviews. The risks in engineering phase categorized into three groups of WBS; technical, managerial and external risks. The identification of the variables is obtained from the literature which is also illustrated in the frame and data from Company X where the independent variables are formulated. From the results of validation by experts who have more than 15 years of experience in construction projects, four risk events were eliminated, and 1 risk event was added. The four risk variables were omitted because at least 3 out of 5 experts stated that the event was less relevant and did not affect the engineering phase of the fuel oil terminal reactivation project. The risk events that are eliminated are:

1. High level of the scope of work which can't handle by engineer. (R/T/09)
2. Workers cannot be briefed, poor workers behavior (R/E/05)
3. Resistance from any advice to contractor (R/E/06)
4. Material and equipment are out of stock (R/E/08)

The variables added are as follows:

1. Low competencies of Project Team from Client, lack of knowledge and experiences on the engineering/design stage (R/T/13)

Validity and Reliability Test

Validity refers to how accurately a method measures what it is intended to measure. This validity test is used to measure the accuracy of every item in the questionnaire. The validity of the item is indicated by the correlation or support for the total item (total score), where the calculation is done by correlating the item score with the item total score. From the results of the calculation of the correlation will be obtained a correlation coefficient that is used to measure the validity of an item and to determine whether an item is suitable for use or not. The value of r table for N = 31 is 0.355 and the calculated r value for all variables is above the r table. Therefore, all variable items are declared valid.

Table 2. Validity Test of Risk Variables

No	Code	Corrected Item-Total Correlation	Result	No	Code	Corrected Item-Total Correlation	Result
1	RT01	0,725	Valid	17	RM05	0,749	Valid
2	RT02	0,632	Valid	18	RM06	0,797	Valid
3	RT03	0,638	Valid	19	RM07	0,785	Valid
4	RT04	0,775	Valid	20	RM08	0,720	Valid
5	RT05	0,715	Valid	21	RM09	0,653	Valid
6	RT06	0,748	Valid	22	RM10	0,688	Valid
7	RT07	0,749	Valid	23	RM11	0,877	Valid
8	RT08	0,706	Valid	24	RM12	0,714	Valid
9	RT10	0,540	Valid	25	RE01	0,707	Valid
10	RT11	0,699	Valid	26	RE02	0,672	Valid
11	RT12	0,552	Valid	27	RE03	0,757	Valid
12	RT13	0,854	Valid	28	RE04	0,777	Valid
13	RM01	0,811	Valid	29	RE07	0,804	Valid
14	RM02	0,811	Valid	30	RE09	0,847	Valid
15	RM03	0,903	Valid	**31**	RE10	0,686	Valid
16	RM04	0,622	Valid				

Reliability test is used to determine the consistency of measuring instruments, whether the instruments used are reliable and consistent if the measurement is repeated. There are several methods of testing this reliability. In this study, Cronbach's Alpha method was used, where the reliability test results can be seen in the Reliability statistics to identify whether the measuring instrument is reliable or not. An instrument is reliable in retrieving the desired data if the Cronbach alpha coefficient is greater than 0.7. The cronback alpha coefficient was calculated using the SPSS 19.0. This test is carried out at the risk level of rework which impact to project delays. Data on risk events are 31 items (31 variables). The coefficient cronback alpha value of the risk variable in this study is greater than 0.7 so that the instrument used in retrieving the data is reliable.

Table 3. Reliability Test of Risk Variables

Reliability Statistics	
Cronbach's Alpha	N of Items
.973	31

Data Analysis

Analysis of risk variables is carried out to analyze the main survey. The analysis is carried out on the risk assessment of project delays as result of rework. From the data, it shows that respondents who have an experience level of 2 to 10 years are 55%, while those with 11 to 25 years of experience are 44%.

The duration of the rework is tracked from the point where the rework is identified from the time the rework is completed and the activity has returned to its original state. The duration of rework includes the duration of the standby/relocation time after the rework is identified, the time required to do the rework, and the time required to prepare to continue with the original scope of activities. An undesirable effect in the form of project delays can occur when critical activities undergo a rework. The simulation of the total project extension can be calculated as follows:

Project Extension (> 0, or 0 if negative) = (New Activity Duration - Original Activity Duration) - Total Float Activity.

Rework that affects the overall project schedule can lead to undesirable results, including project delays and cost overruns. The rework delay equation can be derived as follows:

D*0R* (> 0, or 0 if negative) = ADnew – AD0 - TAF
D*0R*: Rework delay = Project implementation due to
rework ADnew: Duration of new activities after rework
AD0: Original activity
TAF: Total Activity (Activity Total Float)

To find out the value of the probability and impact of risk, the Severity Index (SI) formula is used as follows :

$$SI = \frac{\sum_{i=0}^{4} a_i x_i}{4\sum_{i=0}^{4} x_i}(100\%)$$

a_i = Constanta
x_i = Respondent probability
i = 0, 1, 2, 3, 4,..., n

The risk analysis phase started by conducting a Respondent Survey to obtain the probability and impact value of each relevant and previously validated variable. From the survey results of respondents involved in the project analyzed using the Severity Index (SI) the objective is to obtain a combination of probability assessment results and impact risk. Severity Index value scale was determined and converted to an assessment of the probability and impact of risk as follows:

***Table 4**. Severity Index Level*

Category	*SI (%)*	*Risk Matrix*
Very Likely	80≤ SI<100	5
Likely	60≤ SI <80	4
Moderate	40≤ SI <60	3
Unlikely	20≤ SI <40	2
Rare	SI <20	1

After obtaining the category of probability and impact, an analysis of the risk value is carried out. The risk value is obtained by entering the value into the Probability and Impact Matrix. The categories of probability and impact are Negligible, Low, Medium, High and Extreme. Based on the assessment of probability and impact above into probability and impact, there are 8 risk categories high and 23 risk categories medium.

Table 5. Probability and Impact Matrix

probability \ impact	1 : Trivial	2 : Minor	3 : Moderate	4 : Major	5 : Extreme
5 : Very Likely	M	H	H	E	E
4 : Likely	L	M	H	E	E
3 : Moderate	L	M	H	H	H
2 : Unlikely	L	L	M	M	H
1 : Rare	N	L	L	L	M

Risk Response

Based on the results of the analysis above, there are several risks that are on the scale *"High"* and *"Medium"* that must be managed risks, so that the risk is controlled. High-level risks must be reduced to lower levels According to the Australian Standards (1999), risk reduction is a selective application of appropriate management techniques and principles to reduce the likelihood of events, or their consequences, or both. The risk variable with a high category is then validated by *expert judgment*, to ask for an opinion whether the variable or risk factor is in the high category. The high-risk categories that have been validated will be developed on how to respond / act on these risk events by expert judgement.

Table 6. Probability and Impact Result

Code	Risk Event	Probability Scale	Impact Scale	Matrix	Result
R/T/01	Design error and omission	2	4	8M	Medium
R/T/02	Late design submission / revision submission	3	4	12H	High
R/T/03	Lack of control on shop drawing	2	3	6M	Medium
R/T/04	Miss understanding of specification by Contractor	2	3	6M	Medium
R/T/05	Low quality of design	2	3	6M	Medium
R/T/06	Improper field survey	2	3	6M	Medium
R/T/07	Ineffective coordination and poor integration of the design team	2	4	8M	Medium
R/T/08	Lesson learn was not implemented	3	3	9H	High
R/T/10	Schedule pressure	3	4	12H	High
R/T/11	Software or tools is not compatible	2	3	6M	Medium
R/T/12	Scope of work was not well identified in engineering phase	3	3	9H	High
R/T/13	Low competencies of Project Team from Client, lack of knowledge and experiences on the engineering/design stage	2	4	8M	Medium
R/M/01	Unclear work specification by Client	2	3	6M	Medium
R/M/02	Inadequate coordination between engineer and supervisor	2	3	6M	Medium
R/M/03	Supervisor was not referring the latest construction drawing	2	3	6M	Medium
R/M/04	Inconsistency of organization chart, rules & responsibilities was not well identified	2	3	6M	Medium
R/M/05	Lack of quality assurance commitment	2	4	8M	Medium
R/M/06	Invalid information from engineer to purchasing personnel.	2	4	8M	Medium

R/M/07	Poor management system of contractor / ineffective management	3	4	12H	High
R/M/08	Insufficient of engineer	3	4	12H	High
R/M/09	Poor of document control	2	3	6M	Medium
R/M/10	Poor strategy on leadership of Contractor Project Manager	3	4	12H	High
R/M/11	Poor of teamwork and communication	2	3	6M	Medium
R/M/12	Lack of stakeholder engagement in engineering phase	2	3	6M	Medium
R/E/1	Organization chart change	2	3	6M	Medium
R/E/2	Design change / scope change by Client	2	3	6M	Medium
R/E/3	Inadequate of skill engineer	2	3	6M	Medium
R/E/4	Inadequate of skill supervisor to do design cross-checking	2	3	6M	Medium
R/E/7	Longer procurement of material (long lead item)	3	4	12H	High
R/E/9	Unpredicted facilities or equipment damage during work execution	2	3	6M	Medium
R/E/10	Insufficient of existing data sheet and drawing	2	3	6M	Medium

The risk response in this study is in the form of efforts to prevent a risk event (preventive risk strategies) and efforts to handle it (curative risk strategies) of the causes and impacts of these risks.

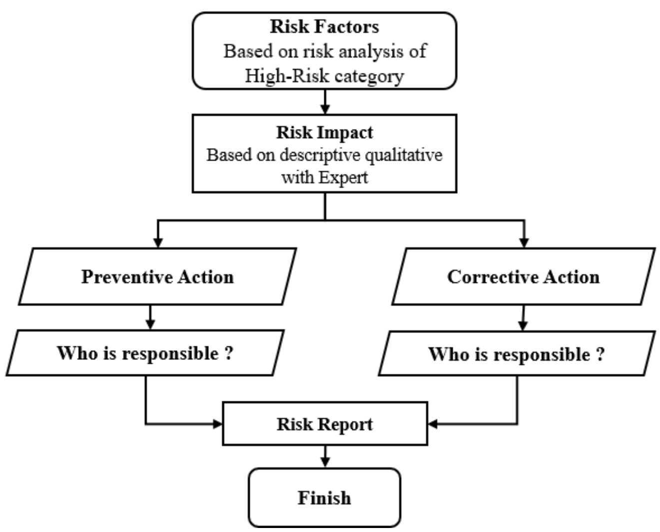

Figure 1. Diagram of the Risk Response Determination Process

Table 7. Impact, Cause and Risk Response of Risk for High Category Technical Aspects

Risk Variable	Impact	Causes	Risk Response	Risk Owner
1. *Technical Aspect*				

1.1 Late design submission / revision submission - RT02	The delay in submitting the last revised drawing resulted in the late receipt of construction documents by the team in the field, so the team in the field did not follow the latest and updated design in carrying out construction activities. This results in a rework due to an image error.	The delay in submitting design drawings by the contractor was due to the small number of drafter and along with several other projects. Several revisions drawing was late submitted for inspection by the Engineer because the drafter was still busy working on the drawings that were needed immediately.	**Corrective:** Adding a team to meet the needs of the project, including drafter and engineer. The team can come from existing contractor employees or recruit if needed to meet project needs. **Preventive:** The scope of work and work methods need to be determined at first. Distribution of personnel following scope of work. The determination of the number of drafter and engineer is based on the work item or field work. Periodically or if there is a delay in submitting design drawings, monitoring and evaluation of the number of drafter and engineers need to be performed.	**Contractor** **Contractor**

4. CONCLUSSION

From the results of the factor analysis on 31 variables, 6 variables were obtained with a high category of 12H, and 2 variables with a value of 9H. Variables or risk events that fall into the high category in the implementation of the Company X fuel oil terminal reactivation project.

a. Technical Aspects
   - Late design submission / revision submission
   - Schedule pressure
   - Lesson learn was not implemented
   - Scope of work was not well identified in engineering phase

b. Managerial Aspects
   - Poor management system of contractor / ineffective management
   - Insufficient of engineer
   - Poor strategy on leadership of Contractor Project Manager

c. External Aspects
   - Longer procurement of material (long lead item)

The risk response as a preventive step that must be taken to overcome high category risks are:

a. Technical Aspects
   - Put additional manpower to meet the project needs including drafters and engineers.
   - Client to performs proper project execution by develop Project Execution Plan for engineering design deliverables, hence the time given to the contractor is reasonable.
   - Develop lesson learn registers during the project.
   - Preparation of SOW documents to ensure that all activities have covered all defined requirements, and there is no additional activities which requirements.

b. Managerial Aspects

- Improve the existing system and establish a good contractor management system. Develop a coordination flow chart which is easy to understand by the workers.
- The recruitment and placement process for engineers must be match between job value and manpower loading based on the type of project handled and the level of difficulty of the project.
- Due diligence for the Project Manager who will run the project, such as interview key personnel by Client

c. External Aspects

The TA approval process is carried out early, hence the procurement of materials can be carried out earlier.

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REFERENCES

Deshpande, A.S., Filson, L.E., Salem, O.M. (2012), “Lean techniques in the management of the design of an industrial project”, *Journal of Management in Engineering*, 28(2): P 221- 223.

Dey, P.K. (2011), “Issues and challenges of managing projects in India: A case study in Budhwar. Doing business in India: Building research-based practice”, New York: Routledge.

Emmanuel, O.O. dan Adedotun A.O. (2016), “A Prototype AHP System for Contractor Selection Decision” P. 299

Karim, E.D., Emad, A.R., Zakariya E.D. (2006), “Risk Management in the design phase of large-scale construction project” P2

Lopez, R., Love, P. E., Edwards, D. J., & Davis, P. R. (2010). “Design Error Classification, Causation, and Prevention in Construction Engineering”, *Journal of Performance of Constructed Facilities*, vol 24, no 4, P 399-408.

Love, P.E.D., Wyatt, A.D., and Mohamed, S. 1997. “Understanding rework in construction. Construction Process Re-Engineering”. Griffith University, Gold Coast, Australia.

Robinson, A.F., Dissanayake, M.P., Campero, O. (2003), *Measuring and Classifying Construction Field Rework: A Pilot Study*, Department of Civil and Environmental Engineering, University of Alberta. Canada.

Rogge, D.F., Cogliser, C., Alaman, H., and McCormack, S. (2001). “An investigation of field rework in industrial construction” Construction Industry Institute.

Walker, D. H. (2009). “Exploratory factors influencing design practice learning within a Thai context”, *Engineering, Construction and Architectural Management*, vol 16, no 3, P 238- 253.

Wellington Didibhuku Thwala and Godfrey Mofokeng (2012), *An Exploratory Study of Problems Facing Small and Medium Sized Contractors in the Free State Province of South Africa*, P.149

Zou, P.X.W., Zhang, G., Wang, J. (2007), “Understanding the key risks in construction projects in China” *International Journal Project Management* 25(6): P 601–614.

RISK ANALYSIS PROJECT FRONTAGE ROAD AND BRIDGE CONSTRUCTION WARU – BUDURAN KABUPATEN SIDOARJO

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ABSTRACT

The Sidoarjo government has taken an initiative to increase the service level of road capacity through the 9.45 km Waru - Buduran Frontage Road Development which has a fairly complex level of implementation. The development has a high probability of risk due to weather factors, the uncertainty of land survey data, uncertainty of land acquisition area maps so that during design and implementation, changes are often made due to conditions in the field. This study aims to analyze the highest level of risk from identified risks, analyze the appropriate risk response, and analyze the contingent costs needed to anticipate the possible risks that occur. This research uses descriptive qualitative and quantitative approaches. The analysis begins by identifying the risks of similar projects, followed by testing the relevance of possible risks and testing the risk impact level. The results of this study found the 9 highest risks such as design changes, inadequate data collection and surveys before the design, traffic management in the construction area, the occurrence of damage to existing buildings due to the impact of construction, access roads for material mobilization and narrow heavy equipment, incomplete compensation for land compensation for both private and state-owned enterprises, coordination, and relocation of existing facilities such as infrastructure, cultural heritage and cemeteries, temporary work stoppages as a result of citizen protests and bad and unpredictable weather conditions.

Keyword: Risk analysis, risk identification, Sidoarjo frontage road

1. INTRODUCTION

Sidoarjo Regency is currently growing very rapidly, especially in the industrial, trade and residential sectors which have resulted in the growth of passenger and goods traffic. This growth causes the service level of National Road 23 to be very low, as evidenced by long queues at intersections and very long delays. This will cause high production costs, especially vehicle operating costs.

The Sidoarjo government has taken an initiative to increase the level of road services through the 9.45 km Waru - Buduran Frontage Road Project which has a fairly complex level of implementation. This development has a high possibility of risk due to weather factors, uncertainty of land survey data, uncertainty of the map of land acquisition area so that during design and implementation, changes are often made due to adjusting conditions in the field. Another possible risk is the uncertainty of the map of land acquisition that has been acquired or where there are still disputes and rejection of the compensation value offered by the Sidoarjo government. The risk of impacting utility buildings also needs to be considered, such as g pipelines (PGN), especially in the Waru (STA 0 + 780) and Aloha (STA 3 + 150) areas, which are planned to be constructed of 12 meter and 20 meter girder bridges with spun piles a depth of 14 meters. Relocation of existing buildings must also be carried out such as relocation of electric poles, telephone poles, railroad guard posts as well as a mosque building and a part of public grave land in the Waru area which certainly has a high social impact.

The failure of planners to provide detailed and adequate drawings, failure of owners to accurately convey field conditions to contractors and failure of contractors to convey changes to subcontractors are risks that have a major impact on transportation project in developing countries (Nguyen, Bhagavatulya, & Jacobs, 2014). The risk of land acquisition consists of 4 risk factors, including: land availability, compensation process, community refusal and the number of land brokers are risks that occur in road construction at the pre-construction stage (Sandhyavitri & Saputra, 2019). Risk management in construction projects is important to ensure that projects are completed on time and on budget. This underlies the need for a risk analysis in the implementation of the Frontage Road Waru - Buduran project.

2. LITERATURE REVIEW

Risk is Uncertainty of an event or events that if it occurs will have a positive or negative impact on project performance in terms of cost, quality and time. Common risk management uses a five-stage process, namely risk identification, qualitative risk analysis, quantitative risk analysis, risk response and risk monitoring. Risk identification is the process of determining the risks that may have an impact on a project and documenting their characteristics. There are several ways (tools & techniques) that can be done to identify risks, including: document review, information gathering techniques, checklist analysis, assumption analysis, SWOT analysis, expert judgment. Risk classification aims to classify the sources of risk that are likely to occur. The identified risks are then assessed in the form of probability and impact using a qualitative approach that is often used to determine the level of risk, namely the probability matrix method and the risk impact. At this stage of quantitative risk analysis, the probability and impact of identified risks will be analyzed using quantitative methods to obtain detailed and comprehensive project risks. The risk response stage is the stage for developing alternative options and responses to increase opportunities and minimize threats to project targets. There are four techniques commonly used to respond to risk, including: risk avoidance, risk transference, risk mitigation, accepted risk (Project Management Institute, 2017).

3. RESEARCH METHODOLOGY

This research is a type of case study research, which examines an object of research in depth, the results of which provide a broad overview of the object. This research is qualitative descriptive and quantitative. Descriptive qualitative, namely analyzing in depth about the background and environmental interactions of certain objects as they are

3.1 Risk Identification

The first technique to get an initial identification of the risk obtained from the project data objects of research and literature studies. Furthermore, from these results, a preliminary questionnaire of respondents was conducted to obtain the relevance of risks that may occur in the project. In order to obtain additional and risk verification, an FGD was conducted with respondents. Respondents of this study were 4 people from PU Bina Marga and Water Resources Sidoarjo Regency and 5 people from Construction Management

3.2 Risk Assessment

Determination of the level of risk using the main questionnaire to the respondent. Respondents of this study were 4 people from PU Bina Marga and Water Resources Sidoarjo Regency and 5 people from Construction Management. The results from processing the probability value and impact value data are then used to determine the level of risk for each risk. The method used in determining the level of risk is the probability impact grid method which is adopted from the Qualitative Risk Matrix - AS / NZS as in Table 3.1.

Table 3.1 Risk Level Assessment Matrix

Probability	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
	1	2	3	4	5
Almost Certain	M	H	H	H	H
Likely	M	M	H	H	H
Moderate	L	M	M	H	H
Unlike	L	L	M	M	H
Rare	L	L	L	M	M

Source : Australian and New Zealand Standards (1999)

4. ANALYSIS AND RESULTS

4.1 Risk Variables

Risk variables from the research Kartam & Kartam (2001), Perera, Dhanasinghe & Rameezdeen (2009), Nguyen et al., (2014), Dang et al. (2017), Szymański (2017), Frontage A. Yani Surabaya project data that has been in construction and the project conditions under study cannot be determined as the research variable used, because this variable needs to be verified whether the variable is in accordance with the research object. From the 6 risk categories and 48 risk variables from the preliminary questionnaire results. FGD participants consisted of the construction management team and the owner associated with the research object project. FGD forum an agreement was obtained into 2 categories, namely during the planning and implementation period, but there are sub 6 categories with 32 risk variables that are considered suitable for the object of this research. The final results of the risk variables in the FGD are shown in Table 4.1.

Table 3.2 Research Risk Variables

NO	RISK VARIABLES
IN THE PLANNING	
I	**DESIGN**
R-1	Design change
R-2	Shop drawing incomplete and unclear
R-3	Unclear survey and data collection before design
R-4	Error in calculating the RAB
IN THE EXECUTION PERIOD	
II	**RISK OF HUMAN RESOURCES**
R-5	Availability of workers
R-6	Lack of / not competent field implementers
R-7	Lack of / not competent field supervisors
III	**FINANCIAL RISKS**
R-8	Increase in material prices due to inflation
R-9	Pending payments
R-10	The occurrence of corruption
IV	**TECHNICAL RISKS**
R-11	Difficulty / delay in material arrival
R-12	Material quality is not suitable
R-13	The occurrence of project delays
R-14	Safety and security in the workplace
R-15	Traffic management in construction areas
R-16	Improper construction method
R-17	Quality of work
R-18	Equipment failure when using at a location which takes a long time to be repaired
R-19	Low productivity and efficiency
R-20	Damage to existing buildings due to construction impacts (PGN pipes and residents' houses)
R-21	Access road for mobilizing difficult materials and heavy equipment
R-22	Conditions and field data do not match the design
R-23	The existence of material theft / sabotage
V	**REGULATION OF THE ENVIRONMENT**
R-24	Intervention during construction
R-25	Regulations and difficulties in obtaining permits and approvals
R-26	Tender Delay
R-27	Change or change of government (political)
R-28	The land compensation for both private and state-owned companies (BUMN) has not been completed
R-29	Coordination and relocation of existing facilities such as infrastructure, cultural heritage and cemeteries
R-30	Temporary suspension of work as a result of citizen protests

NO	RISK VARIABLES
VI	**NATURAL RISKS AND SITUATIONS**
R-31	Bad and unpredictable weather conditions
R-32	The occurrence of force majeure

Source: Kartam & Kartam (2001), Perera, Dhanasinghe & Rameezdeen (2009), Nguyen et al., (2014), Dang et al. (2017), Szymański (2017), Frontage A. Yani Surabaya project data that has been in construction and the project conditions under study

4.2 Risk Assessment

The research variable is then tested how likely it is and how big the impact is. Testing is done by distributing the main questionnaire to the respondents. Respondents of this study were 4 people from PU Bina Marga and Water Resources Sidoarjo Regency and 5 people from Construction Management. There are more than one respondent so that the questionnaire results are collected and the severity index value is calculated. In this study, there are 3 levels of risk with their categories, namely, Low (with code L) is the lowest risk category, Middle (with code M) is a medium risk category and High (with code H) is a high category risk. Determination of the level of risk using a grade matrix. The results of the questionnaire recapitulation are in the table 4.2.

Table 4.1. Determination of Risk Level

NO	RISK VARIABLE	VALUE		RISK INDEX	RISK LEVEL
		PROBABILITY	IMPACT		
IN THE PLANNING					
I	**DESIGN**				
R-1	Design change	4.00	3.00	12.00	H
R-2	Shop drawing incomplete and unclear	3.00	2.00	6.00	M
R-3	Unclear survey and data collection before design	3.00	4.00	12.00	H
R-4	Error in calculating the RAB	2.00	3.00	6.00	M
IN THE EXECUTION PERIOD					
II	**RISK OF HUMAN RESOURCES**				
R-5	Availability of workers	1.00	1.00	1.00	L
R-6	Lack of / not competent field implementers	3.00	2.00	6.00	M
R-7	Lack of / not competent field supervisors	3.00	2.00	6.00	M
III	**FINANCIAL RISKS**				
R-8	Increase in material prices due to inflation	2.00	3.00	6.00	M
R-9	Pending payments	2.00	2.00	4.00	L
R-10	The occurrence of corruption	2.00	2.00	4.00	L
IV	**TECHNICAL RISKS**				
R-11	Difficulty / delay in material arrival	3.00	1.00	3.00	L

R-12	Material quality is not suitable	2.00	2.00	4.00	L
R-13	The occurrence of project delays	2.00	3.00	6.00	M
R-14	Safety and security in the workplace	2.00	3.00	6.00	M
R-15	Traffic management in construction areas	4.00	3.00	12.00	H
R-16	Improper construction method	3.00	2.00	6.00	M
R-17	Quality of work	2.00	2.00	4.00	L
R-18	Equipment failure when using at a location which takes a long time to be repaired	1.00	2.00	2.00	L
R-19	Low productivity and efficiency	2.00	2.00	4.00	L
R-20	Damage to existing buildings due to construction impacts (PGN pipes and residents' houses)	3.00	4.00	12.00	H
R-21	Access road for mobilizing difficult materials and heavy equipment	3.00	4.00	12.00	H
R-22	Conditions and field data do not match the design	2.00	2.00	4.00	L
R-23	The existence of material theft / sabotage	2.00	2.00	4.00	L
V	**REGULATION OF THE ENVIRONMENT**				
R-24	Intervention during construction	2.00	2.00	4.00	L
R-25	Regulations and difficulties in obtaining permits and approvals	2.00	2.00	4.00	L
R-26	Tender Delay	1.00	2.00	2.00	L
R-27	Change or change of government (political)	2.00	2.00	4.00	L
R-28	The land compensation both private and state-owned companies (BUMN) has not been completed	4.00	4.00	16.00	H
R-29	Coordination and relocation of existing facilities such as infrastructure, cultural heritage and cemeteries	5.00	4.00	20.00	H
R-30	Temporary suspension of work as a result of citizen protests	4.00	3.00	12.00	H
VI	**NATURAL RISKS AND SITUATIONS**				
R-31	Bad and unpredictable weather conditions	4.00	3.00	12.00	H
R-32	The occurrence of force majeure	2.00	2.00	4.00	L

Note: L = Low, M = Medium, H = High

Source: Main Survey Questionnaire Results

Based on table 4.2 above, if it is plotted into a probability impact matrix in accordance with the *Australian and New Zealand Standards, 1999* it will look like in Figure 4.1.

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain				R29	
Likely			R1.R15.R30.R31	R28	
Moderate	R11	R2.R6.R7.R16		R3.R20.R21	
Unlike		R9.R10.R12.R17.R19.R22.R23.R24.R25.R27.R32	R4.R8.R13.R14		
Rare	R5	R18.R26			

Remarks: : low risk : medium risk : high risk

Figure 4.1 Plotting of Risk Variables in the Probability Impact Grid

Based on Figure 4.1, there are 9 risk variables in the risk level group that are at a high or intolerable level, which means that the risk is unacceptable, 8 risk variables in the risk level group are at the medium level, which means the risk is still acceptable but needs reduction. the risk level and 15 risk variables in the risk level group that are at the lowest or acceptable level, which means that the risk variable can be accepted without taking mitigation steps. The 9 highest risks such as :

Design changes

Design changes in the project are influenced by the project owner's budget and the condition of the project to be constructed very close to residential areas. Changes in the width of the right of way (ROW) of the road from 10 meters to 15 meters for the TNI AL land area. This is because the owner wants to maximize the land so that the TNI AL is used or fully constructed. The change in the bridge design from the box culvert girder was due to a suggestion from the irrigation agency. Design risk that does not meet the indicated specifications can cause delays, additional costs, decreased performance, increased operating costs or reduced plan life Sandhyavitri, A., & Saputra, N. (2019).

Unclear survey and data collection before design

The data collection and survey referred to are land survey data, coordinate data and the latest price survey. Coordinating data were collected in 2013 but some of these data cannot be used because the road alignment and width plans have undergone revisions from the original design.

Traffic management in the construction area

Traffic management must also be considered because the project location is the traffic flow of heavy vehicles. This has the potential to cause congestion and disrupt work, one of which is the rigid pavement casting. The project location is also close to the railroad linking Surabaya - Sidoarjo which has the potential to also endanger jobs

Damage to existing buildings due to construction impacts

This risk is very likely to occur because the project location is directly adjacent to existing buildings and residents' houses which can cause work to stop if there is damage to the existing buildings. These existing buildings include PDAM pipes, PGN pipes, electricity poles and telephone poles

Access roads for material mobilization and narrow heavy equipment

Access roads for material and heavy equipment mobilization are narrow, which can cause heavy materials and equipment to damage people's homes and cause accidents and scattered materials.

Incomplete compensation for land compensation for both private and state-owned enterprises

The incomplete compensation for land compensation, both private and state-owned, causes work to be hampered, so additional implementation time is needed because land acquisition that has been affected by the road ROW has not been completed. Multiple land certificates held by PT. KAI and residents of the Buduran area also hampered frontage road construction work because it was necessary to trace which data was more authentic and valid.

Coordination, and relocation of existing facilities such as infrastructure, cultural heritage and cemeteries

In this project, there are existing buildings such as railroad gates (JPL 40), gate, security post, electricity and telephone poles located in the ROW area. There are also cemeteries and mosques in the Waru area which are likely to cause high social risks.

Temporary work stoppages as a result of citizen protests

Citizen protests may occur if the environment or community area is damaged or affected due to project work such as damaged roads due to excessive project vehicle loads, dirty roads due to spilled project material and compensation for unfinished land due to inappropriate appraisal values.

Bad and unpredictable weather conditions.

Bad and unpredictable weather conditions on the project greatly interfere with work productivity. This is because the project location is in an open area so that it has a high chance of bad weather. With bad and unpredictable weather occurring on the project all work will come to a halt.

5. CONCLUSION

The results of this study found the 9 highest risks such as design changes, unclear survey and data collection before design, traffic management in the construction area, damage to existing buildings due to construction impacts, access roads for material mobilization and narrow heavy equipment, incomplete compensation for land compensation for both private and state-owned enterprises, coordination, and relocation of existing facilities such as infrastructure, cultural heritage and cemeteries, temporary work stoppages as a result of citizen protests, bad and unpredictable weather conditions. For further research, an appropriate risk response analysis and contingency costs are carried out to anticipate possible risks that occur in the project

6. REFERENCES

Australian and New Zealand Standards. (1999). *Risk Management,* Standards Association of Australia.

Dang, C. N., Le-Hoai, L., Kim, S. Y., Nguyen, C. Van, Lee, Y. D., & Lee, S. H. (2017). Identification of risk patterns in Vietnamese road and bridge construction: Contractor's perspective. *Built Environment Project and Asset Management*, *7*(1), 59–72.

Kartam, Nabil A., & Kartam, S. A. (2001). Risk and its management in the Kuwaiti construction industry: A contractors' perspective. *International Journal of Project Management*, *19*(6), 325–335.

Nguyen, T. H., Bhagavatulya, G., & Jacobs, F. (2014). *Risk Assessment: A Case Study for Transportation Projects in India*. *3*(9), 1–14.

Perera, B. A. K. S., Dhanasinghe, I., & Rameezdeen, R. (2009). Rizikos valdymas tiesiant kelius: Šri lankos atvejis. *International Journal of Strategic Property Management*, *13*(2), 87–102.

Project Management Institute. (2017). *A Guide to the Project Management Body of Knowledge.* 14 Campus Boulevard Newtown Square, Pennsylvania 19073-3299 USA: Project Management Institute, Inc.

Sandhyavitri, A., & Saputra, N. (2019). Analisis Risiko Jalan Tol Tahap Pra Konstruksi (Studi Kasus Jalan Tol Pekan Baru-Dumai). *Jurnal Teknik Sipil*, *9*(1), 1–19.

Szymański, P. (2017). Risk management in construction projects. *Procedia Engineering*, *208*, 174–182.

RISK ANALYSIS OF ENERGY EFFICIENCY PROJECTS BASED ONPERFORMANCE – RATIONALIZATION OF PJU ESCO X

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ABSTRACT

The construction and development of roads, which are almost all equipped with street lighting facilities (PJU), the number of PJU continues to grow with the increase in PJU account expenditures. Efforts to reduce accounts can be achieve with energy efficiency and have been done with the use of solar PJUs. One of it is the problem of the period of returnon investment funds. Therefore, it is important to di energy efficiency projects based on performance. All activities related to energy efficiency must be paid from savings accounts themselves. From this background, the purpose of this study is to obtain the concept of risk mitigation from performance-based energy efficiency projects. This research will discussthe application of Fault Tree Analysis as a risk system to look for risk factors, which enables ESCO (Energy Service Company) to deal with the risk that occur. The process is carried out by risk identification, risk analysis, and risk evaluation. With the FTA method, this study identified 13 risk variables that were assessed according to their probabilities. To reduce risk, mitigation is carried out in the form of in-depth socialization of the ESCO project to all related parties so as to increase the success rate of the project.

Keywords: ESCO, Street Lighting Facilities, Fault Tree Analysis, Energy Efficiency.

1. INTRODUCTION

The energy conservation program is one of the government's priorities in ensuring national energy security. In this regard, one of the biggest energy savings potentials of the country comes from the use of electricity in Public Street Lighting (PJU). Along with the construction and development of roads, the number of PJU points continues to increase, resulting in an increase in payment for PJU accounts. However, this was not accompanied by an increase in the value of the Regional Budget (APBD). So that local governments often find it difficult to pay PJU bills, especially if it is related to the electricity subsidies that have to be borne by the very large government. In addition, the cost of PJU accounts will increase from year to year if they do not use energy efficiency.

The cooperation pattern that adopts a performance-based cooperation business model promoted by ESCO (Energy Service Company) can be a solution. By implementing an energy saving performance contract where selected private parties can carry out construction,rehabilitation and management of PJUs at their own expense with the guarantee that they can save a certain amount of energy and are mutually agreed upon and given management rights to obtain a return on capital with reasonable benefits from the energy savings of PJUs. was successfully achieved.

This study will analyze a performance-based energy efficiency project based on an unsolicited scheme from the point of view of implementing risk, namely ESCO X. Therefore, an analysis of the risks inherent in ESCO energy efficiency projects, especially Unsolicited is carried out. This risk needs to be known to the root of the problem, so the use of FTA (Fault Tree Analysis) is applied in this study to analyze the factors that cause an energy efficiency project not to be implemented. This method is expected to explain the root causes of this risk.

2. LITERATURE REVIEW

ESCo (Energy Service Company)

According to the Energy Efficiency Directive (EED.2012 / 27 / EU) ESCO is a company that offers energy services, including the implementation of energy efficiency projects to sustainable energy projects. The scope of work of ESCO includes: energy analysis and audits, energy management, project design and implementation, maintenance and operations, monitoring and evaluation of savings, energy suppliers, and energy consultants. Bertoldi (2014)

In the efficiency project undertaken by ESCO, there are two types of project schemes, Solicited and Unsolicited, where these two types have differences, as follows:

- Solicited

  The Solicited Scheme is an investment process for implementing projects in certain sectors, which are based on project ideas from the initiation of the ministry or government or project owner.

- Unsolicited

  This scheme is a collaborative project proposed by a private business entity outside of a project proposed by the government or not yet included and registered in the master plan in the related sector.

FTA (Fault Tree Analysis)

According to Kocecioglu (1991), FTA is a simple fault tree analysis which can be described as an analytical technique. The fault tree is a graphical model that involves various parallels and various combinations of pilot errors that will result in the occurrence of undesirable events that have been previously defined or can also be interpreted as a description of the logical interrelationships of basic events that lead to events that undesirable to be the culmination of events.

Minimal Cut Set

To determine the minimum cut set used in FTA is the MOCUS (Method Obtain Cut Set) method. MOCUS is an algorithm that is used to obtain a minimum cut set. According to Clemens (2002) cut set is a combination of forming a fault tree, which if all happens will cause the peak event to occur. Cut Sets are used to evaluate fault tree diagrams and are obtained by drawing a linethrough the blocks in the system to show the minimum number of failed blocks that caused the entire system to fail.

In the fault tree analysis, there are OR and AND gates, where the OR gate is a gate that describes a combination of events that exist in the problem being raised. The OR gate is equivalent to the symbol "+". For n events the input events depicted on the OR gate are equivalent to the formula $T = C1 + C2 + \ldots + Cn$ for T are the output events (probability) and C1, C2,…, Cn are the input events (Vesely et al. 2009). Meanwhile, the AND gate is a gate that describes an intersection of events. The AND gate is equivalent to the symbol ".". For n events the input at the AND gate is equivalent to the formula T = C1 * C2 *… * Cn. In the fault tree "0" is defined as a failure event that did not occur and "1" is defined as a failure event that occurred.

3. RESEARCH METHOD

This type of research is a descriptive type of research, which aims to collect actual information in detail describing existing symptoms, identifying problems or seeing conditions in the field. In this study, research was carried out on risk assessment at ESCO X in Magetan
to be able to assess which risk is the highest in order to be mitigated or handled, so that the ESCO energy efficiency project can run.

The methods used for primary data collection are questionnaires and interviews with experts or experts involved in the ESCO energy efficiency project. Data collection is carried out by parties directly related to the ESCO energy efficiency project. Secondary data used is the one used is based on a literature review on a similar ESCO energy efficiency project.

Based on the qualifications of the respondents, the number of respondents used in this project is 5 people. They will be given a questionnaire and interviewed to find out the existing problems. The analytical method used in the data processing process is Fault Tree Analysis (FTA),this method is considered the most suitable for the conditions on the project. This is because the main problem (top event) in the project is already known. So, it is necessary to find the factors forming the problem, which are not known in detail.

The provisions for the risk index assessment against time are based on the frequency of events / probabilities that will be given by the expert judgment based on the probability scale from Heldman's (2005) publication, namely a value scale of 0.05 (will never happen) to 0.8 (always happens). Table 1 shows the probability scale rating criteria for an assessment of occurrence frequency:

Table 1. Probability Rating Criteria

Score	Description
0.8	Very Critical
0.6	Critical
0.4	Significant
0.2	Negligible
0.05	Very Negligible

From the results of the risk value assessment will be analyzed using FTA.

Table 2. Basic Event Probability

Code	Basic Event
A.1.1.1	Lack of knowledge on the reliability of ESCO
A.1.1.2	Unclear user requirements for the project
A.1.2.1	Unsolicited collaboration is still new
A.1.2.2	Lack of regulations regarding the EE ESCO project
A.2.1	Lack of coordination between users and contractors
A.2.2	Late instructions given by the user
B.1.1.1	PJU procurement standards are different for each region

B.1.1.2	Change of Stakeholders
B.1.3	Lack of legal policies compatible with ESCO energy efficiency projects
B.2.1	Accounting calculation errors
B.2.2.1	Quite high administrative and transaction costs
B.2.2.2	Lack of a rational and feasible approach to financing EE ESCO projects
B.2.2.3	ESCO energy efficiency projects have long cycles and high financing

4. RISK ANALYSIS

The use of FTA is intended to thoroughly explain the causes of risks to ESCO energy efficiency projects. All these processes will be described in the form of the root of the FTA fault tree diagram, it is hoped that later the root causes of the problem can be found.

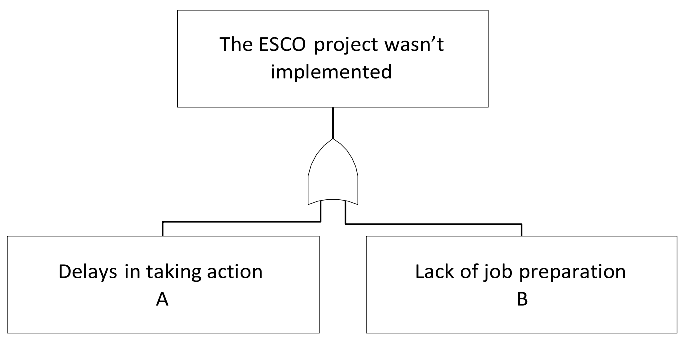

Figure 1. Top Event on ESCO project

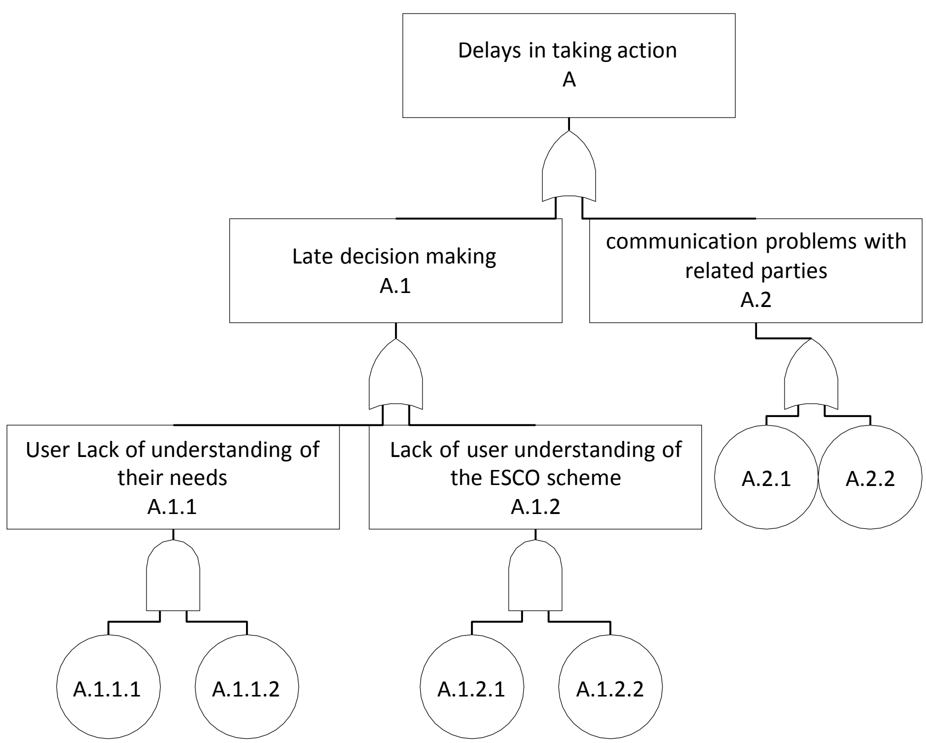

Figure 2. Risk factors due to delay in taking action

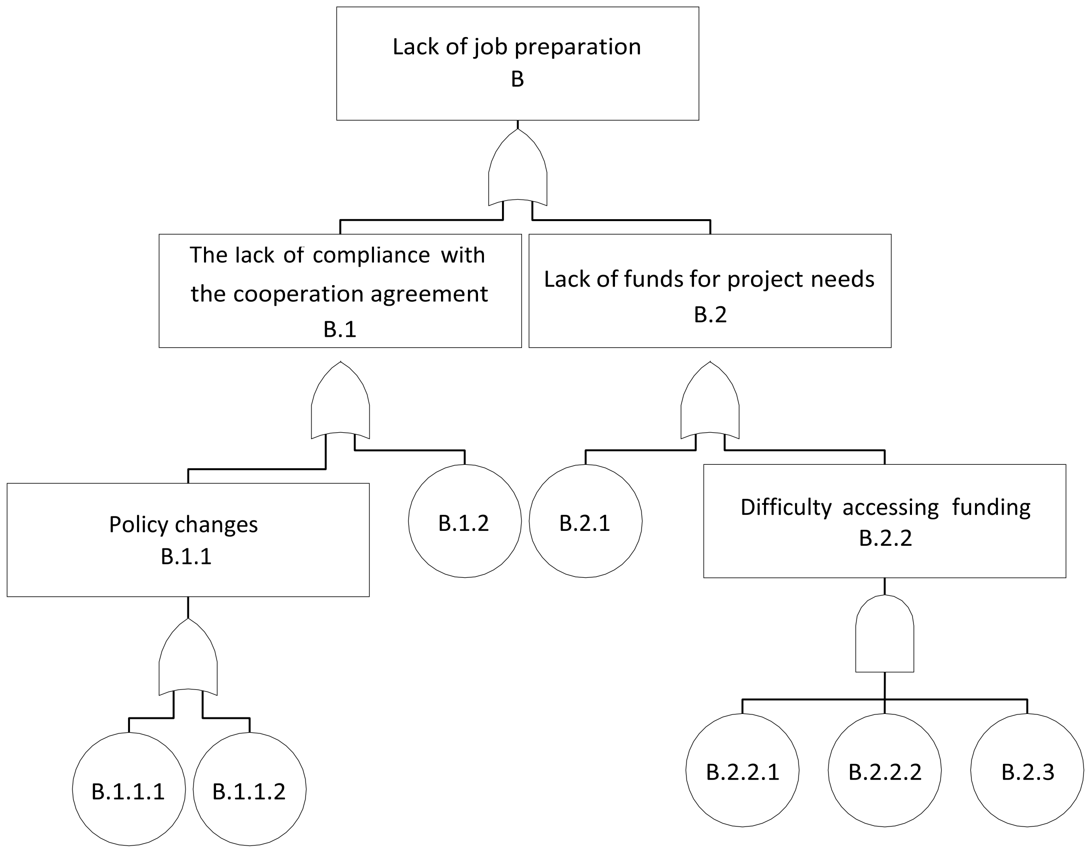

Figure 3. Risk factors due to lack of job preparation

Basic Event Combination

The process of describing the FTA diagram (Fault Tree Analysis) has been carried out. The next step is to analyze the Fault Tree quantitatively using the logic gate law where there is a probability formula in addition (or gate) and multiplication (and gate).

The purpose of this analysis is to find a minimum cut set. Cut set is a combination that forms a fault tree. If all factors occur, the peak event or major risk will occur. Minimal cut set is a combination of the smallest events.

A = A.1 + A.2
= (A.1.1 + A.1.2) + (A.2.1 + A.2.2)
= ((A.1.1.1 * A.1.1.2) + (A.1.2.1 * A.1.2.2)) + (A.2.1 + A.2.2)

Table 3. Minimal Cut Set of a delay in taking action

Code	Probability
A.1.1.1	0,8
A.1.1.2	0,4
A.1.2.1	0,8
A.1.2.2	0,4
A.2.1	0,2
A.2.2	0,4
Minimal Cut Set	0.778

B = B.1 + B.2
= (B.1.1 + B.1.2) + (B.2.1 + B.2.2)
= ((B.1.1.1 + B.1.1.2) + B.1.2) + (B.2.1 + (B.2.2.1 * B.2.2.2 * B.2.2.3))

Table 4. Minimal Cut Set for lack of job preparation

Code	Probability
B.1.1.1	0,2
B.1.2.2	0,05
B.1.2	0,6
B.2.1	0,05
B.2.2.1	0,2
B.2.2.2	0,4
B.2.2.3	0,8
Minimal Cut Set	0.5945

The next stage is to calculate the total number of minimum cut set combination probabilities for the Top Event. Where for the event "Delay in taking action" the probability is 0.778, the event "Lack of preparation for work" the probability is 0.5945. Then each minimum cut set added will know the total value of the minimum cut set probability for the top event, which is:
T = C1 + C2 + … + Cn
T = A + B
= 0.778 + 0.5945
= 0.8972

5. CONCLUSIONS AND SUGGESTIONS

Based on the analysis and discussion that has been done, it can be concluded that the most important risks are: (1) Risk of "Lack of knowledge of the reliability of ESCO" can be overcome with socialization and education about the ESCO business model, the benefits of cooperation, and the motivation for the importance of energy saving need to be carried out by users as well as ESCO (2) The risk of "unsolicited cooperation as new" can be overcome with central government as a policy maker is needed to socialize the unsolicited project ESCO scheme. Where the guarantee of payment for ESCO services is payment from saving after achieving the KPI target (energy efficiency and reducing energy costs), and facilitating the financing of energy conservation projects (3) Risks "ESCO energy efficiency projects are long cycle and high financing" handled by the guarantee of payment certainty from the client or user for the unsolicited scheme and socializing it to guarantor and financing institutions so that it is easy to accept and understand.

6. REFERENCES

Augustins, Edgars, Dzintars Jaunzems, Claudio Rochas, and Agris Kamenders., (2018). Managing Energy Efficiency of Buildings: Analysis of ESCO Experience in Latvia. *Energy Procedia*, Elsevier Ltd, 614–23.

Bertoldi, Paolo, and Benigna Boza-Kiss., (2017). Analysis of Barriers and Drivers for the Development of the ESCO Markets in Europe.” *Energy Policy* 107: 345–55.

Buganová, Katarína, and Jana Šimíčková., (2019). Risk Management in Traditional and Agile Project Management. *Transportation Research Procedia*, Elsevier B.V., 986–93.

Ellis, Jennifer, and International Institute for Sustainable Development (IISD). 2010. "EnergyService Companies (ESCOs) in Developing Countries." (May).

Joubert, Hpr., (2016). *Improved Risk Management Processes for South African Industrial ESCos*.Kleindorfer, Paul R., (2012). Risk Management for Energy Efficiency Projects in Developing Countries. *SSRN Electronic Journal*.

Liu, Guiwen, Saina Zheng, Pengpeng Xu, and Taozhi Zhuang., (2018). An ANP-SWOT Approachfor ESCOs Industry Strategies in Chinese Building Sectors. *Renewable and Sustainable Energy Reviews* 93: 90–99.

Peixoto, Joana, Anabela Tereso, Gabriela Fernandes, and Rui Almeida., (2014). Project RiskManagement Methodology: A Case Study of an Electric Energy Organization. *ProcediaTechnology* 16: 1096–1105.

Qian, Dong, and Ju'e Guo., (2014). Research on the Energy-Saving and Revenue Sharing Strategyof ESCOs under the Uncertainty of the Value of Energy Performance Contracting Projects. *Energy Policy* 73: 710–21.

Rolik, Yurii., (2017). Risk Management in Implementing Wind Energy Project. *ProcediaEngineering*, Elsevier Ltd, 278–88.

Suhonen, Niko, and Lasse Okkonen., (2013). The Energy Services Company (ESCo) as BusinessModel for Heat Entrepreneurship - A Case Study of North Karelia, Finland. *Energy Policy* 61: 783–87.

Vedpuriswar, A V., (2014). Operational Risk Management in the Energy Industry. *ManagementSolutions* (Oct): 255.

Vine, Edward., (2005). "An International Survey of the Energy Service Company ESCO Industry. *Energy Policy* 33(5): 691–704.

RISK ANALYSIS AND RESPONSE PLAN IN CONVEYOR SYSTEM DEVELOPMENT PROJECT IN THE AREA OFFSHORE

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ABSTRACT

The purpose of this study is to provide an accurate description of the high category risk factors that may appear in the conveyor system construction project undertaken by PT Weltes Energi Nusantara, along with the appropriate risk response to minimize the impact of these high category risks. The method used is a case study with research data obtained from the FGD and interviews with research informants. The data obtained were analyzed using EMV and a decision tree to obtain the most effective response for each identified high risk category. The results of the study stated that there were 8 high category risks with the response to each of these risks as follows: The most effective response to the risk of heavy equipment damage is to check the crane repair history record. The most effective response to inefficient use of heavy equipment is to make schedules and targets for field supervisors. The most effective response to risks to lifting operations is to select the conditions in which the crane lift sensors are operating accordingly. The most effective response to design changes due to changes in field conditions is to involve operations, project supervisors, and maintenance during the design process and request approval with the agreed design. The most effective response to risks to barges while operating is to survey the sea lanes where the barges pass to determine the condition of the route. The most effective response to the risk of balancing the weight capacity of the barge with the weight of the conveyor is to perform manual calculations and simulations using the barge load capacity software with the largest conveyor segment. The most effective response to the risk of cainblock breaking during conveyor erection is to check the cainbloc certificate. The most effective response to the risk of a traveler breaking during conveyor erection is to calculate the traveler's capacity and perform software simulations on loads greater than 50% of the calculation.

Keywords: Risk management, conveyor, qualitative-quantitative analysis, expected monetary value, decision tree.

1. INTRODUCTION

The construction of the conveyor system project for the offshore area of PT Petrokimia Gresik by PT Weltes Energi Nusantara has several challenges that must be faced during the process. Specifically, the challenges faced in the work area of the M7102-2E and M7102-2F projects include the occurrence of sea level tides, limited access to construction work, the impact of environmental pollution and erratic ocean currents (Anwar, 2014). So that in the working process there will be a risk that might occur. Development in offshore areas needs to be considered because the impacts that arise can be detrimental to related parties (Indraswari et al., 2018).

Another thing that needs to be considered in the construction of a conveyor project in an offshore area besides the problem of cost and access to the work site is the problem of potential risks that the project may have. This is in accordance with research findings by Indraswari, Norken, & Suthanaya (2018) which state that infrastructure development in the port area has various potential risks from various aspects that must be anticipated. These risks are from the aspects of political policy, environmental risk, planning risk, marketing risk, economic risk, financial risk, natural risk, project risk, technical risk, human risk, criminal risk, safety risk. According to Pratama (2014), the potential risks possessed by a development project in the port area can be divided according to the project implementation stages, namely the pre-construction stage, the construction stage and the operational stage. The potential risks at the pre-construction stage consist of political risks; potential risks at the construction stage consist of environmental risk, planning risk, economic risk, financial risk, natural risk, project risk, technical risk, human risk and safety risk; potential risks at the operational stage consist of natural risks, social risks and political risks.

The most potential risk in the conveyor system construction project undertaken by PT Weltes Energi Nusantara is at the construction stage because the work location is in an offshore area, so it has a high level of difficulty. Thus it is necessary to carry out further risk identification to find out all the risks that must be faced at that stage.

Based on the description above, this research was carried out with two objectives, namely: 1) Conducting risk identification analysis and risk assessment to determine the high category risk in the conveyor system project development project in the offshore area of PT Petrokimia Gresik; and 2) Analyze the risk response form for each high category risk in the construction project of the PT Petrokimia Gresik offshore conveyor system project. The various risks that may arise in the project will be identified using a literature study reinforced by the results of a focus group discussion (FGD) with related parties, which are then analyzed qualitatively and quantitatively to obtain the most effective response to address any high category risks that may arise. in a conveyor construction project by PT Weltes Energi Nusantara.

2. METHOD

2.1 Research Data

The type of data used in this study is primary data. The primary data includes probability data and impact data obtained from informants through Focus Group Discussion (FGD) and interviews.

2.1.1 Focus Group Discussion (FGD)

The use of FGD as a data collection method in this study is in accordance with the provisions in the Project Management Body of Knowledge (PMBOK) established by the Project Management Institute (PMI), which is about using expert judgment in an effort to identify the risk of events in a project. along with the most effective responses to overcome them.

2.1.2 Interview

Interviews were conducted to deepen the information needed to support the answers provided by the informants in the FGD. Interviews were conducted after the FGD was held with informants, so that the information obtained from the FGD could be deepened.

2.2 Research Variable

The variables in this study were obtained from literature studies and field studies by interviewing the construction expert judgment involved in the construction of this conveyor project. The variable is a list of identification of risks that may occur when the construction of conveyors in offshore areas is carried out. Especially the risk identification that will be discussed is the stages during the implementation of the conveyor construction. According to Anwar (2014), the determination of risk sources during project implementation is human, technical, and environmental sources. So in the synthesis of this research, risk identification is carried out at each stage of the work, with sources of risk focused on human risks, technical risks and environmental risks. The following is a synthesis of job risk variables at each stage of work:

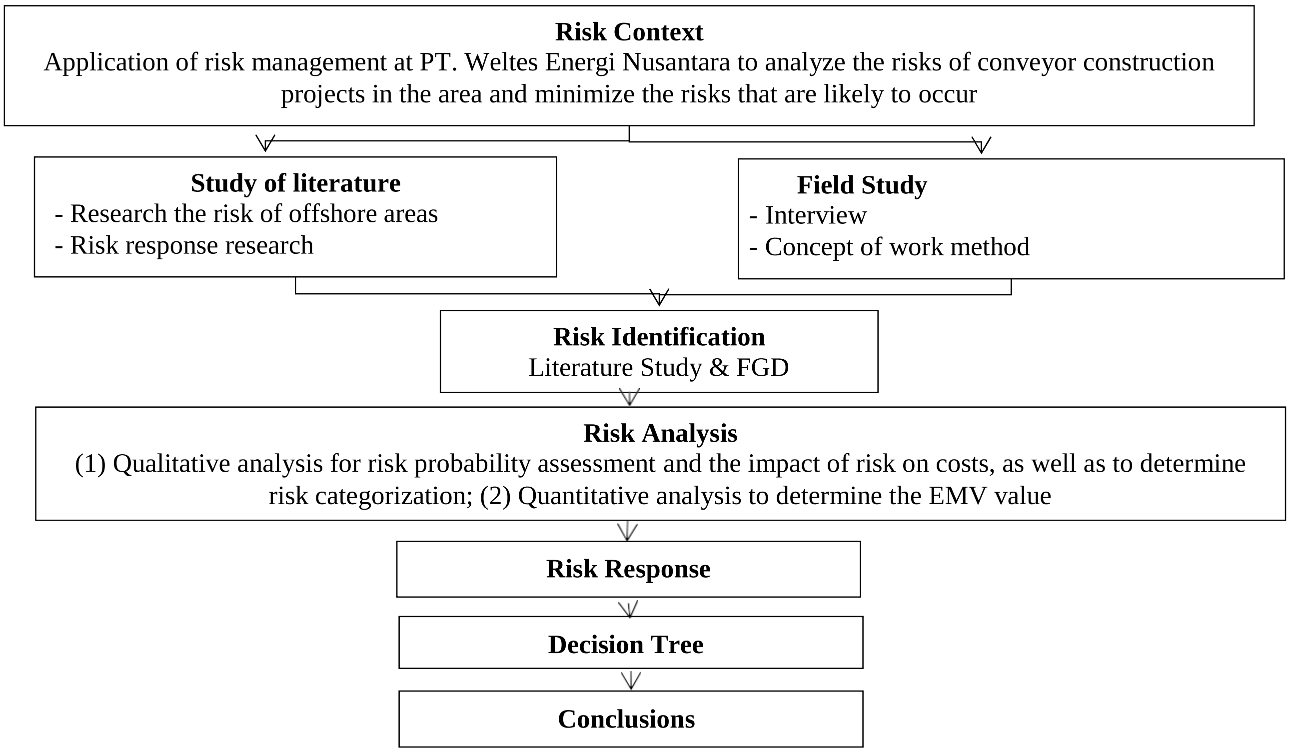
Table 1. Risk Variable for Offshore Area Conveyor Project Development

No	Risk Identification	Source
1	**Assembly Conveyor Stage**	
	Technical Risk	
	There is a heavy equipment failure	Anwar, (2014)
	less efficient use of heavy equipment	Anwar, (2014)
	Unproductive construction equipment	Indraswari et al. (2018)
	Delay in mobilization	Prabowo, (2016)
	Risks to surgical removal	Prabowo, (2016)
	Material or equipment needs are imported from outside Gresik	Pratama, (2014)
	Material damage due to loading and unloading	Pratama, (2014)
	Overtime lighting malfunction	Pratama, (2014)
	Design changes due to changes in field conditions	Pratama, (2014)
	Natural Risks	
	Potential damaging natural disasters during project implementation	Indraswari et al. (2018)
	Human Risk	
	Conflict between contractor and client / supervisor	Prabowo, (2016)
	Shortage of qualified workers	Prabowo, (2016)
	Operators work not according to procedure and instructions	Pratama, (2014)
	Work is carried out at night	Pratama, (2014)
	Lack of coordination between workers.	Indraswari et al. (2018)
	Environmental Risk	
	Environmental pollution from cleaning activities	Prabowo, (2016)
2	**Moving Conveyor Stage to the Installation Area**	
	Technical Risk	
	Unproductive construction equipment	Indraswari et al. (2018)
	Natural Risks	
	Ocean currents or waves	Pratama, (2014)
	high tide	Pratama, (2014)
	Potential damaging natural disasters during project implementation	Indraswari et al. (2018)
	Human Risk	
	Shortage of qualified workers	Prabowo, (2016)
	The tug boat operator worked not according to procedure and instructions	Pratama, (2014)
	Work is carried out at night	Pratama, (2014)
	Lack of coordination between workers.	Indraswari et al. (2018)

No	Risk Identification	Source
	Environmental Risk	
	Community actions that have not accepted the project's existence	Pratama, (2014)
3	**Erection Conveyor Stage**	
	Technical Risk	
	Unproductive construction equipment	Indraswari et al. (2018)
	Design changes due to changes in field conditions	Pratama, (2014)
	Natural Risks	
	Ocean currents or waves	Pratama, (2014)
	high tide	Pratama, (2014)
	Potential damaging natural disasters during project implementation	Indraswari et al. (2018)
	Environmental Risk	
	Community actions that have not accepted the project's existence	Pratama, (2014)

Source: Processed Sources 2020

2.3 Research Flow



2.4 Risk Identification

The identification of the risks of this research is carried out by gathering information from respondents and studying literature. Tools for determining risk categories use the risk breakdown structure method, where this method can be used to classify risks into a logical, systematic, and structured risk hierarchy composition according to the conditions of the conveyor construction project in the offshore area.

In accordance with the risk identification tools according to PMI (2008) risk identification is obtained from a literature study, which is then complemented by the FGD results to determine risks from literature studies relevant to the research context as well as additional risks that are in accordance with the knowledge of the respondents who participated in the FGD. In accordance with attachment 4 the working method of conveyor construction in the offshore area is a brief description as follows:

1. Conveyor assembly process in the dock area
2. Moving conveyor installation point using a barge
3. Erection conveyor from barge to conveyor installation point

In each conveyor construction work process, of course, different risks. The source of risk is something that must be known in risk identification (Godfrey, 1996). So that in this study the temporary variables in Table 1. become FGD material which will then get additional variables and find out specific variables for further analysis.

2.5 Qualitative Data Analysis

Project risks that have been identified are then analyzed qualitatively, which is based on data obtained from FGDs with research respondents to obtain an assessment of risks in order to obtain the information needed for further analysis. The risk aspects assessed in the FGD consist of the possibility of unwanted events as a consequence of project risk; the final result of the risk; adverse effects or benefits that can be received from the risk; probability or chance of risk occurring; and the time the risk is likely to occur (Gray & Larson, 2006).

Qualitative analysis is carried out by referring to the probability scale in accordance with table 2 which is used as the basis for assessing the possibility of risk and filling in the impact scale according to table 3. The standard used to determine the categorization of possible risks, that a risk is said to have a very high, high probability, moderate, low, or very low if it occurs with a certain frequency and within a period that refers to the previous project. Based on these standards, each informant can have the same perception in assessing the likelihood of events for each risk.

Table 2. Assessment of Possible Risks

Score	Predicate	Description
0.1	Very low	It tends to be impossible
0.3	Low	It's unlikely
0.5	Moderate	Just as likely happened and did not happen
0.7	High	Most likely happened
0.9	Very high	Very likely will happen

Source : Keshk, Maarouf, & Annany (2018)

Table 3. Risk Impact Assessment on Cost

Project Objectives	Predikat, deskripsi, dan Score				
	Very low	Low	Moderate	High	Very high
	0.05	0.1	0.2	0.4	0.8
Cost (Against Target Profit)	Increased costs are not important	≤ 5% increase	5% <Increase ≤ 10%	10% <Increase ≤ 20%	Increase> 20%

Source : Keshk, Maarouf, & Annany (2018)

2.6 Quantitative Analysis

After qualitative analysis is carried out, quantitative analysis is also carried out as measurable data to determine the impact on costs using expected monetary value (EMV) and a decision tree. The use of these two instruments in risk analysis has been carried out by Dey (2012), where EMV is used to determine the costs that must be incurred for each alternative response, while the decision tree is used to select the best response among several alternative responses.

2.7 Risk Response

Based on the results of the Expected Monetary Value, then we look for the most appropriate response for each high risk according to the respondent's opinion obtained through interviews. The data taken is the percentage of the effect of the response effort and how much the response effort costs.

2.8 Decision Tree

By using a decision tree, a comparison is made between the cost of the response and the effect of the response effort. If the cost of the response is less than the impact, the response is profitable. Vice versa, if the cost of the response is greater than the impact after it has been done, then the response is not profitable and another alternative is needed. Previous research that suggested the use of a decision tree in the quantitative analysis of risk was Keshk et al. (2018) and Sari (2016). The use of a decision tree allows analysis for decision making that contains several possible response scenarios to overcome the identified high risks. The result of the decision tree is an alternative response that has the most optimal value.

3. RESULTS AND DISCUSSION

3.1 Analysis of Risk to Likelihood and Impact

Based on the results of the FGD and the use of consent tools, it is possible to obtain the possible value of the risk and the resulting cost impact. This information is then used to determine the risk category until the 8 high risk variables are obtained in the project studied in this study. The risks belonging to the high category include:

Table 4. High Category Risk Value

Risk Identification	Probability Value	Impact Value	Risk Value
Assembly Conveyor Stage			
There is a heavy equipment failure	0,3	0,8	0,24
less efficient use of heavy equipment	0,5	0,4	0,2
Risks to surgical removal	0,3	0,8	0,24
Design changes due to changes in field conditions	0,5	0,4	0,2
Moving Conveyor Stage to the Installation Area			
Barge damage	0,3	0,4	0,12
Unbalance between the weight capacity of the barge and the weight of the conveyor	0,3	0,8	0,24

Risk Identification	Probability Value	Impact Value	Risk Value
Erection Conveyor Stage			
Chainblock breaks during erection conveyor	0,3	0,8	0,24
Traveler breaks during erection conveyor	0,3	0,8	0,24

3.2 Expected Monetary Value (EMV)

The impact value with a known percentage as presented in the table above is then calculated in a detailed cost through FGD. These values are used to calculate the EMV value as follows:

Table 5. High Category Risk EMV Value

Identifikasi Risiko	Probability Value	Impact Value	EMV
Assembly Conveyor Stage			
There is a heavy equipment failure	0,3	IDR 130.356.000	IDR 39.106.800
less efficient use of heavy equipment	0,5	IDR 146.040.000	IDR 73.020.000
Risks to surgical removal	0,3	IDR 415.040.000	IDR 124.512.000
Design changes due to changes in field conditions	0,5	IDR 51.180.000	IDR 25.590.000
Moving Conveyor Stage to the Installation Area			
Barge damage	0,3	IDR 365.982.000	IDR 109.794.600
Unbalance between the weight capacity of the barge and the weight of the conveyor	0,3	IDR 365.982.000	IDR 109.794.600
Erection Conveyor Stage			
Chainblock breaks during erection conveyor	0,3	IDR 409.520.000	IDR 122.856.000
Traveler breaks during erection conveyor	0,3	IDR 347.768.000	IDR 104.330.400

Based on the data above, it can be seen that the greatest EMV value at the assembly conveyor stage is at the risk of the lifting operation with an EMV value of IDR. 124,512,000. At the stage of moving conveyor to the installation area, the EMV value of the two risks is the same, which is IDR 109,794,600. The greatest EMV value at the erection conveyor stage is the risk of chainblock breaking, which is IDR. 122,856,000.

If the risks between development stages are compared, it can be seen that the first largest EMV value is at the assembly conveyor stage, which is the risk to the lifting operation with an EMV value of IDR 124,512,000. The second largest EMV value is at the erection conveyor stage, which is the risk of the cainblock breaking during the erection conveyor with an EMV value of IDR. 122,856,000. The third largest EMV value is at the stage of moving conveyor to the installation area, namely damage to the barge and unbalanced weight capacity of the barge with the weight of the conveyor with EMV values of IDR 109,794,600

3.3 Calculation of Decision Tree

The response to the risk of heavy equipment damage during the conveyor assembly process in a conveyor system construction project has a quite high probability of happening, namely 30%, with a cost impact value of IDR 130,356,000. Based on the results of the interview, three alternative responses were obtained that could be applied to reduce the cost impact of these risks. The alternatives consist of selecting a heavy equipment vendor that has high credibility, checking the crane repair history records, and renting a crane with a new year of use. The following is the calculation of an effective response to reduce the risk value :

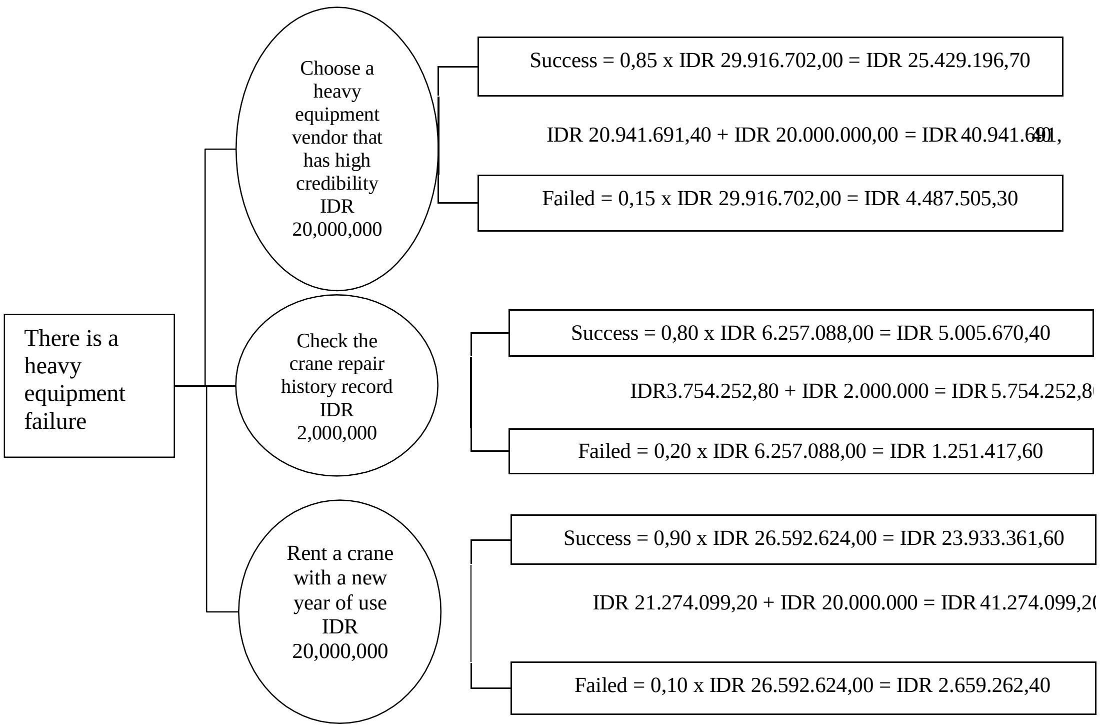


Figure 1. Decision tree for response to the risk of heavy equipment damage

The results of the analysis using the decision tree above show that the three alternative responses to the risk of inefficient use of heavy equipment can provide benefits because they can reduce the impact of increased costs due to risks. The alternative that is considered to provide the greatest benefit among the three alternatives is the second response, namely making schedules and targets for field supervisors. This alternative is the most effective response because it has the lowest risk value after response than the other two alternatives. Based on the analysis using a decision tree, the best risk response is obtained for each high risk category. The following is the risk response:

Table 6. Response to High Risk

No	High risk	Alternative response	The most appropriate response
1	There is a heavy equipment failure	1. choose a heavy equipment vendor that has high credibility 2. Check the crane repair history record 3. Rent a crane with the new year of use	Check the crane repair history record
2	less efficient use of heavy equipment	1. Choose a manpower that is experienced 2. make schedules and targets for field supervisors, 3. Choose the operator of the rigger who has the certificate and experience	make schedules and targets for field supervisors
3	Risks to surgical removal	1. select the conditions on the crane lift sensor operating according to the actual 2. Rent a crane with a new year of use 3. Choose a crane operator who has experience and has certificates	select conditions on the crane lift sensor operating according to actual
4	Design changes due to changes in field conditions	1. conduct a thorough survey and actual field measurements 2. Involving operations, project supervisors, and maintenance during the design process requesting approval with the agreed design	Involves operations, project supervisors, and maintenance during the design process and asks for approval with the agreed design
5	Barge damage	1. conduct NDT inspection on barge before operation 2. conduct a survey on the sea route that is passed by the barge to determine the condition of the route 3. selection of better barge material	conduct a survey on the sea route that is passed by the barge to find out the condition of the route
6	Unbalance between the weight capacity of the barge and the weight of the conveyor	1. Select a trusted and experienced barge design consultant 2. perform manual calculations and simulations using the barge load capacity software with the largest conveyor segment	perform manual calculations and simulations using barge load capacity software with the largest conveyor segment
7	Chainblock breaks during erection conveyor	1. Perform a simulation with the actual load conditions that the cainblock will hold 2. Check the cainblock certificate 3. calculate the cainblock capacity greater than 50% of the calculation result	Check the cainblock certificate and calculate the cainblock capacity kapasitas cainblock
8	Traveler breaks during erection conveyor	1. consists of calculating the traveler capacity and performing software simulations on loads greater than 50% of the calculation 2. Perform NDT on welding joints and verify the material used by the traveler 3. simulate the actual load conditions that will be withheld by the traveler	Conduct an NDT inspection on the barge before operation and calculate the cainblock capacity and choose a cainblock capacity greater than 50% of the calculation result

4. CONCLUSION

The application of risk identification in conveyor system development projects is very important to identify the risks that may occur. After knowing the list of risks that occur, an assessment of the probability and impact on each risk can be carried out using qualitative analysis to obtain the risk value that needs further analysis. Risk analysis that has an impact on project losses will be measured using quantitative analysis, especially in the high risk category. From several alternative responses, the decision tree can make it easier to make the right decision by comparing the probability of success or failure of the response and a large reduction in the risk value, so the response can be recommended for application. So that the application of risk management is highly recommended in the construction of a conveyor system in offshore areas to minimize losses in development projects that will take place.

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6. REFERENCES

Anwar., (2014). *Analisa Resiko Teknis Yang Mempengaruhi Kinerja Waktu Proyek Pembangunan Pengaman Pantai di Provinsi Sulawesi Barat*, Institut Teknologi Sepuluh November.

Arikunto, S., (2016). *Prosedur Penelitian Suatu Pendekatan Praktik*, Rineka Cipta.

Dey, P. K., (2012). Project risk management using multiple criteria decision-making technique and decision tree analysis: a case study of Indian oil refinery. *Production Planning & Control*, *23*(12), 903–921.

Fraser, D., & B.J., C., (2005). Risk management: developing a framework for a water authority, Management of Environmental Quality. *An International Journal*, *16*(3), 235–249.

Gray, C. F., & Larson, E. W., (2006). *Project management: the managerial process*. Oregon State University.

Heizer, J., & Render, B., (2005). *Manajemen Operasi (edisi ketujuh)*, Salemba Empat.

Indraswari, P. P. A., Norken, N., & Suthanaya, P. A., (2018). Manajemen risiko perencanaan pembangunan infrastruktur pelabuhan benoa. *Jurnal Spektran*, *6*(2), 144–151.

Institute, P. M., (2008). A Guide to the Project Management Body of Knowledge, Third Edition. *American National Standard, P.A.*

Keshk, A. M., Maarouf, I., & Annany, Y., (2018). Special studies in management of construction project risks, risk concept, plan building, risk quantitative and qualitative analysis, risk response strategies. *Alexandria Engineering Journal*, 1–9.

Mironescu, R., (2005). Managementul riscului în proiectele finanțate prin programe europene. *Annals of University of Oradea*, 641–643.

Pratama, I. A., (2014). Identifikasi Risiko pada Pelaksanaan Proyek Pembangunan Dermaga/Pelabuhan di Nusa Penida, *Media Bina Ilmiah*, *8*(1), 24–29..

RISK MANAGEMENT IMPLEMENTATION AT XYZ PROJECT USING FAILURE MODE EFFECT ANALYSIS AND HYBRID FUZZY MULTI CRITERIA DECISION MAKING

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ABSTRACT

The demand for electricity supply in developing countries such as Indonesia, especially in the capital city area, is increasing. The increase in demand for electricity supply is not supported by electricity production capacity power plant unit which has experienced significant decline in its equipment performance due to aging. Therefore, XYZ Project which is expected to support the increasing demand of electricity in Indonesia's capital area. However, the implementation of the project has been delayed from the target. This study aims to perform risk analysis on each stage of the project which is influenced to the delay of power plant project. Furthermore, this study uses Failure Mode and Effect Analysis method and Hybrid Fuzzy Multi Criteria Decision Making (MCDM) such as Fuzzy Decision Making Trial Evaluation and Laboratory and Analytic Network Process to identify risk priority and find out priority of risk mitigation steps that need to be implemented. The result found that priority risk factors which significantly contribute to delay of power plant project for each stage of project are land acquisition dispute, incompetence of plant design consultant, non-conforming material or engines, work accident, and power plant synchronization failure. Therefore, by using Hybrid Fuzzy MCDM method, the risk mitigation steps that should be implemented to reduce risk of delay are by implementing socialization of land acquisition, design consultant performance monitoring, factory acceptance test, contractor safety management system audit, and inspection for synchronization stage preparation.

Keywords: Project Management, Risk Management, Power Plant, Multi Criteria Decision Making.

1. INTRODUCTION

Power generation projects have a significant role in helping developing countries to progress in several aspects of industry, economy and social welfare (Heravi, 2018). Indonesia as a developing country has a very rapid economic growth which requires a lot of demand for electricity supply, especially in urban areas such as the Special Capital Region (DKI) Jakarta. The more rapidly a country's economy develops, the higher the demand for electricity (Sudirman, 2018). This also happens in Indonesia, especially in DKI Jakarta, which is the capital city of Indonesia as well as the center of business and economy. However, the high demand for electricity supply is not supported by the electricity supply capacity that can be produced by very old Power Plant Units.

Based on the PT XYZ Power Plant Report as of February 2020, it is known that the installed power is 2423 MW, while the capable power continues to decrease to 1729 MW. This shows that the production power to generate electricity by the 25 years old Power Plant has decreased by about 30 percent of installed power if the power plant operates optimally. The decrease in the power to produce electricity is inseparable from the aging factor of the old generating equipment (aging) which causes disruption to the equipment which often results in the unit being unable to operate or experiencing a trip.

With these problems, PT XYZ built a project to support the increasing demand for electricity in the capital which could not be met by other old PT XYZ Power Plants. Project It is expected that the additional electricity production of 650 MW of electricity consists of 150 MW for Block 2, 250 MW for Block 3, and 250 MW for Block 4.

2. LITERATURE REVIEW

2.1 Risk

Based on Muhlbauer (2004), risk can be defined as the possibility of an event that may result in failure or potential loss. Risk can also be defined as a condition of decision making in which there is the possibility of a certain alternative that will lead to a determined outcome (Scott and Bringham, 2000).

Risk can also be defined in the context of a project, namely an event that is. Uncertain and if it occurs has a negative impact on project objectives. According to Soemarno (2007), project risk can be defined as a possibility that can have financial or physical consequences and have an unfavorable impact to achieve project goals, both in terms of time, project quality and cost. Every project for a project manager will be attached to a risk that will occur, because the project cannot be separated from risk. According to Soeryani (2004), project risk can affect one project performance with other performance targets such as delays in project processing time which will also result in an increase in project costs.

2.2 Risk Management

Project risk management covers the process of planning risk management, identification, analysis, response planning, and risk control in projects (Rose, 2013). Based on ISO 31000: 2009, risk management can be defined as a structured process in managing company risk to achieve the goals contained in the key performance indicators or other goals.

2.3 Project Management

Projects can be defined as a series of activities and tasks that have specific objectives to be completed with a specified target time, amount of funds, and require human and other resources (Kerzner, 2006). Based on the ISO 21500: 2012 document, project management can be defined as the application of the methods, techniques and competencies needed to carry out a project.

2.4 Failure Mode and Effects Analysis (FMEA) Method

According to Carlson (2012), FMEA is an analysis technique that combines technology and experience of experts to identify the causes of failure of a product or process and planning to eliminate the causes of failure. Chrysler (2008) states that there are three FMEA activities consisting of finding out and evaluating the potential failure of a product and its effects, identifying actions that can reduce potential failures and recording processes.

McDermott et al. (2002) defines FMEA as a technical analysis which, when carried out appropriately, will provide great value in helping the decision-making process. FMEA relies on the knowledge and experience of occupational experts to find potential failure modes, ranking priorities according to the consequences of each failure and eliminating the possibility of potential failure that will occur (McDermmot et al., 2002).

2.5 Fuzzy Hybrid Multi Criteria Decision Making

According to Kahraman (2008), multiple decision-making parameters are a model and technique for coping with complex issues. Decision makers often face many problems related to incomplete and unclear information regarding multiple criteria decision making.

The fuzzy set approach is suitable for use when human knowledge and evaluation are required to create a model. As an important problem modeling and solution methodology, Fuzzy set theory is recognized and has been extensively studied over the past 40 years. In engineering, business, medicine, health science, and natural sciences, Fuzzy set theory has been applied to problems.The multiple criteria decision making approach can be viewed as an alternative method for combining the information in the problem decision matrix together with additional information from the decision maker to determine the final ranking or selection of alternatives. The multiple approach to decision-making criteria can also be coupled with other methods of decision-making criteria that have been seen from previous research, such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Case-Based Reasoning (CBR), Data Envelopment Analysis (DEA), Fuzzy Theory, and other hybrid methods. The Hybrid Multi-Criteria Decision Making approach is carried out to make more reliable decisions and also uses quantitative and qualitative analysis.

2.6 Decision Making Trial Evaluation and Laboratory (DEMATEL) Method

The DEMATEL method is a multi-criteria decision making (MCDM) method that can serve to describe and form intercalations or linkages between criteria and sub criteria. The DEMATEL method aims to find and analyze the dominant criteria in a system (Tzeng et al, 2007). DEMATEL can also be combined with other MCDM methods such as the Analytic Network Process (ANP) method (Lin et al, 2010; Sarkis and Talluri, 2002; Shyur and Shih, 2006).

2.7 Fuzzy DEMATEL Method

In order to define and create an interpretation or linkage between criteria and sub criteria, the DEMATEL method was established. The fuzzy technique is then used to measure the weight of the parameters and the satisfaction value of each element or variable that can be adapted to human perception patterns (Chen et al., 2007). Based on Chiu et al. (2006), while the DEMATEL approach is a good method for problem assessment and decision-making, it is generally recognized that human interpretations of decision factors are usually subjectively evaluated.

2.8 Analytic Network Process (ANP) Method

Analytic Network Process (ANP) is an approach in a multi-criteria analysis technique that can model problems using the relationship between criteria (Saaty, 2006). ANP can combine subjective judgments and intangible values with statistical data and other tangible factors.

Both AHP and ANP use pairwise comparation in determining weights. In AHP, each element in the hierarchy can be considered as independent and independent from one another, but because of the increasingly complex criteria in decision making, the hierarchical system that is commonly used cannot analyze the influence between and within a cluster of criteria.

3. RESEARCH METHOD

In this research, the research methods used are literature study, questionnaire, and technical data from project monthly report. Literature study is an activity carried out to find guidelines or references needed to support the basis of this research. Literature studies are carried out to obtain various information needed in conducting research. The literature used is in the form of journals, theses, final projects, books, and other literature that have concepts in accordance with research and are related to the subject matter.

The following is the research flow in this research. 1) Problem Formulation and Methodology, 2) Risk Identification Stage, 3) Risk Analysis Stage, 4) Risk Evaluation Stage, 5) Interrelation

Analysis Stage between Criteria, 6) Risk Mitigation Stage, 7) Conclusion and Suggestion Stage.

4. RESULTS AND DISCUSSION

4.1 Questionnaire Assessment Criteria

Risk identification at the XYZ project stage is obtained by conducting a Focus Group Discussion (FGD) on the Head of Division, Supervisors and expert staff who are experienced in the field of power plant construction projects. Based on the results of the FGD, 24 risks were obtained from each stage of the project starting from the initiation, planning, pre-implementation, implementation, to completion stages which could cause delays in completing the power plant project.

The next step is distributing Questionnaire I to determine the severity, occurrence and detection value for each risk event for each stage of the project. The criteria for determining severity, occurrence and detection values in this study use the criteria adopted by a research conducted by Liu and Yieh-Lin (2012) which have been adapted to the conditions of the power plant project.

The determination of severity, occurrence, and detection values is done by distributing Questionnaire I to respondents in the Division or Unit responsible for managing and supervising power plant projects. Therefore, with the qualifications and experience possessed by the respondents, it is hoped that the results of the risk identification from this expert judgment can be justified for their validity.

At this stage the research will be carried out recapitulation of data on Questionnaire I that has been filled in by respondents so that the value can be obtained *Severity* (S), Occurrence (O), and Detection (D) for each risk per project stage.

Table 1. Severity (S), Occurrence (O), and Detection (D) Assessment Results

Step	No.	Risk List	Mean *S*	Mean *O*	Mean *D*
Initiation	A1	Demands for land acquisition by the community	9.0	8.6	7.5
	A2	Change in land use by the government	8.5	7,8	7.9
Planning	B1	The duration of the approval drawing by the design supervision consultant	8,4	8.3	7,2
	B2	Lack of competence of design supervision consultants	8.5	8.2	7.5
Pre Impleme nta tion	C1	Incoming material does not comply with contract specifications	8.9	7.5	6.8
	C2	*Laydown area* full so that it can't accommodate new material arrivals anymore	6.9	7.4	6.3
	C3	Bank Guarantee submitted by the contractor cannot be withdrawn	6.6	6.3	6.6
	C4	Material breakdown	7.9	6.8	6.8
	C5	Changes in government regulations regarding taxation for EPC contracts	6.6	6.9	6.1
	D1	Occurrence of work accidents	9,2	8.5	7.0
Impleme nta tion	D2	There is an activity process that must be carried out by the contractor, but the mechanism and payment are not regulated in the contract	7,6	6.9	6.6

	D3	Lack of HR competence in controlling construction	8.3	8.3	7.0
	D4	The occurrence of environmental damage	8.6	7,1	7.3
	D5	Rejection or protest demonstrations from the surrounding community	8.3	7,6	7,1
	D6	Differences in the perception of contract clauses between contractor and owner	8.0	8.0	7,2
	D7	Methods for pile installation activities that are not in accordance with the recommendations in the Feasibility Study	8.9	8.3	7.0
	D8	Disruption of existing unit operations	8.1	7.5	6.5
	D9	*Progress* payment exceeds the physical progress of the goods installed due to human errors in the calculation	6.1	5.5	5.0
Completion	E1	Power plant synchronization failure	8.9	8.6	7.5
	E2	Failure of the load rejection test	8.9	8.1	7.3
	E3	Insufficient supply of fuel for power plants	8.0	8.6	7.0
	E4	There are claims problems that have not been resolved	8.8	7.0	7.4
	E5	The repeatability of the reliability run stage is due to a system failure	8.9	7,1	7.3
	E6	The closing contract was not achieved with the contractor due to a dispute	7.9	7,1	7,8

Based on the results of the severity assessment, it can be identified that the risks that affect the delay in project completion in this study are risks with a high severity category with a value of 8.16 or it can be said that the impact severity level of the risks on this project is high and 10% - 20%. impact the critical path.

Based on the results of the occurrence assessment, it can be identified that the risks that affect the delay in project completion in this study are the risks with the category of occurrence or high probability of occurring with a value of 7.58 or it can be said that there is a possibility that these risks will occur in several conditions.

Based on the results of detection assessments, it is known that the average detection value is 6.99. Therefore, it can be identified that work plans or procedures such as hazard analyzes and job analyzes that are owned by companies are less likely to detect risks.

4.2 Priority Risk Calculation

This section will conduct a risk analysis by calculating priority risk using the Failure Mode and Effect Analysis (FMEA) method. The FMEA method is a method that aims to prioritize and fix failures or determine the types of failures that will be taken preventive actions by identifying the possible types of failures that may arise in the product and planning process (Özveri & Kabak, 2015).

Based on the data in Table 1 above, then the RPN calculation is carried out for each risk per project stage. The RPN calculation is formulated based on the multiplication of the average value of severity, occurrence, and detection for each risk source and then the RPN value is calculated for each risk per project stage. The results of calculating the RPN for each risk per project stage can be shown in the table below:

Table 2. Calculation Results of Risk Priority Number (RPN)

Steps	No	Lists of Risk	RPN
Initiation		Demands for land acquisition by the community	580,50
		Change in land use by the government	523,77
Planning		The duration of the approval drawing by the design supervision consultant	501,98
		Lack of competence of design supervision consultants	527,75
Pre Implemen tati on		Incoming material does not comply with contract specifications and ulations	453,90
	C 2	*Laydown area* full so that it can't accommodate new material arrivals anymore	321,68
		Bank Guarantee submitted by the contractor cannot be withdrawn	274,43
		There is material damage	365,30
		Changes in government regulations regarding taxation for EPC contracts	277,79
Implemen tati on		Occurrence of work accidents	547,4
	D 2	There is an activity process that must be carried out by the contractor, but the mechanism and payment are not regulated in the contract	346,10
	D 3	Lack of HR competence in controlling construction	482,23
		The occurrence of environmental damage	445,74
		Rejection or protest demonstrations from the surrounding community	447,87
		Differences in the perception of contract clauses between contractor and owner	460,80
	D 7	Methods for pile installation activities that are not in accordance with the recommendations in the Feasibility Study	517,09
		Disruption of existing unit operations	394,88
	D 9	*Progress* payment exceeds the physical progress of the goods installed due to human errors in the calculation	167,75
Completio n	E 1	Power plant synchronization failure	574,05
		Failure of the load rejection test	526,26
		Insufficient supply of fuel for power plants	481,60

		There are claims problems that have not been resolved	455,84
		There is a system failure that causes the repeatability of the reliability run stage	461,29
	E6	There was a dispute with the contractor which was prolonged so that the closing contract was not reached	437,50

Based on the results of the RPN calculation using the FMEA method, the following are risk events that have a high risk priority per project stage

Table 3. List of Project Priority Risks

Step	No.	Risk List	RPN
Initiation	A1	Demands for land acquisition by the community	580.50
Planning	B2	Lack of competence of design supervision consultants	522.75
Pre-Implementation	C1	Incoming material does not comply with contract specifications and regulations	453.9
Implementation	D1	Occurrence of work accidents	547.40
Completion	E1	Power plant synchronization failure	574.05

Based on the table of the results of the project priority risk assessment, it can be seen that the priority risk that has the highest RPN is the risk of land acquisition claims by the community. This shows that the risk of demands for land acquisition by the community must be given the highest priority for risk mitigation, especially since this risk occurs in the early stages of the project, namely the initiation stage which has a very important role in the successful implementation of the next project stage.

4.3 Analysis of Relationship Between Risk Events

At this stage, analysis of the relationship between risk criteria per project stage will be carried out using the Fuzzy Decision Making Trial Evaluation and Laboratory (DEMATEL) method with the help of Microsoft Excel and Matlab software. In this study using numbers *fuzzy* in the DEMATEL method for linkage analysis between the criteria in this study.

4.4 Calculation of Cause and Effect Relationships

The value of ri and cj is obtained from the total relationship matrix. According to Seker and Zavadskas (2017), ri + cj is defined as "superiority" which indicates the level of importance of a criterion, while the trend value of the level of influence of each decision sub-criteria is denoted by (ri-cj). If the value (ri-cj) is known to be positive, then the criteria or sub-criteria tend to be more influential, and conversely, if the value (ri-cj) is negative, then the criteria or sub-criteria tend to be more influenced by other criteria or sub-criteria.

Table 5. Crips values of ri, cj, ri + cj, and ri - cj

Code	ri	cj	ri + cj	ri - cj
A1	2.54	1.71	4.25	0.83

A2	1.93	1.51	3.43	0.42
B1	2.30	2.08	4.38	0.21
B2	2.38	1.71	4.09	0.67
C1	2.42	1.76	4.18	0.66
C2	2.19	1.62	3.81	0.57
C3	2.18	1.62	3.80	0.56
C4	2.28	1.76	4.04	0.52
C5	1.34	1.37	2.71	-0.03
D1	2.36	1.77	4.14	0.59
D2	2.32	1.94	4.26	0.38
D3	2.33	1.89	4.22	0.44
D4	2.09	1.66	3.75	0.43
D5	1.96	1.58	3.53	0.38
D6	1.59	2.02	3.61	-0.43
D7	2.24	1.97	4.21	0.28
D8	1.95	2.31	4.26	-0.37
D9	1.39	1.94	3.33	-0.55
E1	1.63	2.35	3.98	-0.72
E2	1.40	2.28	3.68	-0.88
E3	1.35	2.20	3.55	-0.85
E4	1.36	2.39	3.75	-1.03
E5	1.32	2.27	3.59	-0.95
E6	1.26	2.41	3.68	-1.15

4.5 Results of the Analysis of the Relationship Between Risk Events

Based on the crips values of ri, cj, ri + cj, and ri - c that have been obtained in the previous stage, a cause-effect relation diagram is prepared to explain the relationship between risk events such as which risk categories have an influence on other risks and risks. which are more affected by other risk events which can be shown in the figure below:

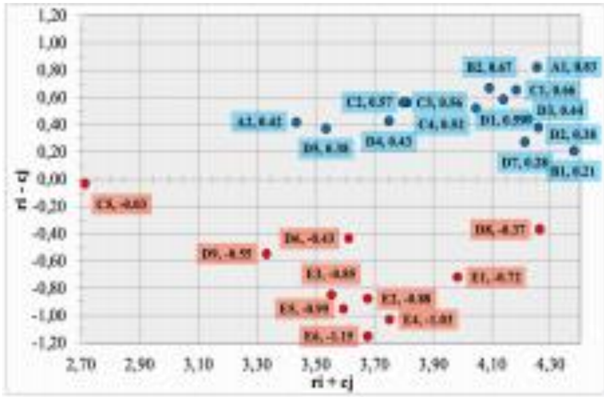

Figure 1. Cause-Effect Relationship Diagram

Based on the impact map diagram, it can be seen that risks with codes A1, A2, B1, B2, C1, C2, C3, C4, D1, D2, D3, D4, D5, D7 which are given blue information can be categorized into groups of causes while risks with codes C5, D6, D8, D9, E1, E2, E3, E4, E5, E6 which are marked in red, can be classified into groups of causes.

Based on the calculation table for the value of ri + cj, and ri - cj above, it is known that the risk of land acquisition claims by the community (A1) has the highest ri-cj value of 0.83. Therefore the risk of demands for land acquisition by the community has the most significant effect onproject work, Moreover, the risk occurs in the early stages of the project, namely the initiation stage which very much determines the start of project implementation, while the risks There was a dispute with the contractor which was prolonged so that the closing contract was not reached receive the impact (E6) the greatest effect of other risks, namely with a value of -1.15.

4.6 Priority Risk Mitigation Analysis

After finding a linkage between the sub-criteria in each project using Fuzzy DEMATEL, at this stage the next stage will be carried out, namely priority risk mitigation analysis using the ANP method. The following is the result of risk mitigation identification per project stage that has been obtained from the Second FGD conducted with experts or power plant project management experts.

Table 6. Priority Risk Mitigation Per Project Stage

Priority Risk	Risk Mitigation
Demands for Land Acquisition by the Community	1. Conducting outreach through local village officials prior to land acquisition 2. Calculating the value of compensation is carried out using a certified independent consultant 3. Cooperate with local village officials and local security forces in negotiating efforts with the community

Lack of competency of design supervision consultants	1. Prepare a detailed design supervision consultant qualification in the Terms of Reference (TOR) 2. Prepare a Service Level Agreement (SLA) for target performance for consultants 3. Monitor and evaluate consultant performance regularly.
Incoming material does not comply with contract specifications and regulations	1. Make procurement monitoring before giving shipment approval to contractors 2. Perform inspection or Factory Acceptance Test (FAT) on the manufacturer either directly by the owner or through a third party 3. Include sanctions in the contract clause if the goods that arrive are not in accordance with the contract. 4. Ensure that the delivery of materials is accompanied by insurance or warranty
Occurrence of work accidents	1. Monitor heavy equipment administration and worker competence 2. Ensure use of personal protective equipment 3. Perform routine safety inspections or patrols 4. Conducting a Contractor Safety Management System (CSMS) Audit
Power plant synchronization failure	1. Carry out routine technical inspections to ensure that the conditions stated in the study or project engineering documents are still relevant 2. Use the services of an accompanying consultant to ensure that the generator design is appropriate and according to the planned specifications 3. Coordinating with PT PLN Load Management Center related to interconnection studies 4. Coordinating or pre-closing meetings before the commissioning process is carried out between the owner, contractor, supervision consultant and certification consultant.

4.7 Preparation of Questionnaires to be Processed using the ANP Method

In this study, there is an ANP network structure design that aims to make it easier to describe a decision-making system based on eligible criteria and sub-criteria. The ANP network structure design in this study is arranged per project stage so as to describe the objectives, namely priority risk mitigation per project stage, criteria, sub-criteria, priority risk mitigation alternatives as shown in this picture below.

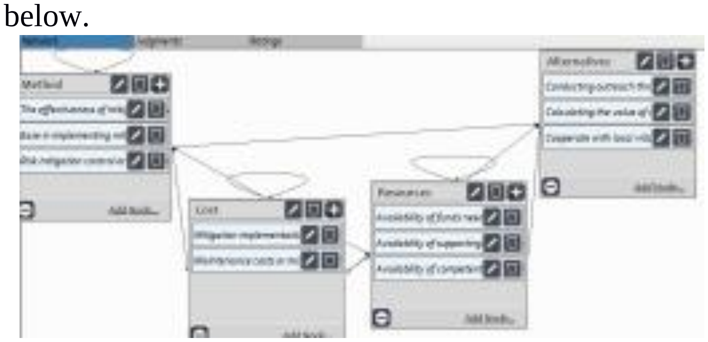

Figure 2. ANP Network in Superdecision Software

At this stage, a pairwise comparison questionnaire will be prepared to find out the best priority risk mitigation alternatives from several risk mitigations that have been identified at each project stage.

This questionnaire also uses decision criteria and sub-criteria, which have also been identified by expert respondents in FGD II, to assist in selecting priority risk mitigation per project stage as can be seen in the following tables:

Table 7. Decision Criteria Code

No.	Code	Indicator
1	A	Cost
2	B	Method
3	C	*Resources*

Table 8. Decision Subcriteria Code

No.	Code	Indicator
1	A1	Mitigation implementation costs
2	A2	Maintenance costs or monitoring mitigation
3	B1	The effectiveness of mitigation measures to mitigate risks
4	B2	Ease in implementing mitigation
5	B3	Risk mitigation control or monitoring
6	C1	Availability of funds needed
7	C2	Availability of supporting materials and equipment
8	C3	Availability of competent and experienced human resources

4.8 Consistency Test

According to Saaty (2006), if the consistency ratio or CR <0.1, then the input from the experts' questionnaire is correct. The consistency test process in this study was carried out with superdecision software when inputting data from the consensus of the pairwaise comparation that had been obtained. The consistency ratio of this study can be seen in the result inconsistency section, if the result is less than 0.1 then the pairwaise comparation results can be accepted. In this study, it was found that the value of the consistency ratio was or less than 0.1, so the results of the assessment for the pairwise comparison matrix were consistent.

4.9 Priority Risk Mitigation in Initiation Stage

Based on the identification of risk mitigation with experts in the field of power generation projects and processed by the ANP method through the help of Superdecision software, the priority risk mitigation for the initiation stage is formulated by conducting socialization through local village officials prior to land acquisition.

5.0 Priority Risk Mitigation Planning Stage

Based on calculations using the ANP method, it is known that priority risk mitigation at the planning stage, namely the lack of competence of design supervision consultants, is monitoring and evaluating the consultant's performance on a regular basis.

5.1 Priority Risk Mitigation for Pre-Implementation Stage

Based on calculations using the ANP method, it is known that priority risk mitigation at the pre-implementation stage, namely material that came not according to specifications, is with is conduct an inspection or Factory Acceptance Test (FAT) to the manufacturer, either directly by the owner or through a third party.

5.2 Priority Risk Mitigation Implementation Stage

Therefore, with the priority risk mitigation analysis obtained through FGD and processed by the ANP method, it is possible to obtain priority risk mitigation for the work accident risk event by conducting an audit. *Contractor Safety Management System* (CSMS).

5.3 Priority Risk Mitigation Completion Stage

With priority risk mitigation analysis using the ANP method, priority risk mitigation can be formulated which must be the main concern to mitigate this risk by conducting routine technical inspections for ensure that the conditions stated in the study or project engineering documents are still relevant.

5. CONCLUSION

From the risk weight assessment using the FMEA method, it is known that several risk events at each stage of the project are very influential on delays in the power generation project, namely:

a. The priority risk at the project initiation stage is demands for land acquisition by the community, with an RPN value: 580.5

b. The priority risk at the project planning stage is the lack of competency in the design supervision consultant, with an RPN value: 522.75

c. Priority risk in the pre-implementation stage is material that comes not in accordance with applicable contract specifications and regulations, with a value of RPN: 453.9

d. The priority risk at the implementation stage is the occurrence of work accidents, with RPN value: 547.4.

e. The priority risk at the completion stage is that the synchronization power plant has failed, with an RPN value: 574.05.

Based on the results of the Focus Group Discussion (FGD) that has been conducted with leaders and experts in the field of power plant project construction, several mitigation alternatives were obtained for priority risks per selected project stage as shown in Table 4.11. Furthermore, questionnaires were distributed using the pairwise comparison method which would be processed using the ANP method. From the results of this data processing, priority risk mitigation needed to overcome the risk of delays in power plant projects such as the XYZ project can be formulated as follows:

a. The priority risk mitigation that needs to be done to address priority risks at the initiation stage such as demands for land acquisition by the community is to conduct socialization through local village officials before land acquisition is carried out. The initiation stage is a crucial stage for ensuring the smooth running of a project because obstacles or constraints at the initial stage will inevitably affect the next project stage.

b. The priority risk mitigation that needs to be done to address priority risks at the planning stage, such as the lack of competence in design supervision consultants, is by monitoring and evaluating the consultant's performance on a regular basis. Lack of competence in human resources such as consultants in project work can result in design mismatches and result in delays in the power plant project from the target set and the project will suffer a cost and time loss.

c. The priority risk mitigation that needs to be done to overcome priority risks in the pre implementation stage, such as the incoming material that does not comply with contract specifications and regulations, is by conducting an inspection or Factory Acceptance Test (FAT) to the manufacturer, either directly by the owner or through a third party. The objective of the FAT is to ensure the quality of the material order before completing the procurement process so that the commissioning process of the generator material can be installed and run optimally.

d. The priority risk mitigation that needs to be done to address priority risks at the implementation stage such as the occurrence of work accidents is to conduct a Contractor Safety Management System (CSMS) audit. At the project implementation stage, work accidents are prone to fatal consequences and can cause project delays or even the project can be terminated.

e. The priority risk mitigation that needs to be done to overcome priority risks at the completion stage such as synchronizing power plants experiencing failure is to carry out routine technical inspections to ensure that the conditions listed in the project engineering studies or documents are still relevant. Power plant synchronization is a crucial phase at the completion stage of a power plant project. The success of power plant synchronization states that a power plant has met the requirements and if the synchronization of the power plant fails, it will repeat the commissioning process from the beginning and will take a long time to complete.

6. REFERENCES

Carlson, C.S, 2012, *Effective FMEAs Achieving Safe, Reliable, and Economical Product and Process Using Failure Mode And Effects Analysis*, New Jersey, John Wiley & Sons Inc.

Chen-Yi, H., Ke-Ting, C., & Gwo-Hshiung, T. (2007). FMCDM with Fuzzy DEMATEL Approach for Customers' Choice Behavior Model. *International Journal of Fuzzy Systems*, 9(4).

Chiu, Y. J., Chen, H. C., Tzeng, G. H., & Shyu, J. Z. (2006). Marketing strategy based on customer behaviour for the LCD-TV. *International journal of management and decision making*, *7*(2-3), 143-165.

Chrysler, LLC. (2008). Potential Failure Mode And Effect Analysis (FMEA): Fourth Edition. Ford Motor Company. General Motors Corporation.

Heravi, G., & Gholami, A. (2018). The influence of project risk management maturity and organizational learning on the success of power plant construction projects. *Project Management Journal*, 49(5), 22-37.

Kahraman, C. (Ed.). (2008). *Fuzzy multi-criteria decision making: theory and applications with recent developments* (Vol. 16). Springer Science & Business Media.

Kerzner, Harold, (2006), *Project Management: A system approach to planning, scheduling, and controlling,* 9th edition, John Wiley & Sons, Inc., New Jersey.

Lin, Y. T., Lin, C. L., Yu, H. C., & Tzeng, G. H. (2010). A novel hybrid MCDM approach for outsourcing vendor selection: A case study for a semiconductor company in Taiwan. *Expert systems with applications*, *37*(7), 4796-4804.

Liu, H.T & Yieh-Lin, T, 2012. *A Fuzzy Risk Assessment Approach for Occupational Hazards in The Construction Industry*. Safety Science.

McDermott, R. E., Mikulak, R. J., dan Beaurgard, M. (2002). Failure Mode and Effect Analysis (FMEA). FMEA Team Instruction Guide. Southern California: Kaiser Permanente.

Muhlbauer, W. K. (2004). *Pipeline risk management manual: ideas, techniques, and resources*. Elsevier.

Öxveri, O., & Kabak, M. (2015). The Usage of MCDM Techniques in Failure Mode and Effect Analysis. *Journal of Economics and Management Research*, 4(2), p94-108.

Rose, K. H. (2013). A Guide to the Project Management Body of Knowledge (PMBOK® Guide)—Fifth Edition. *Project management journal*, 44(3), e1-e1.

Saaty, Thomas L and Vargas, Louis G. (2006). *Decision Making with the Analitic Network Process. Economic, Political, Social and Technological Applications with Benefits, Opportunities, Costs and Risks. Springer*. RWS Publication, Pittsburgh

Sarkis, J., & Talluri, S. (2002). A model for strategic supplier selection. *Journal of supply chain management*, *38*(4), 18-28.

Scott, B. dan Bringham, E. F. 2000. *Essentials of Managerial Finance Twelfth Edition*. Orlando : Harcourt Inc.

Seker, S., & Zavadskas, E. K. (2017). Application of fuzzy DEMATEL method for analyzing occupational risks on construction sites. *Sustainability*, *9*(11), 2083.

Shyur, H. J., & Shih, H. S. (2006). A hybrid MCDM model for strategic vendor selection. *Mathematical and computer modelling*, *44*(7-8), 749-761.

Soemarno, M. S. (2007). Risiko Penggunaan Lahan dan Analisisnya Laboratorium PPJP Jurusan Tanah.

Malang: FBUP

Soeryani, N. 2004. *Analisis Risiko pada Penjadualan Proyek Jembatan*. Yogyakarta. Universitas Atma Jaya Yogyakarta

Sudirman, W. B., & Hardjomuljadi, S. (2011). Project risk management in hydropower plant projects: A case study from the state-owned electricity company of Indonesia. *Journal of Infrastructure Development*, 3(2), 171-186.

Tzeng, G. H., Chiang, C. H., & Li, C. W. (2007). Evaluating intertwined effects in e-learning programs: A novel hybrid MCDM model based on factor analysis and DEMATEL. *Expert systems with Applications*, 32(4), 1028-1044.

RISK AND HAZARD ANALYSIS REVIEWS FOR SENSE AND AVOID SYSTEMS IN UAVS USING THE RISK PRIORITY NUMBER VALUE IN THE FAILURE MODE AND EFFECTS ANALYSIS METHOD.

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ABSTRACT

Unmanned Aerial Vehicle (UAV) has been increasingly used and operated since last decade. It is inevitable that soon UAVs will be operating in a civilian (regulated) airspace. This will cause various risks, including midair collision which can be fatal. One requirement that must be met by a UAV to operate safely in civilian air space, is to have ability to identify collision potentials and conduct avoidance maneuver.

Usually, the task for identifying and avoiding collision is carried out by the Sense-and- Avoid (SAA) system. In general, the SAA system has a function to sense, detect and perform maneuvers to avoid. In order to function properly, the SAA must have five performance parameters, namely detection range, field of view, accuracy, measurement rate and latencies, and integration. These performance parameters will be used for assessing the SAA. Additionally, two more parameters related to the situation when a UAV encounters other vehicles (intruders) are added: the intruder distance and the intruder closing speed.

This paper focusses on the formulation for quantifying the risk of collision when a UAV operates in a regulated airspace, by taking into account parameters that define the performance of SAA system, as explained above.

To get the level of safety from the SAA system, a risk analysis based on the Failure Mode and Effects Analysis (FMEA) method is conducted. Level of safety will be obtained from the Risk Priority Number (RPN) value. By knowing the level of safety of this risk assessment, the users and developers of UAV can have a guidance in choosing the right SAA system to meet the level of safety prescribed by regulation.

Keywords: UAV, Risk Analysis, Sense and Avoid System

1. INTRODUCTION

Recently, Unmanned Aerial Vehicle (UAV) has proven succesful in carrying out several military missions. Thus, UAV begin to play an important role in many military operations. On the other hand, UAVs are also starting to be widely used for non-military purposes, from hobbyists to professional commercial use. The wide range of UAV users has an impact on the UAV operating area and, inevitable, UAV will enter into civilian airspace, where there are other aircraft operating in this airspace.

When UAVs or drones will enter into civilian air space, a safety issue will be one of the concern, such as midair collision. Based on the incident and accident data contained in the Aircraft Owners and Pilots Association (AOPA) database in the period 2010-2020, there were 85 midair Collision incidents and accidents throughout America. More than 50% of these midair events are fatal. DeGarmo (2204) revealed several issues related to problems arising from the integration of UAVs into civilian airspace, one of which is safety issue. Whie Simon and Braasch (2009) suggest that one of the main contributions in the case of midair collision on manned aircraft is the failure of the see-and-avoid system function.

According to reguations, for a manned aircraft to fly in a civilian airspace the aircraft must meet the see-and-avoid requirements. In a UAV, the see-and-avoid function is carried out by the sense-and-avoid (SAA) system, also known as the detect-and-avoid (DAA) system.

The ability of SAA or DAA is one of the requirements that must be met for UAV to fly over populated areas and in civiian airspace, where the probability of entering into dense air traffic is quite large. With the great possibility that UAVs will enter civilian airspace, the SAA system is increasingly needed to become one of the main systems in UAV. Currently the aviation authority in Indonesia, namely DGCA, is discussing and evaluating so that the SAA / DAA system becomes one of the requirements that must be met for a certain UAVs class to be certified.

Currently there have been many studies and articles discussing risk and hazard analysis regarding UAV integration into civilian airspace. Evans (2006) underlines the possible hazards when UAV is integrated into unsegregated airspace, one of which is midair collision. Clothier and Walker (2006) reveal the safety objectives needed in carrying out a risk analysis for the case of UAV integration into civilian airspace.

This paper discuss how the SAA system relates to risk analysis in determining the level of safety when UAVs fly in civilian airspace. The focus of this research discuss how the SAA system can contribute to determining the level of safety of UAV ehen entering civilian airspace. The results of this study are expected to help UAV developers and users to choose the right SAA system to meet the safety requirements specified by regulations. These results can also be taken into consideration for the authorities in drafting regulations for UAV operation.

This paper starts with an introduction, followed by discussion on the risk analysis method, then proceed with review of the SAA system and for in risk analysis.

2. HAZARD AND RISK ANALYSIS

There are several methods that can be used for conducting hazard and risk analysis. In aviation, the method that is widely used for hazard and risk analysis is Failure Mode and Effects Analysis (FMEA), due to the flexibility on conducting the risk analysis assesment which can be done both qualitatively or quantitavely.

Sellapan et al (2015) mentioned that in the FMEA method, risk can be evaluated using the Risk Priority Number (RPN). This Risk Priority Number method is a technique for analyzing risks associated with potential problems that have been identified in the FMEA analysis. Therefore, the

RPN can be used as a measure in determining the level of risk or also the level of safety of each potential problem.

There are three determining factors in RPN, namely Severity (S), Occurance (O), and Detection (D). Each of these factors has particular respective levels or values. Severity rating describes how much impact will arise if the risk arises. Occurance describes how likely the danger will arise. Meanwhile, Detection is a factor that describes how much risk or danger can be detected early or not.

The RPN rating value can be calculated using the equation below:

$$RPN = S \times O \times D$$

The RPN rating value can be used to rank each potential hazard that may arise, as well as to determine the mitigation requirements regarding each of these risks. The rating value is calculated by arranging the whole potential problems that were identified from the highest to the lowest value of the RPN to determine what steps should be taken to minimize risks.

The general rule of thumb is that the higher the RPN value, the more critical the potential risk or hazard is. Since the RPN value is determined only by the 3 abovementioned factors, it is very possible that different distributions of S, O, and D resulting in a similar RPN value. For this reason, in some cases, the value S and O have more weight in determining priority than the value of D. For Example case A has an S value of 5, an O value of 6, and a D value of 3, then the RPN of case A is 90. Case B has an S value of 3, an O value of 5, and the value of D is 6, then the RPN for case B is 90 as well. For the two cases above, case A gets more priority than case B, because case A has S and O valuas greater than S and O values in case B (Table 1)

Table 1. Example Distribution Value RPN

	Severity	Occurrence	Detection	RPN	Remarks
Case A	5	6	3	90	More Priority
Case B	3	5	6	90	

3. SENSE AND AVOID SYSTEM

The SAA systems was developed to answer the see-and-avoid requirements of UAV aircraft, especially if the UAV operates autonomously. The SAA system works under the following principles: firstly, the sense and avoid system must have the ability to ‘see’ an object, secondly the system estimates whethe the object has potential danger to the UAV. If this object is dangerous then this system must be able to give orders to the flight control computer of the UAV to carry out evasive manoeuvres.

The SAA system provided with sensors that can detect objects, especially those that potentially intersect with the UAS’s flight path. The SAA system is classified based on their type of detecting sensor. Skowron et al (2019) mentioned several methods in SAA technology. The method is divided into two categories (figure 1), cooperative and non-cooperative. The cooperative SAA system consists of TCAS and ADS-B, while the non-cooperative SAA system is divided into passive and active systems. Passive systems include optical, acoustic, and GPS. While active systems include RADAR, LIDAR, SONAR. Each sensor has its own uniqueness in their ability to detect objects

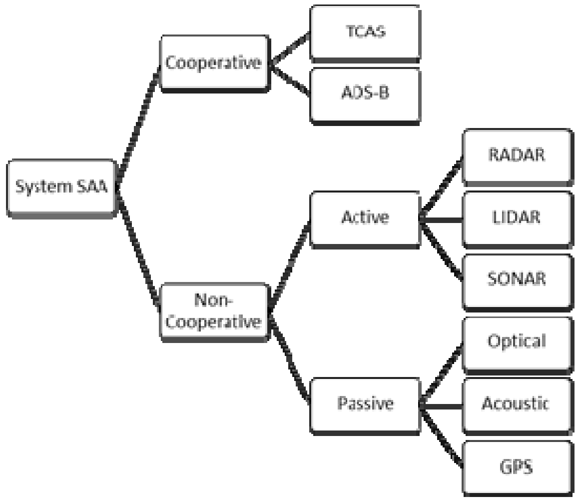

Figure 1. SAA Technology

B. Nikil Chand et al (2017) prsented that SAA technology consists of three main function, which are: Sense, Detect, and Avoid. These three functions are mandatory for the SAA system to function properly. The Sense function is a function for observing the area or airspace in front of the flight path of the UAV. This area is known as the sensing area and its size depends on the ability of each sensor. These objects can be either stationary objects or moving objects, such as manned aircraft or fellow UAVs.

As the Sense function can only detect whether there are objects or not, the Detection function has function to estimate whether the object that has been detected by the Sense system will intersect the flight path of the UAV. This function must have the ability to estimate the directions of motion of an object by taking into account the fight direction of the UAV. There are many variations of potential solutions to meet the requirements for the system to determine the level of threat based on previous sensing information, ranging from simple warning of hazard to more complex ones which predict the flight path of aircraft.

Sometimes these two functions of sense and detct, can become one unit since these two functions are closely related. The Sense function does not have much meaning without Detect function, and vice-versa the detect function will not work without the Sense function.

Lastly, the Avoid function is the ability to create or provide a new direction for the UAV to avoid a possible collision base on the results of Detect function. The ability to evade is depended on the capabilities of the flight control system of each UAV. There are various methods for doing this avoidance manoeuvre. Pham et al (2015) mentioned several approaches to collision avoidance, such as geometric, optimized trajectory, bearing angle based, and force field. Avoiding function is a function where the SAA system can communicate with the UAV flight control system. In addition, after being able to communicate, the SAA system must also be able to give orders to the flight control system to perform evasive manoeuvres. In order to communicate with the flight control system, it is necessary that the output of the SAA system can be read and received by the FCS.

4. SAA SYSTEM REQUIREMENTS

Apart from three afore-mentioned functions, the SAA system also has five requirements or characteristics to have properly functioned. These requirements are the main parameters in determining the capabilities of each SAA system, which are:

1. Detection Range
2. Field of View
3. Sensing Accuracy
4. Measurement Rate and Latencies
5. Integrity.

These requirements are highly dependent on the type of sensor used by the SAA system which can be used to determine the quality of each SAA system. Furthermore, the above requirements will also be used as parameters when quantifying the SAA system. Each of the requirements above has measurable parameters so that the required quantification can be carry out.

Detection Range is the distance parameter needed by the sensor to sense and detect an object. The type of sensor that is used to capture objects determines the Detection Range. The value will be correlated with the minimum distance the ability of the UAV to manoeuvre to avoid if there is a dangerous object in the UAV's trajectory. If the detection range of sensor is greater than the minimum manoeuvre distance that the UAV has for avoiding manoeuvres, the potential risk of collision in the air is smaller. Or in other words, it is safer from the risk or hazard that will occur.

Field of View is an area where sensors can capture objects, which affected by the type and capabilities of the sensor. This area depends on the detection range, elevation and azimuth angle of the the sensor. Detection range and angle of elevation and azimuth determining the sense area.The wider the sensing area, the more objects the SAA system can detect. Assuming the UAV can perform evasive manoeuvres, the more objects it can detect, the lower the risk of collisions in the air.

The abovementioned detection range and field of view, are required to carry out the sense function of the SAA system. The ability or minimum value of the detection range and field of view for each sensor is different. This ability determines the value in risk analysis. The farther the detection range and the wider the field of view, the greater the probability that an object cn be detected. The more objects that can be detected, the smaller the risk value of midair collision.

The third requirement, namely sensing accuracy, is a requirement required by the SAA system to be able to detect objects more accurately. This requirement is one that is quite difficult to assess its value. Depending on the size of the object, each type of sensor will have specific parameters to measure the accuracy of detecting objects.

Each SAA sensor will take time to detect an object. Measurement rate and latencies requirements determine how much time the sensors takes since the signal is sent and then recived back by the sensor (for radar, lidar, acoustic types). Because the problems that arise are dynamic, the longer it takes, the greater the potential for harm. The greater the rate measure that is owned by this system and the smallaer the latency, the lower the potential risk or danger. This means that the system has a smaller rating and is getting safer.

The third and fourth requirements above are needed to carry out the second function of the SAA system, namely Detect. Sensing accuracy and measurement rate and latencies affect the ability to detect objects, whether the object will meet the UAV flight direction or not. If the sensor can accurately detect objects, the risk will also be smaller. Likewise with latency, where this cannot be avoided, the longer it takes to be able to capture and respond to an object, the higher the risk.

The last requirement is the ability of the SAA system to be integrated with the FCS system. This requirement demands that the output from the SAA system can be used as input for the SAA system. For sensors that have output in digital form, it will be easier to integrate than the sensors whose output is still analogue. Another thing that must be considered is what parameters must be issued by the SAA system so that it can be input to the FCS system. This requirement is required to perform the avoiding function of the SAA system.

5. SAA OPERATION

The type of UAV to be operated will determine the type of SAA system to be used. In general, UAVs with medium size and above will be able to fly at high altitudes, where there is manned aircraft traffic and entry into controlled airspace. In this airspace the UAV will interact with other aircraft. Both Instrument Flight Rule (IFR) and Visual Flight Rule (VFR) regulations apply to all users of this airspace. Therefore the SAA system must be applied to avoid the possibility of a collision in the air. It is highly recommended for UAVs with the ability to fly medium altitude and above, using a cooperative SAA system in addition to a non-cooperative system.

Whereas the type of UAV with a small size will mostly fly at low altitude or in uncontrolled airspace. At this altitude and airspace it is usually rare or even manned aircraft to fly in it. The rules that apply to this airspace are VFR. For this type or class the SAA system is not mandatory. But if the UAV will fly by using the autopilot, it will be safer if the UAV system also uses SAA, wherein SAA system used type of non-cooperative.

In the operation of this SAA system, the condition of the object or intruder is one of the parameters that must be considered. The position and distance of the intruder to the UAV are one of the considerations in determining the performance of this system in use. Traffic density conditions and the speed of the object or intruder are also parameters in determining the level of risk that may occur.

6. SAA AND RPN

In determining the RPN value of the SAA system, it can be divided into two points of view (Figure 2). The first is from the SAA system itself, where the five SAA requirements will be the parameters. The second is seen from how this SAA is operated in a UAV. For this purpose, two parameters will be used, namely the distance of the object or intruder and the closing speed.

The above mentioned five SAA system requirements can be correlated to determine the RPN value to be used for risk and hazard analysis. Each of these requirements will be used to assess the rating of the RPN parameter. Of the five requirements above, four requirements will be used to determine the Detection (D) parameter rating in the RPN calculation. The four requirements are detection range, field of view, sensing accuracy, and measurement rate and latencies. As previously explained, the Detection range and Field of View are used to assess the sense function of the SAA system function. Meanwhile, Sensing Accuracy, and Measurement Rate and Latencies are focused on assessing the detect function.

The fifth requirement of the SAA system, namely Integration, will be used to determine the value of the Occurance (O) in the RPN equation. This requirement is used in assessing the avoid function of the SAA system function.

In determining the RPN value of the SAA system, what must also be considered is when the system is operated. As mentioned above, the object/intruder range and closing speed will be used as parameters for the operation of the SAA system. These two parameters will be used to determine the value of the Occurance (O) in the RPN calculation. Both of these parameters will be affected by the UAV capability, namely the ability to perform evasive manoeuvre, and the position, speed and direction of objects detected by the SAA.

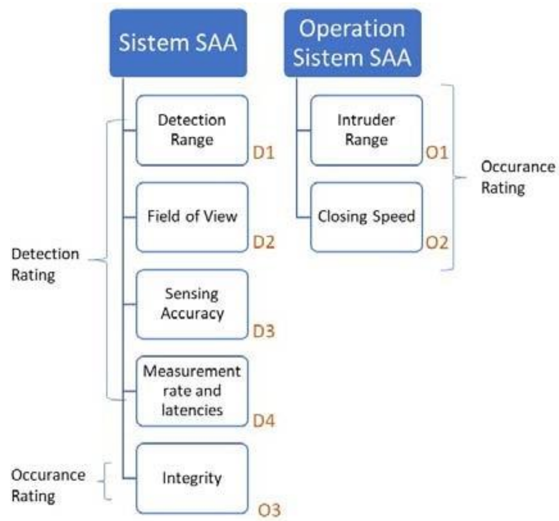

Figure 2. SAA and RPN

7. SAMPLE CASE

An example case, a UAV weighing 1,300 kg fly at a constant speed of 125 kts over a heavily populated area that is not too dense (500 pop / sq.km). This UAV uses a radar as a SAA system with a detection distance of 1,500 m with an azimuth angle of 120 deg and an elevation angle of 40 deg. An intruder aircraft weighing 1,000 kg fly at a constant speed of 116 kts in a direction perpendicular to the direction of flight of the UAV (figure 3).

The first parameter in calculating the RPN value is the Severity rating. The SAA system has no role in determining the rating severity. One of the rating severity factors is the area where the aircraft operates. Because both of them fly over a less dense area population, the severity value is assumed to have a value of 4.0.

The Detection rating for the SAA system on the RPN equation are determined by four parameters as described above, namely detection range, field of view, sensing accuracy, and measurement rate and latencies. By using the above conditions, the detection range rating (from 1 to 5) is assumed to be 2, because a distance of 1,500 m is enough distance for the UAV to maneuver to evade, so it has less risk. With a large enough elevation angle, the field of view is wide enough, so the rating is 2. The radar has a good ability for sensing accuracy and measurement rate, so these two parameters also have a rating of 2. With the value of each parameter, the Detection value is 4.0.

Occurance rating is determined by the parameters integrity, intruder range, and closing speed. Assuming the system can be integrated with the UAV autopilot, the rating for integration is 1. For the intruder rating range, the value depends on the position conditions between the uav and the intruder. With the assumption of taking the largest rating value, the rating for intruder range 3 and closing speed is also 3. Of the three parameters above, the occurrence rating is 4.3.

Using the three parameters above, the RPN value for this example is 74.7. The calculation results can be seen in the Table 2.

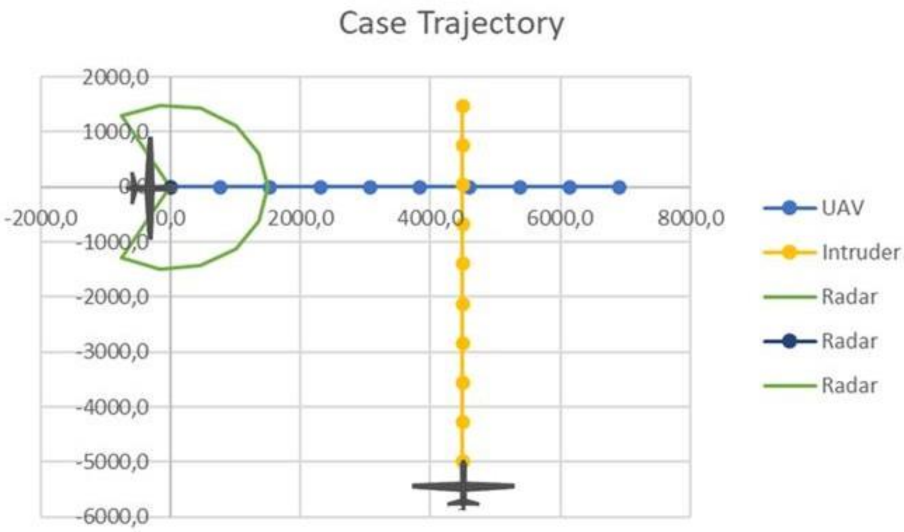

Figure 3. Trajectory

Table 2. Example of cases

	Case 1	Case 2
Detection Range	2,0	4,0
Field of View	2,0	4,0
Sensing Accuracy	2,0	2,0
Measurement Rate & Latency	2,0	2,0
Integration	1,0	1,0
Distance	3,0	3,0
Closing Speed	3,0	3,0

S	4,0	4,0
O	4,7	4,7
D	4,0	6,0
RPN	**74,7**	**112,0**

If the UAV flies using another radar that has a detection range of 500 m with azimuth and elevation angle of 70 deg and other conditions are the same as in the first case. Then the value for the detection range becomes larger, because with a short detection ability, the risk of midair getting bigger. This also applies to the field of view. Meanwhile, the other parameters are assumed to be the same. In this case, the RPN value becomes 112. In other words, the second case has a greater risk of midair collision than the first case. Because the difference between the first and second cases lies in the capabilities of the SAA radar, it can also be concluded that the first radar is better than the second radar in terms of the risk of a midair collision.

8. CONCLUSION

The risk/hazard analysis method using FMEA, in particular the RPN value, can be used to assess the risk of the SAA system on a UAV, especially in the case of midair collision. Each SAA requirement, as well as the function of this SAA can be used in determining the value of RPN, especially for Occurrence and Detection. The requirements or characteristics of the SAA system can be used as a parameter in quantifying the safety level by using the RPN rating value.

9. REFERENCES

Chand, B. N., Mahalakshmi, P., and Naidu VPS (2017): Sense and Avoid Technology in Unmanned Aerial Vehicles : A Review, *International Conference on Electrical, Electronics, Communication, Computer and Optimization Techniques (ICEEECCOT)*, IEEE.

Clothier, Reece A. and Walker, Rodney A. (2006) Determination and Evaluation of UAV Safety Objectives. *In Proceedings 21st International Unmanned Air Vehicle Systems Conference*, pages 18.1-18.16, Bristol, United Kingdom.

DeGarmo, Matthew T. (2004): Issues Concerning Integration of Unmanned Aerial Vehicles in Civil Airspace, *Center for Advanced Aviation System Development McLean*, Virginia.

Evans, Andrew R. (2006): The hazards of unmanned air vehicle integration into unsegregated airspace, *The University of York*.

Pham H., Smolka S.A., Stoller S.D., Phan D., and Yang J. (2015): A Survey on Unmanned Aerial Vehicle Collision Avoidance Systems, *Department of Computer Science*, Stony Brook University.

Popovic V., and Vasic, B. (2008): Review of Hazard Analysis Methodsand Their Basic Characteristics, *FME Transactions* (2008) 36, 181-187.

Sellappan N., Nagarajan D., and Palanikumar K. (2015): Evaluation of Risk Priority Number (RPN) in Design Failure Modes and Effects Analysis (DFMEA) using Factor Analysis, *International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10*, Number 14 (2015) pp 34194-34198.

Simon, J.N., and Braasch, M.S. (2009): Deriving Sensible Requirements for UAV Sense and Avoid Systems, *IEEE/AIAA 28th Digital Avionics Systems Conference*.

Skowron, M., Chmielowiec, W., Glowacka, K., Krupa M., and Srebro, A. (2019): Sense and Avoid for small unmanned aircraft systems: Research on methods and best practices, *Proc IMechE Part G: J Aerospace Engineering* 0(0) 1–19.

EARTHQUAKE RISK ANALYSIS IN FACILITIES OF PT SSS

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ABSTRACT

Indonesia located in area with active tectonic plate conditions. This happens because the location of Indonesia is the meeting point of 4 earth plates: Eurasia, Indo-Australia, Pacific, and the micro-plate of the Philippines. Active tectonic conditions make Indonesia prone to geological disasters such as earthquake. The earthquake disasters can affect many economic lines, as well as the business process carried out by PT SSS, that have 15 facilities located throughout Indonesia. The study aims to identify the risks of earthquake disasters of 15 (fifteen) the location of PT SSS facilities, as well as recommendations for disaster mitigation at facilities with high catastrophic risk levels. The study refers to secondary data include earthquake threats generated by government agencies and based on data obtained by PT SSS. Analysis of earthquake risk parameters made up of threat parameters, vulnerabilities and capacities. Priority scale each parameter used questionnaire from a geologist, earthquake expert, and practitioner. The analysis weight of the parameters using Analytic Hierarchy Process (AHP) method. The disaster risk analysis based on analysiss of threats conditions, vulnerabilities and capacities of each PT SSS facility. The results of earthquake risk analysis on each facilites indicate that mostly locations have low risks, locations with medium earthquake risk are office Banda Aceh and office Bandung, while locations with high earthquake risk is office Padang. Disaster mitigation or risk reduction recommended for Padang locations that have a high earthquake risk zone. The mitigations to reduce risk such as reduce infrastructure vulnerability by building reinforcement refer to earthquake resistance building standard and increase nonstructural capacity by increasing earthquake simulation by two times per year.

Keywords: risk analysis, earthquake, disaster.

1. INTRODUCTION

The research of earthquake disasters risk has been carried out in Indonesia and elsewhere. Schmidt-Thome, (2006) doing a study on the economic risks resulting from the earthquake disaster and flood. The data used are potential disaster maps and flood and avalanche maps, as well as land-use data that are present in some European areas. Mori and friends (2011) conducted a survey on the earthquake and tsunami that occurred in Japan in 2011, results show a maximum height of Japan's 17.5 meters (17.5 m) tsunami with a sweeping of the plains about 5 km. Tadjer, Bensaibi, (2017) conducted research on the risk of earthquakes in Blida using the GIS method. In his research, the parameters of lithology, distance from the structure, also the magnitude of the earthquake are used as a reference for determining earthquake risk. In addition, the social factors used are population density and infrastructure density which are used as vulnerability factors. The results of each parameter were overlaid using GIS. research shows Blida has a moderate to high risk of seismicity

With the growing trend toward disaster events in Indonesia and more research on the risks of natural disasters, PT SSS which has access to most of Indonesia's facilities, has a potential for earthquake disaster. Need for preparedness of disaster risk, knowing the level of risk at each PT SSS facilities. The study aims to identify risk of earthquake disaster on 15 (fifteen) the location of PT SSS facilities, and to recommend disaster mitigation at facilities that have a high of disaster risk.

2. RESEARCH METHODS

The study was conducted on 15 (fifteen) the location of PT SSS facilities that are currently operating and distributed throughout much of Indonesia (**Figures 1** and **Table 1**). The data used in this study is secondary data that has been published by agencies such as INARISK, PUSGEN, BMKG, and ESDM. As well as secondary data from PT SSS such as data about the parameters of each of the locations needed for analysis. The data variable used in the study are threats, vulnerabilities, and the capacity to cope with the catastrophe.

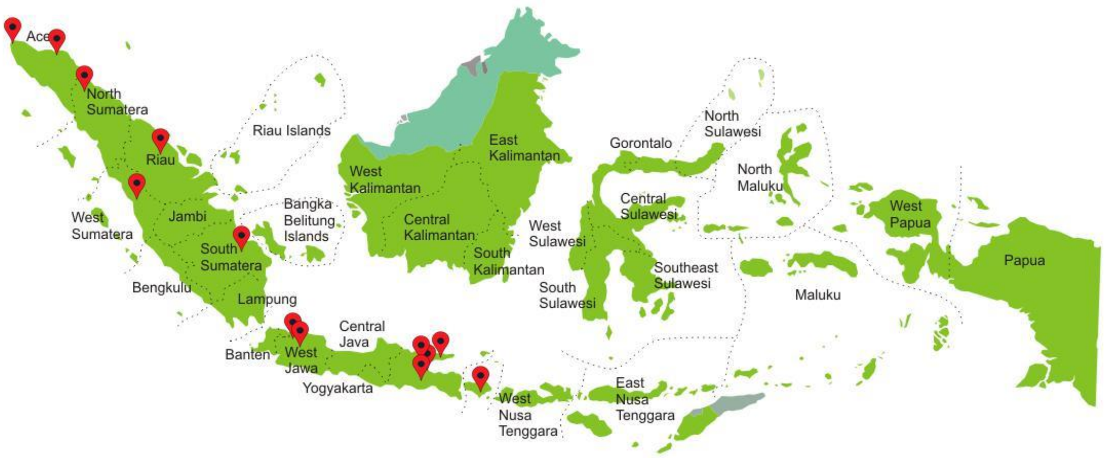

Figure 1. Map of Research Locations

Tabel 1. Research Location

No.	Facility Location	Building Function
1	Banda Aceh	Office and Warehouse
2	Lhokseumawe	Office and Warehouse
3	Pekanbaru	Office and Warehouse
4	Padang	Office and Warehouse
5	Medan	Office and Warehouse
6	Palembang	Office and Warehouse
7	Karawang	Factory
8	Bandung	Office and Warehouse
9	Surabaya 1	Headquarters and Factory

10	Surabaya 2	Factory
11	Sidoarjo	Office and Warehouse
12	Malang	Factory
13	Sukorejo Pasuruan	Factory
14	Pamekasan	Office and Warehouse
15	Denpasar	Office and Warehouse

The primary risk parameters are the threats of the earthquake, the vulnerability of the earth and the earthquake capacity. Earthquake threats identification covers 4 parameters refer to Jena, and friends, (2007), Hassan, and friends, (2020) that are : the subprime risk conditions obtained from the Inarisk map of the earthquake wildlife, the known geological conditions issued by the geological agency, the earthquake and the epicentrous distance of the research site, and the value of Peak Ground Acceleration (PGA) over 50 years, obtained from PUSGEN data (2017). Identifying the vulnerability of the earthquake consists of 3 (three) parameters: social vulnerability based on the number of people in facility and surrounding, infrastructure vulnerability based on the building conditions, and vulnerability of building elevation based on the building conditions . The parameters for structural capacity include any structural infrastructure when disaster occurs and nonstructural capacity are seen by companies' efforts to build resilient workers (May and friends, 1994).

In determining the priority scale of each parameter, the questionnaire is used for respondents who are geologists, earthquake experts, and practitioners. Then the analysis weight of the parameters used the Analytical Hierarchy Process (AHP) method. Each parameter has a different weight or value based on the order of influence. The assessment of each parameter is based on the intensity scale of importance in the AHP method. The results of the AHP for each identification of earthquake risk parameters from all respondents are processed and averaged by the geometric mean, the analysis based on the intensity of importance scale is entered in the paired matrix table, then the paired matrix is normalized to obtain the indicator weight of each parameter. Where the pairwise comparison compares between the criteria for each alternative hierarchical system in the form of a matrix for numerical analysis (Saaty, 1980).

The analysis of disaster risk is carried out with concepts released by UNISDR (United Nations International Strategy for Disaster Reduction) and BNPB (National Board for Disaster Management) Indonesia. The disaster risk analysis based on analysiss of the threats conditions, vulnerabilities and capacities of each PT SSS facility. Where probability is based, $= \frac{h \quad \times}{}$. Risk grade distribution is based on the normal frequency distribution of 3 grades to 5 grades by the following **Table 2**.

Table 2. Disaster Risk Grade

Grade	Interval	Risk Zone
Grade I	1.00-1.40	Very Low Risk
Grade II	1.40-1.80	Low Risk
Grade III	1.80-2.20	Medium Risk
Grade IV	2.20-2.60	High Risk
Grade V	2.60-3.00	Very High Risk

3. RESEARCH RESULTS

Analysis of the risk level of the earthquake is determined after pating out 3 primary parameters for the risk (**Table 3**), which is identifying the earthquake threat, identification of earthquake vulnerabilities, and identification of earthquake capacities. An earthquake risk analysis provides an overview of the level of risk of an earthquake in an area. Earthquake risk analysiss were carried out on 15 (fifteen) facility locations belonging to PT SSS which are currently still operating and scattered throughout Indonesia, so that the risk of earthquakes is known at each facility location owned by PT SSS. **Table 4** is an example of results in the earthquake risk analysis for the location of Banda Aceh, with a medium risk rate of 2.140 included in the grade III risk level.

Based on the results of the earthquake risk analysis at 15 (fifteen) facilities owned by PT SSS, it shows in variation risk zone. locations with medium risk zones are Banda Aceh and Bandung, while locations with high risk zones are Padang locations with a value risk 2.313 is classified as Grade IV risk.

Summary results of earthquake risk analysis shown on **Table 5**.

Table 3. Score off identification earthquake risk parameter

Parameters for Disaster Risk	Parameter	Distribution of Parameter Conditions	Weight Indicator	Score	Weight
Earthquake threat	Earthquake prone	Low earthquake prone	30.16%	1	0.302
		Medium earthquake prone		2	0.603
		High earthquake prone		3	0.905
	Geological conditions	Good rock compaction, low weathering, <2 meters, no active geological structure	24.07%	1	0.241
		Medium-high rock compaction, many discontinuities, soil <2 meters, no active geological structure		2	0.481
		Rocks in the form of sediment, thick soil, active geological structures, rocks exposed to intensive structures		3	0.722
	The epicenter event and the distance to the epicenter	Medium-deep earthquake, distance from epicenter> 20 km	23.35%	1	0.233
		Medium-deep earthquake, distance from the epicenter <20 km or 20 - 40 km, shallow earthquake conditions		2	0.467
		Shallow earthquake, distance from epicenter <20 km		3	0.700
	The PGA value is exceeded by 50 years	PGA value <0.2g	22.42%	1	0.224
		PGA value 0.2 - 0.4g		2	0.448
		PGA value> 0.4g		3	0.673

	Social vulnerability	Population density <500 people / km	29.12%	1	0.291
		Population density of 500 - 1000 people / km		2	0.582
		Population density> 1000 people / km		3	0.874
Earthquake vulnerabilities	Infrastructure vulnerability	The building condition is able to accommodate the PGA value at the location, the building condition is good	34.48%	1	0.345
		The condition of the building is able to accommodate the PGA value on site, but has minor damage to the building support structure		2	0.690
		The building condition is able to accommodate the PGA value at the location, but there is major damage to the building support structure, or the building condition is unable to accommodate the PGA value at the location		3	1.034
	Infrastructure height vulnerability	Number of building floors 1 - 2	36.40%	1	0.364
		Number of building floors 2 - 4		2	0.728
		Number of building floors> 4		3	1.092
Earthquake Capacity	Structural Capacity	The structural mitigation effort is low if in the office area there are no earthquake risk reduction attributes	50.00%	1	0.50
		Medium structural mitigation efforts if there is an evacuation route but there is no evacuation route map		2	1.00
		High structural mitigation efforts if the office area has an evacuation route map,		3	1.50

Parameters for Disaster Risk	**Parameter**	**Distribution of Parameter Conditions**	**Weight Indicator**	**Score**	**Weight**
		arrows indicating evacuation routes, emergency stairs, and gathering points.			
	Nonstructural Capacity	Non-structural mitigation efforts are low if there are no socialization activities or evacuation drills for employees in the office	50.00%	1	0.50
		Medium non-structural mitigation efforts if the company only carries out an agenda of disseminating the earthquake disaster to employees once a year		2	1.00
		High non-structural mitigation efforts if the company socializes employees about the earthquake disaster at least 2 times a year and conducts earthquake evacuation drills to employees		3	1.50

Table 4. Results of an earthquake risk analysis, Banda Aceh

	Parameter	**Distribution of Parameter Conditions**	**Weight Indicator**	**Score**	**Weight**	**Total Score**
Earthquake Threat	**Earthquake-prone conditions**	High earthquake prone	3016%	3	0.05	**2.776**
	Geological conditions	Alluvium (indistinguishable): gravel, sand, mud, etc.	24.07%	3	0.722	
	Earthquake occurrence and distance to epicenter	Shallow earthquake	23.35%	3	0.700	
	PGA value	PGA value 0.3 - 0.4g	22.42%	2	0.448	
	Social vulnerability	Population density> 1000 people / km	29.12%	3	0.874	

Earthquake Vulnerability	**Infrastructure vulnerability**	Concrete construction office, steel construction warehouse, there are minor damage to the building support structure based on structure analysis model	34.48%	2	0.690	**1.927**
	Infrastructure height vulnerability	The number of floors of the building 2 floors	36.40%	1	0.364	
Earthquake Capacity	**Structural Capacity**	The office area has an evacuation route map, arrows indicating evacuation routes, emergency stairs, and gathering points	50.00%	3	1.500	**2.50**
	Nonstructural Capacity	The company only conducts outreach agenda regarding the earthquake disaster to employees once a year	50.00%	2	1.00	
EARTHQUAKE RISK		**(Threat × Vulnerability) / Capacity**	**(Grade III – Medium Risk)**			**2.14**

Table 5. Summary of the results of earthquake risk analysis

No	Facility Location	The result of earthquake risk analysis		
		Value of risk	Risk Zone	Risk Grade
1.	Banda Aceh	2.140	Medium Risk	Grade III
2.	Lhokseumawe	1.547	Low Risk	Grade II
3.	Pekanbaru	1.375	The Risk is Very Low	Grade I
4.	Padang	2.313	High Risk	Grade IV
5.	Medan	1.322	The Risk is Very Low	Grade I
6.	Palembang	1.142	The Risk is Very Low	Grade I
7.	Karawang	0.927	The Risk is Very Low	Grade I
8.	Bandung	2.140	Medium Risk	Grade III
9.	Surabaya 1	1.734	Low Risk	Grade II
10.	Surabaya 2	1.734	Low Risk	Grade II
11.	Sidoarjo	1.734	Low Risk	Grade II
12.	Malang	1.362	The Risk is Very Low	Grade I
13.	Sukorejo Pasuruan	1.266	The Risk is Very Low	Grade I
14.	Pamekasan	1.189	The Risk is Very Low	Grade I
15.	Denpasar	1.547	Low Risk	Grade II

4. DISCUSSION

The results of the earthquake disaster analysis taken at 15 (fifteen) the location of PT SSS facilities have been obtained that locations with high earthquake risks is Padang. The analysis of disaster risk is carried out with concepts released by UNISDR (United Nations International Strategy for Disaster Reduction) and BNPB (National Board for Disaster Management) Which is Risk = (Threats x Vulnerability) / Capacity. From such concepts the risk of disaster can be minimized by reducing threats and vulnerability, and increasing capacity.

Capacity is made up of 2 (two) parameters, which are structural capacity and nonstructural capacity. For structural capacity, the current condition of the Padang location, namely the office area has an evacuation route map, arrows indicating evacuation routes, emergency stairs, and assembly points, for that the structural capacity score is a maximum, namely a score of 3 (three). Whereas for today's nonstructural capacity conditions, companies only do socialized agendas regarding earthquake disasters to employees 1 times in 1 year, for that nonstructural capacity score is 2. In order to reduce the risk of disaster, it can be done by increasing nonstructural capacity, by corporate efforts to introduce employees to earthquake disasters at least twice in one year and to perform earthquake evacuation programs for employees. If this is done, then nonstructural capacity to the target field has a score of 3, and it will impact disaster risk reduction. In addition to increase nonstructural capacity, to reduce the risk of the earthquake disaster of padang locations, it also increases infrastructure vulnerability. The current condition building is minor damage in the partial structure, where the score for infrastructure vulnerability parameters is score 2. Need building reinforcement in the structural supports so that the building is in good condition and can accommodate PGA refer to building standard, the score for a parameters of infrastructure vulnerability becomes score 1. If both mitigation are done, by increasing nonstructural capacity and reducing infrastructure vulnerability, the risk of the disaster in Padang will be reduced to 1.622 score and the range in the low risk category (Grade II).

5. CONCLUSION

Based on the results of the risk analysis that has been carried out, the earthquake risk zones at 15 (fifteen) PT SSS facilities are divided into several groups, high risk (Padang), medium risk (Banda Aceh and Bandung), low risk (Lhokseumawe and Denpasar), and the very low risk (Pekanbaru, Medan, Palembang, Karawang, Surabaya 1, Surabaya 2, Sidoarjo, Malang, Sukorejo, and Pamekasan). The location of the PT SSS facility which has a high risk of earthquake is the location of Padang, the recommended disaster mitigation or earthquake risk reduction for the Padang location are increasing nonstructural capacity and reduce infrastructure vulnerability.

6. REFERENCES

BNPB. (2010). *Peta Indesks Risiko Gempabumi Indonesia*. *Badan Nasional Penanggulangan Bencana* (BNPB), Jakarta.

BNPB. (2011). *Peta Hazard Gempabumi Indonesia*. *Badan Nasional Penanggulangan Bencana* (BNPB), Jakarta.

BMKG. (2019). *Peta Persebaran Kejadian Gempabumi Di Indonesia*. BMKG,

Jakarta UNISDR. (2005) United Nations International Strategy for Disaster

Reduction.

Hassan, H. M., Frischknecht, C., ElGabry, M. N., Hussein, H., & ElWazir, M. (2020). Tsunami hazard and risk analysis for Alexandria (Egypt) based on the maximum credible earthquake. *Journal of African Earth Sciences*, *162*, 103735.

May, P.J. and Birkland, T.A., (1994). Earthquake risk reduction: An examination of local regulatory efforts. *Environmental Management*, *18*(6), pp.923-937.

Mori, N., Takahashi, T., Yasuda, T., & Yanagisawa, H. (2011). Survey of 2011 Tohoku earthquake tsunami inundation and run-up. *Geophysical research letters*, *38*(7).

P. Schmidt-Thome. (2006). Natural and Technological Hazards and Risks Affecting the Spatial Development of European Regions. *Geological Survey of Finland*, Special Paper 42.

PUSGEN. (2017). *Peta Sumber dan Bahaya Gempa Indonesia*. Bandung: *Pusat Studi Gempa Nasional*.

Saaty, T.L. (1980) The Analytic Hierarchy Process, New York: McGraw Hill. International, Translated to Russian, Portuguese, and Chinese, Revised editions, Paperback (1996, 2000), Pittsburgh: RWS Publications.

Schmidt-Thomé, P., Greiving, S., Kallio, H., Fleischhauer, M., & Jarva, J. 2006. Economic risk maps of floods and earthquakes for European regions. *Quaternary International*, *150*(1), 103-112

Tadjer, K., & Bensaibi, M. (2017). Earthquake risk assessment of Blida (Algeria) using GIS. *Energy Procedia*, *139*, 645-650

TOPIC

Marketing Management

ANALYSIS OF FACTORS THAT AFFECTING SALES EFFECTIVENESS OF CONSUMER GOODS ON MARKETING PERFORMANCE BY USING STRUCTURAL EQUATION MODELING PARTIAL LEAST SQUARE (SEM PLS)

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ABSTRACT

The increasingly competitive competition in the consumer goods industry requires research subjects to have a competitive advantage in order to win the market. Several studies say that salesperson (sales) are the main contributor to influenced sales effectiveness. Theoretically there are differences in research related to the dominant factors affecting the performance of salespeople (sales), is the most influential factor is the character of the salesperson, in contrast to research from Djoni et al that the most influential factor is the salesperson's satisfaction with the company.

The data collection technique used is the interview method which is conducted directly by using a structured questionnaire using a scale of 1-5. The number of respondents in this study was 120 respondents, where the respondents were salesperson from consumer goods distributor company in Balikpapan. The analytical method used is the Structural Equation Model Partial Least Square (SEM PLS) in the SMART PLS 3 program.

The conclusion, the results of this research indicate that the Q-Square value formed from the SEM-PLS model is 62.7%, indicators that have a significant positive effect on salesperson performance are the salesperson's character is 0.261, salesperson reliability of 0.133, and salesperson's satisfaction is 0.338. Salesperson's satisfaction has the most influence on salesperson's performance, so that increased salesperson's satisfaction with the company has a significant effect on increasing salesperson's performance on company effectiveness.

Keywords: Distributor Consumer Goods, Efektivitas penjualan, Kinerja pemasaran, Tenaga Penjual, Structural Equation Modeling Partial Least Square (SEM PLS), SMART PLS

1. INTRODUCTION

The development of the Consumer Goods industry, it can increasing the business opportunities in the industry, but it also has an impact on increasingly competitive competition so that research subjects are increasingly required to have a competitive advantage in order to win the competition with competitors and be able to survive and developed. In the Fast Moving Consumer

Goods (FMCG) distributor business, the company cannot take a large margin to maintain the market share. Therefore, companies must be selective to adjusting the costs incurred, both those directly related to the business and other operating expenses. One of the biggest costs is direct labor costs, in this case the sales force. As a result, many companies have reduced their sales force, relying instead on investing in technology to build relationships with consumers. However, the reality is that technology in Indonesia has not been able to completely replace the performance of salespeople, measured by the ratio of turnover obtained by companies in the same financial period. That way salespeople who are directly related to customers are the main contributors that affect the sales effectiveness of a consumer goods distributor company. There needs to be a contribution from company management to direct salespeople to always be on the track by determining several indicators or factors that affect the salesperson's performance that can increase the company's sales effectiveness.

Theoretically, there is a research gap related to the most dominant factor affecting the performance of salespeople (sales), is according to research from (Kusmanto, JS, 2006) that the most influential factor is the salesperson character variable, in contrast with research from (Djoni, oktaviani, R. & Kirbrandoko, 2016) where it was found that the most influential factor was salesperson's satisfaction with the company. These factors include the variables to be measured in this study using the Structural Equation Modeling Partial Least Square (SEM PLS) approach.

2. RESEARCH FRAMEWORK

2.1 Salesperson Control System Theory

The definition of a salesperson control system according to (Mulyadi & Setyawan, 2001) is a system used by company management to monitor the implementation or implementation of plans for the realization of the organization's vision through the mission agreed upon by the company and its salesperson.

2.2 Salesperson Reliability Theory

The reliability of the sales force is a form of consumer confidence and trust that the salesperson has a variety of specialized knowledge that is relevant and supportive of the success of a business relationship (Liu & Leach, 2001).

2.3 Salesperson Character Theory

The character of a salesperson who is credible and has high concern for customers needs to be supported by the level of loyalty salesperson to them current company. Apart from the tenure, the salesperson's level of loyalty can be reflected in the increasing number of customers of a salesperson as proof of success that they have won the trust of new customers.

2.4 Salesperson Performance Theory

There are several indicators to assess the performance results of the various salesperson's efforts, that is achieved the sales target given by the company, increasing the marketing coverage / distribution area, and the ability of a salesperson to retain them customers.

2.5 Salesperson's Satisfaction Theory of the Company

The salesperson's performance can be very influential on the company's success. The causes of terms marketing the sales force is the spearhead of the company. From the research (Djoni, oktaviani, R. & Kirbrandoko, 2016) said that there are several indicators that can affect salesperson's performance, that is the provision of incentives (money), satisfaction guarantees, and product rewards.

2.6 Theory of Company Sales Performance Effectiveness

The effectiveness of a firm's sales performance is defined as a summary evaluation of all organizational results (Baldauf, et al., 2001). The effectiveness of the company's sales are company's marketing and sales performance is an achievement that results from the impact of the various roles that have a function in an organization. Good marketing performance indicates a high level of sales and an increase in the number of sales, both in product units and in monetary units. Improved marketing performance is also marked by the achievement of good sales from the previous period (sales volume), sales growth that is higher than competitors (sales growth), and the nominal generated by the company (profitability).

2.7 Research Instrument Test

Research instruments have an important role in quantitative research because the quality of research data is determined by the quality of the instruments used.

2.7.1 Validity test

Processing of validity data in the instrument test can be done in two ways, that is Bivariate Pearson correlation for the number of question items <20 items or Corrected item - total correlation for the number of question items ≥ 20 items. Those both of methods compare r- count with r-table, where r-count can be calculated manually according to the formula for each method or can also be obtained directly using software such as IBM SPSS Statistics. While the r-table is obtained from the distribution table of the r-table values which have been standardized according to the amount of data (N) owned and the significance of the alpha value is 5% or 1%. Standard distribution of r-table values can be seen in Appendix 1.

a. Pearson Bivariate Correlation

According to (Arikunto, 2010) the correlation formula is:

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{[N\sum X^2 - (\sum X)^2][N\sum Y^2 - (\sum Y)^2]}} \quad (2.1)$$

Where:

N = number of respondents X = question score

Y = total score

rxy = correlation coefficient between X variable and Y variable The Bivariate Pearson test criteria are:

- If r-count> r-table (with a significant alpha value = 0.05), then the instrument or question item has a significant correlation to the total score and the test is declared valid.
- If r-count <r-table (with a significant alpha value = 0.05), then the instrument or question item is not significantly correlated with the total score and the test is declared invalid.

2.7.2 Reliability Test

According to H. Umar (Umar, 2003), the reliability test is used to show the effectiveness the measuring device that used can be trusted with the alpha (α) formula. To calculate reliability in the study, the Cronbach Alpha formula was used (Sugiyono, 2016):

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum \sigma^2 b}{\sigma^2 t}\right)$$

$$\sigma^2 b = \frac{\sum X^2 - \frac{(\sum X)^2}{K}}{K}$$

$$\sigma^2 t = \frac{\sum Y^2 - \frac{(\sum Y)^2}{K}}{K} \qquad (2.2)$$

Where:

σ = instrument reliability value
k = number of questions
K = number of respondents
∑a2b = number of variants of each item
a2b = total variant
X = question score
Y = total score

2.8 Partial Least Square (PLS)

Partial Least Square (PLS) is a regression method that introduced by Herman O.A. Wold in 1975. PLS is a comprehensive analysis method because it can be applied to all data scales, does not require many assumptions, the sample size does not have to be large, and the data does not have to be normally distributed multivariate (Garson, 2016). PLS can also be used to describe the presence or absence of a relationship between latent variables. The stages of data analysis and structural equation modeling using PLS software can be carried out in the following stages:

1. Describe the respondent's data
2. Develop Hypotheses
3. The conceptualization of the model includes designing a measurement model (outer model) and a structural model (inner model).
4. Construct a path diagram (path diagram) / framework
5. Evaluating the measurement model (outer model)

3. RESEARCH METHODOLOGY

3.1 Research Data Collection Method

In the preparation of this thesis, the authors collected data through a survey technique carried out on May 1, 2020 to June 30, 2020 with the target of respondents being salespeople of one of the consumer goods distributors in Balikpapan, with 120 respondents.

3.2 Data Analysis Method

The method used in this research is a model of causality or the influence between variables that cannot be measured and other variables, either directly or indirectly. To test the hypothesis proposed in this study, the analysis technique used is SEM-PLS or Structural Equation Model Partial Least Square which is operated through the SMART-PLS program.

PLS-SEM analysis does not require the assumption of a certain distribution to estimate the parameters, so a parametric technique to test the parameter significance is not needed. The PLS model evaluation is based on predictive measurements that are non-parametric in nature. The PLS model evaluation criteria are summarized in Table 1.

Table 1. PLS Model Evaluation Criteria

Test	**Parametric**	***Rule of Thumb***	**Explanation**
Model Pengukuran (*outer model*)			
Validitas Discriminant	*Loading Faktor*	> 0.7 or minimal 0.4	For *Confirmatory Research*
	Average Variance Extracted (AVE) more than 0,5	> 0.5	For *Confirmatory Research* or *Exploratory Resea*
Validitas konvergen	*Cross Loading*	> 0.7	Every single variable
	Akar kuadrat AVE	AVE root square > latent variable correlation (min 0,7)	
Construct Reliability	*Cronbach Alpha*	> 0.7	For *Confirmatory Research*
	CompositeReliability	> 0.7	For *Confirmatory Research*
(*Inner Model*)			
R2	-	> 0.67	Strong model
		> 0.33	model moderate
		> 0.25	Weak model

The path diagram is made to facilitate data processing that will be carried out to test the Measurement Model (outer model), Structural Model (inner model), and Hypothesis Testing (Bootstrapping). The path diagram is made directly in the work area of the SmartPLS application.

4. RESULT and DISCUSSION

4.1 Validity test

Validity testing is carried out by analyzing the correlation between the score of each indicator with the overall score of each variable using SPSS software with the results presented in Table 2

Table 2. Validity test results

Variabel laten	**Indikator**	**Nilai Korelasi**	**P-value**	**Keputusan**
Employee	X1	0,802	0,000	Valid
controlling system	X2	0,847	0,000	Valid
	X3	0,846	0,000	Valid
Salesperson realibility	X4	0,866	0,000	Valid
	X5	0,83	0,000	Valid
	X6	0,871	0,000	Valid
Salesperson character	X7	0,892	0,000	Valid
	X8	0,856	0,000	Valid
	X9	0,864	0,000	Valid

Salesperson performance	X10	0,864	0,000	Valid
	X11	0,892	0,000	Valid
	X12	0,84	0,000	Valid
Satisfaction seller	X13	0,81	0,000	Valid
	X14	0,821	0,000	Valid
	X15	0,766	0,000	Valid
Company selling effectivenes	X16	0,885	0,000	Valid
	X17	0,894	0,000	Valid
	X18	0,914	0,000	Valid

Table 2 shows the correlation values that tend to be high for all indicators. In addition, the results of the validity test show the p-value for all indicators is 0.000. This value is less than the significant level of 0.05 and results in a decision to reject H0 (H0: The indicator cannot measure the same dimension / is not valid). It's means that all indicators used in this study are valid, so these indicators can be used to measure each variable.

4.2 Reliability Test

Reliability test is used to show the extent to which the measuring instrument used is reliable and remains consistent when repeated measurements are made. Reliability testing is done by calculating the Cronbach's Alpha value from the indicators on each variable. The calculations were carried out with the help of SPSS software with the results presented in Table 4.2

Tabel 3. Reliability test results

Variable	***Cronbach's Alpha***
Sales control system	0,776
Sales reliability	0,817
Sales character	0,841
Sales performance	0,832
Sales satisfaction	0,717
Company selling effectiveness	0,880

Table 3 shows that the Cronbach's Alpha value for all variables is above 0.6. This means that the indicators used to measure each variable are reliable, so the questionnaire used in this study is a reliable questionnaire.

4.3 SEM PLS analysis

The results of the estimation algorithm on PLS analysis to evaluate the outer model used for measurement models.

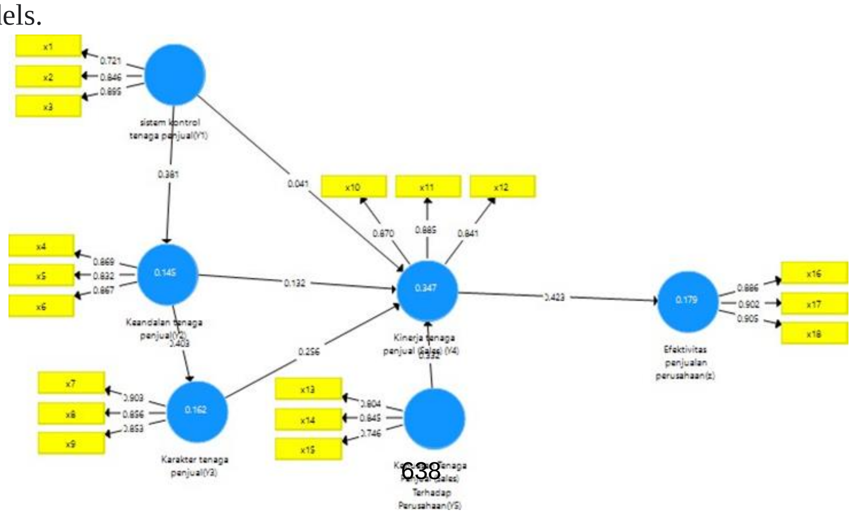

Figure 1. SmartPLS Model 1 Algorithm

The results of hypothesis testing from the above model indicate that the salesperson's reliability (Y2) has no significant effect on salesperson's performance (Y4) and the salesperson's control system (Y1) has no effect on salesperson's performance (Y4). So it is necessary to remodeling it by removing the link from Y1 to Y4 because it has a very large p-value.

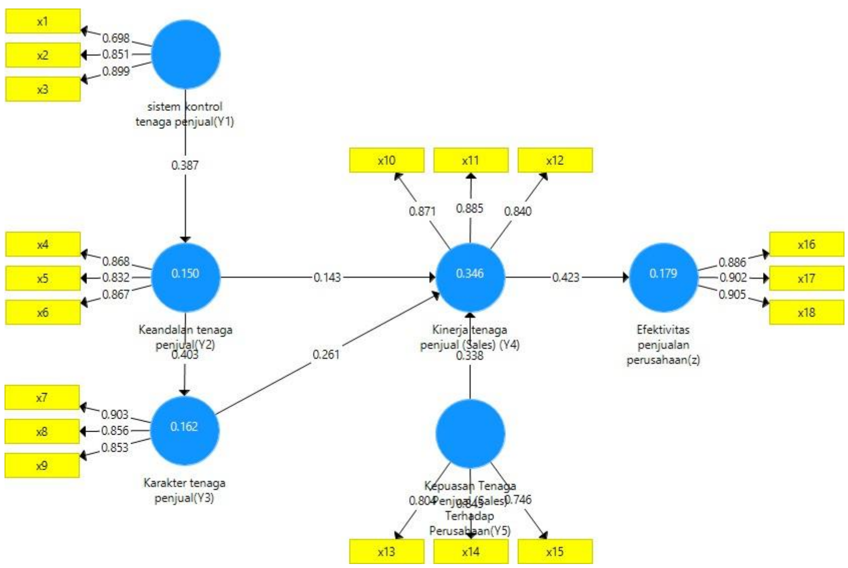

Figure 2. SEM-PLS Model 2 Framework

In the test results of convergent validity and discriminant validity of the above model, the indicator X1 <0.7 is not in accordance with the provisions of outer loading, so it is necessary to remodel to remove the X1 indicator.

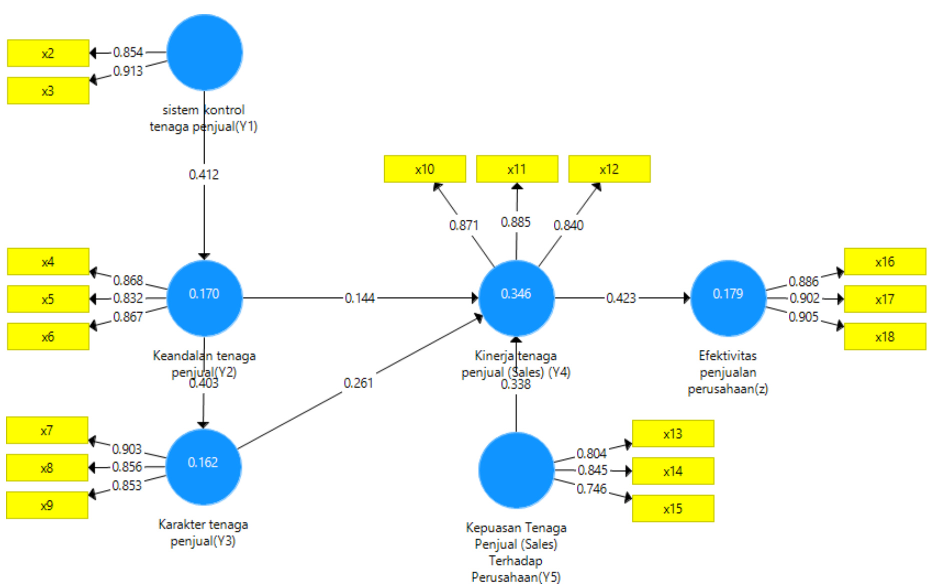

Figure 3. SEM-PLS Model 3 Framework

From the model above, it is obtained the value of R Square from testing the structural model which produces Latent Variables which have Moderate and Weak effects. Latent variable that has moderate effect is salesperson performance (Y4). While the latent variables that have a weak effect are the company's sales effectiveness (z), salesperson character (Y3), salesperson reliability (Y2).

The direct relationship hypothesis testing shows that have a positive significant effect on salesperson performance are the salesperson's character (Y3), the salesperson's character (Y4) and the salesperson's satisfaction (Y5). The most influencing factors to the less influencing of salesperson's performance are salesperson's satisfaction to the company> salesperson's character> salesperson's reliability. In addition, the salesperson's performance directly affects the effectiveness of sales of consumer goods companies.

Hypothesis testing of the indirect relationship between the construct variables shows that the more intervening variables that are passed, the smaller the value of the relationship between the latent variables, and the less significant. There is an indirect influence between the salesperson's character (Y3), salesperson's satisfaction (Y5) with the effectiveness of company sales through intervening salesperson performance.

Based on the bootstrapping hypothesis test, the factors with the highest to lowest effect on salesperson's performance are salesperson's satisfaction to the company> salesperson character> salesperson reliability> salesperson control system. So the company should emphasize more on the variables supporting the salesperson's character.

5. CONCLUSION

In general, in this study can be proven that the better salesperson's performance, make te selling effectiveness. The results of the analysis of Partial Least Square - Structural Equation Modeling (PLS-SEM) show that have a significant positive effect on salesperson performance are salesperson character (Y3), salesperson reliability (Y2), and salesperson satisfaction (Y5). Afterwards, the salesperson's performance directly affects the effectiveness of sales of consumer goods companies. It's means that the better character of the salesperson through high good relationships with customers, it can increase customer trust and loyalty. Thus, it will increase salesperson performance and have an impact on increasing selling effectiveness in the form of increased sales growth from the previous year along with increased sales volume as well. In addition, the increasing salesperson's satisfaction with the company has a significant effect on increasing salesperson's performance on company effectiveness. So that companies can pay more attention to how the company treats sales in terms of job security, incentives, and rewards to maintain salesperson satisfaction.

And factors that are not proven in this study, the company can improve the control system for salespeople and increase the reliability of salespeople through the provision of training / training for salespeople related to company products, communication skills and others. This can be used as an additional solution so that the distributor company in Balikpapan can increase the sales growth rate more than the results obtained.

6. REFERENCES

Anderson, E., & Oliver, R. L. (1987). Perspective on Behavior-Based Versus Outcome-Based Salesforce Control Systems. *Journal of Marketing*, Vol.51, p.76-88.

Baldauf, A, Cravens, D. W, & Piercy, A. N. F. (2001). Examining Business Strategy, Sales Management, and Salesperson Antecedents of Sales Organization Effectiveness. *journal of Personal Selling & Sales Management*, pp. 109-122.

Bonoma, T. V., Clark, & & Bruce, H.;. (1988). *Marketing Performance Assessment. Boston, Harvard Business School Press.*

Djoni, oktaviani, R., & Kirbrandoko. (2016). Factors That Affect The Sales Performance Of PT SKP (A Case Study Of Sales Force Of Moorlife Indonesia In Jabodetabek). *Indonesian Journal of Business and Entrepreneurship*, p. 122.

Djunaidi, B., Suryani, E., & Achmadi, F. (2015). *Analisis Faktor Terhadap Loyalitas Konsumen Dengan Menggunakan Kuesioner Online Dan Structural Equation Modeling (Studi Kasus PT. Profile Asia).* Surabaya: ITS.

Dupre, Kyle, & Gruen, Thomas W. (2004). The Use of Category Management Practices to Obtain a Sustainable Competitive Advantage in The Fast - Moving - Consumer - Goods - Industry. *Journal of Business & Industrial Marketing*, Volume 19 Number 7 pp. 444 - 459.

Grant, K., & D.W, C. (1999). Examining the antecedants of sales organization effectiveness:An Australian

Study. *European Journal Of Marketing,33(9/10)*, pp. 945-957.

Groza, M. D, & Groza, M. P. (2018). Salesperson regulatory knowledge and sales performance. *Journal of Business Research*, pp. 37-46.

Hair, Joseph F., Sarstedt, Marko., Pieper, Torsten M., & Ringle, Christian M. (2012). The Use of partial Least Square Structural Equation Modeling in Strategic Management Research: A Review of Past Practices and Recommendations for future Applications . *Elsevier Ltd. All Right Reserved*, Long Range Planning 45, 320 - 340.

Kusmanto, J. S. (2006). Analisis Faktor-Faktor yang Menpengaruhi Kinerja Hasil Tenaga Penjualan Dan Hubungannya Terhadap Efektifitas Penjualan Perusahaan (Studi Kasus Pada BPR Di Eks. Karesidenan Semarang). *Jurnal Studi Manajemen dan Organisasi,*, p. 64.

Kuzmina, K., Prendeville, S., Walker, D., & Charnley, F. (2019). Future scenarios for fast-moving consumer goods in a circular economy. *Futures*, pp. 74-88.

Liu, A. H., & Leach, M. P. (2001). Developing Loyal Customers with a Valueadding Sales Force: Examining Customer Satisfaction and the Perceived Credibility of Consultative Salespeople. *Journal of Personal Selling & Sales Management*, XXI(No. 2, Spring: 147- 156).

Mahardika, R. (2007). *Analisis Faktor-Faktor Yang Mempengaruhi Efektivitas Penjualan Terhadap Kinerja Pemasaran.* Semarang: UNDIP.

Morgan, R. M., & Hunt, S. D. (1994). The Commitment- Trust Theory of Relationship Marketing. *Journal of Marketing,*, Volume Vol. 58, pp. 20-38.

Mulatsih, R. (2011). *STUDI TENTANG KINERJA TENAGA PENJUALAN (Study of Performance of Sales Persons) Kasus Empiris Pada PT. Sinar Niaga Sejahtera Area Distribusi Jawa Tengah I,.* Semarang: s.n.

Mulyadi, J., & Setyawan. (2001). *Sistem Perencanaan dan Pengendalian Manajemen (Sistem Pelipat Ganda Kinerja Peneliti).* Jakarta: Salemba Empat, p. 3.

Nijssen, E. J. (1999). Success Factors of Line Extensions of Fast - Moving Consumer Goods. *European Journal of Marketing 33,5/6*, vol. 33 lss 5/6 pp. 450 474.

Puspitarin, E. W., Sunaryo, S., & Suryani, E. (2013). *Pemodelan Technological Pedagogical Content Knowledge (Tpack) Berbasis Teknologi Informasi Dan Komunikasi (TIK) Dengan Pendekatan Structural Equation Modeling (Sem).* Surabaya: ITS.

Sarstedt, M., Ringle, C. M., Smith, Donna, Reams, Russell, & Hair Jr, Joseph F. (2014). Partial Least Square Structural Equation Modeling (PLS-SEM): A Useful Tool for Family Business Researchers . *Elsevier Ltd. All Right Reserved*, Journal Family Business Strategy 5, 105 - 115.

Steiger, J. H. (2006). Understanding The Limitations of Global Fit Assessment in Structural Equation Modeling . *Elsevier Ltd. All Right Reserved*, Personality and Individual Differences 42, 893 - 898.

Veno, M., & Subagio, H. (2013). Analisa Pengaruh kepercayaan terhadap tenaga penjual (trust in employee), dan kepercayaan terhadap merek (trust in brand) terhadap niat beli (purchase intention) konsumen pada Bernini furniture di Surabaya, dan Semarang. *JURNAL MANAJEMEN PEMASARAN PETRA*, 1(2), pp. 1-12.

Westland, J. C. (2010). Lower Bounds on Sample Size inStructural Equation Modeling. Elsevier B.V. All Right Reserved, Electronic Commerce Research and Applications 9, 476 - 487.

ANALYSIS OF FACTORS THAT AFFECTING CUSTOMER SATISFACTION IN XYZ COMPANY

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ABSTRACT

Competition in the information technology business similar to PT. XYZ is getting tougher both on the service and product side. Proven in customer tenders, PT. XYZ often meets other competitors and of course this makes the company won and lost, both of old customers or prospective new customers which has an impact on decreasing the company's sales level. Therefore, researchers will focus on service and customer satisfaction using Service Quality (ServQual) methods and Importance Performance Analysis (IPA). ServQual is useful for knowing the level of customer perceptions and expectations of this technology. Then analyzed using the IPA method to determine priorities in improving services to information technology companies. Data obtained from the distribution of questionnaires to customers that discuss ServQual dimensions which include reliability, empathy, tangibility, assurance, and responsiveness and is filled independently using a web-form. The questionnaire is divided into three stages: demographics, customer expectations, and the reality of customer perceptions of the company's performance. The overall result of the research on the average between expectations and reality is positive (gap = 0.03) which means that customer satisfaction is met, while the most influential dimensions are assurance and empathy. Service improvement in the empathy dimension has a top priority in the Cartesian diagram to improve customer satisfaction.

Keywords: Customer Satisfaction, Servqual, Service Quality, Importance Performance Analysis.

1. INTRODUCTION

PT. XYZ is an information technology company with an identical business focus in Automated-Identification (AIDC and RFID), Wireless Infrastructure & Network Security, Enterprise Security Systems (CCTV, Access Control & Alarm) and Enterprise Business Solutions (Software). PT. XYZ has extensive and deep experience in AIDC and Wireless Networks because the company is one of the first providers of such technology in Indonesia. Information technology products and services offered are quite varied so that they can provide many solutions for today's technology needs.

Most of XYZ company's customers are retail, manufacturing and hospitality companies. These companies are using tender policies that must be attended by several vendors. Competition in the information technology product business that similar to PT. XYZ is also getting tighter. Competition is not only seen from the low price of the product, but service is also an important factor that must be considered. Satisfactory products and services make customers loyal because customer loyalty is influenced by customer satisfaction and service quality according to Jamaluddin

(2017). Therefore, the company also provides professional services as an additional service offered to the customers. The possibility that happens if a customer decides to stop using a product or service is that the customer sees another substitute product that is better and is able to provide a level of satisfaction more than PT. XYZ. Proven in customer tenders, PT. XYZ often meet other competitors and of course this makes PT. XYZ has won and lost both of old customers or new prospective customers which have an impact on the company's sales decline.

In order to keep customers purchasing information technology products and services regularly, this paper use the ServQual method approach which is widely used in measuring service quality. This study uses five ServQual dimensions which include tangibility, reliability, responsiveness, empathy, and assurance in an effort to improve service company information technology products by paying attention to customer satisfaction factors. The results of this research, the management is expected to obtain a strategy to develop improvements to the quality of service that is needed by customers so products and services sales of XYZ Company can increase even more.

The objective of this research is to determine the gap between perceptions of the quality of the company's services received by current customer with customer expectations. Then to find out the factors that has most influence on customer satisfaction of PT. XYZ and proposed improvements that must be made to improve the service quality of PT. XYZ.

Quality is the level of good or bad of something according to KBBI (2020). In the opinion of experts, quality is a dynamic condition related to products, people (labor), processes, tasks, and the environment that meet or exceed customer or consumer expectations. Consumer expectations are always changing so the quality must also be adjusted. Hartnett (1988) suggested that with change in quality, it is necessary to increase the skills of the workforce, processes, tasks, and changes in the company's environment in order to meet or exceed consumer expectations.

Services is an economic activity that involve a number of intangible elements (value or benefits) that combine interactions to customers or goods. A process that consists of a series of real activities, but usually does not always occur in interactions between customers and providers of goods or systems which are provided as a solution to solving customer problems according to Edvardsson (2005) so these activities can be offered to customers. KBBI (2020) defined service is helping to prepare or take care of the needs needed by others. Service have four main characteristics according to Kotler (2006), namely intangibility, inseparability, variability and perishability.

1.1 Service Quality

According to Parasuraman (1985), service quality is the overall attitude shown by a company towards customer satisfaction, loyalty, and performance. ServQual is a survey instrument originally developed by marketing researchers to assess service quality based on the gap between expected service delivery and perceived service delivery. ServQual survey instrument consists of 22 items as Parasuraman research (1988), forming five main dimensions customers use to evaluate the quality of service they receive from service providers. Boakye (2020) mention that ServQual is used widely in operational and marketing contexts. The five dimensions of servqual are:

1. *Reliability*, the ability to provide the promised services accurately and reliable.
2. *Assurance*, including knowledge, politeness, credibility and the ability or competence of company employees in overcoming customer problems.

3. *Tangibility*, physical facilities such as neatness of employee appearance, means of communication, adequate company premises, and the equipment.
4. *Empathy*, attention to service that includes personal care and ease of communication in understanding customer needs in depth.
5. *Responsiveness*, employee willingness to fast respond positively, precise, full of enthusiasm and convincing to help customers.

Servqual is one of the factors that determine customer satisfaction which is important to be able to measure the level of company service quality from the customer side. ServQual measures and identifies five gaps which affecting the successfull of services. *First*, the gap between customer expectations and management perceptions. *Second*, gap between management perceptions and service quality specifications. *Third*, gap between service quality specifications and service delivery. *Fourth*, the gap between service delivery and external communication. *Fifth*, the gap between the perception of the service received and the service expected

Li et al. (2015) used ServQual to identify factors affecting patient perceptions of service quality at nine hospitals in China. The result is that empathy and reliability are the most influential ServQual dimensions. Kalaja (2016) assessed the quality of services in an important sector in Albania, namely Durres Hospital with the results of the empathy dimension having the greatest influence. In the public sanitation facilities sector, Alam (2019) measures the quality of services in slum areas with the biggest gap in the tangibility dimension. Ershadi (2019) uses the ServQual method to investigate the weaknesses and strengths of the Information Technology department in detergent companies, with the result that the responsiveness dimension needs to be improved for future service improvements.

1.2 Perception

Perception is defined as a way of thinking and paying attention about something with the sense of sight, hearing, or other senses in order to understand or notice something quickly. In psychology, cognitive science and philosophy, perception is the process of achieving awareness or understanding sensory information. The word "perception" comes from the Latin word *perceptio*, *percipio*, which means the act of taking, collecting, receiving and understanding with thoughts or senses (Qiong, 2017). The perception in this study is the result of an assessment of the performance that has been done and can be felt. So that customer perception is an assessment of company performance that is received and felt by customers for the services provided.

1.3 Customer Satisfaction

Kristianto (2015) explains that satisfaction can be interpreted as an emotional response in an effort to fulfill an adequate need for the use of a product or service. Meanwhile, customers are people or entities that use our services or services to meet their needs. Relating to Kotler (2006), which defines customer satisfaction is a feeling of pleasure or disappointment that arises after comparing the performance (results) of the product that is thought of against the expected performance. This satisfaction can certainly be felt after the customer uses the product or service. Satisfaction has progressed from cognitive to cognitive-emotional. Miranda (2017) also interpret that satisfaction is used to assess evaluations based on the total accumulated experience with a company, service, or product in a sustainable manner.

Customer satisfaction can be achieved by providing high quality service to customers. This also helps the company to gain an increase in market share as today's customer focus on the quality of service provided to them. Customer satisfaction is appropriately characterized as an evaluation made on the basis of a particular service experience according to Shah (2020).

Parasuraman (1988) measures customer satisfaction with service quality in this study using the equation Q = P - E. Customer expectations are the interests that will be obtained from the products and services used or consumed. Kristianto (2015) uses the same formula with a slight modification but has the same meaning as below:

Satisfaction = Performance - Expectation

where :

Satisfaction = Customer satisfaction

Performance = Customer perception, condition of service performance received and felt by customer

Expectation = Customer expectations

The equation above has three result:

1. P < E : The lack of provided service quality so customers are not satisfied.
2. P = E : Provided service quality is equal with expectations so customers are satisfied.
3. P > E : Provided service quality exceed expectations so customers are very satisfied.

2. METHOD

2.1 Survey

A survey is a collection of data obtained by asking individual questions either directly or indirectly. Surveys are a form of primary research because they collect data directly from the source as previous researchers have done. The research questionnaire data consist of 22 multiple choice questions related to the 5 ServQual dimensions. 5 questions about the dimensions of physical tangibility, 4 questions about the dimension of reliability, 5 questions about the dimension of responsiveness, 4 questions about the dimensions of assurance and 4 questions about the dimensions of empathy.

Questionnaire items were assessed using a 5-point Likert scale with the statements "strongly disagree" and "strongly agree" represented by numbers 1 to 5. The questionnaires were distributed to customers who made transactions in the last 12 months.

2.2 Questionnaire Design

The questionnaire was designed into three parts. First, it was designed to gather information about respondents' demographics. Second, it was designed to assess respondents' expectations about company service quality. Third, it aims at measuring perceptions of the customer and items included in this part are based on the 22-item SERVQUAL questionnaire selected as Table 1 below:

Table 1. Measurement selected item

Dimension	Service Quality Items
Tangibility - P1	XYZ has the up to date products and services (Kotler, 2006), (Boakye, 2020)
P2	XYZ employees' appearance is neat / polite / formal (Shokouhyar, 2020), (Boakye, 2020), (Miranda, 2017)
P3	Ease to meet XYZ employees (Shokouhyar, 2020)
P4	Complete information on the XYZ website / social media (Kotler, 2006), (Miranda, 2017)
P5	XYZ's work is neat, clean and appropriate (Kotler, 2006), (Miranda, 2017)
Reliability - P6	XYZ is capable to answer questions clearly and easily understandable (Ershadi, 2019)

P7	XYZ is competent to provide products according to the agreed time or time plan. (Kotler, 2006), (Boakye, 2020)
P8	Products are reliable and rarely defect (Kotler, 2006), (Boakye, 2020)
P9	Easy communication (help-desk, support center, service center, sales or others) when needed (Shokouhyar, 2020)
Responsiveness - P10	XYZ employees are fast in serving customer needs (Shokouhyar, 2020), (Boakye, 2020), (Miranda, 2017)
P11	XYZ employees are fast in providing answers or give solutions (Shokouhyar, 2020)
P12	XYZ employees resolve customer complaints quickly and best (Shokouhyar, 2020)
P13	XYZ employees are always available and quick to respond when contacted (Shokouhyar, 2020), (Boakye, 2020), (Miranda, 2017)
P14	XYZ employees offer a replacement product if the desired product is not available (Alam, 2019)
Assurance – P15	XYZ guarantees the device is running properly (Boakye, 2020)
P16	Product replacement guarantees, if a damaged product is found during the warranty or contract period (Miranda, 2017)
P17	XYZ employees are skilled in carrying out their jobs (Shokouhyar, 2020), (Miranda, 2017)
P18	XYZ employees work professionally (Shokouhyar, 2020)
Emphaty – P19	XYZ employees are friendly and polite (Boakye, 2020)
P20	XYZ employees take the time to listen customer complaints (Kotler, 2006), (Miranda, 2017)
P21	XYZ employees are well communicate (Boakye, 2020)
P22	XYZ employees understand the specific needs of customers (Kotler, 2006), (Boakye, 2020), (Miranda, 2017)

2.3 Validity and Reliability of Questionnaires

36 respondents who filled out the questionnaire, there was one respondent who did not fully fill in the answers to the questionnaire on customer perceptions of the reality of the company's service performance so that only 35 data were used. Then the data is processed in Minitab to test the validity level of the questionnaire using Pearson correlation. The P-value of all the results of the validity test of the expectation and perception questionnaire is less than 0.05, which means significant and valid. Followed by a questionnaire reliability test using the Cronbach Alpha coefficient. All questions in this study are reliable because the Cronbach Alphas value is more than 0.06.

2.4 Importance Performance Analysis

This IPA analysis will produce a visual display, namely Cartesian diagram shown on Figure 1, a scatter chart that shows the distribution of services which are quadrant A, quadrant B, quadrant C or quadrant D. In making a Cartesian diagram, points x (average customer perception / reality) and y (average customer expectations / interests) are needed. From this calculation, it can also be calculated the gap for each service as well as the overall average value of all service expectations and realities.

Quadrant A shows that the company's performance has a lower value than customer expectations. Factors that are considered very important but not satisfactory because the company has not implemented according to customer expectations or wishes. Companies must focus on the attributes included in this quadrant to improve customer satisfaction.

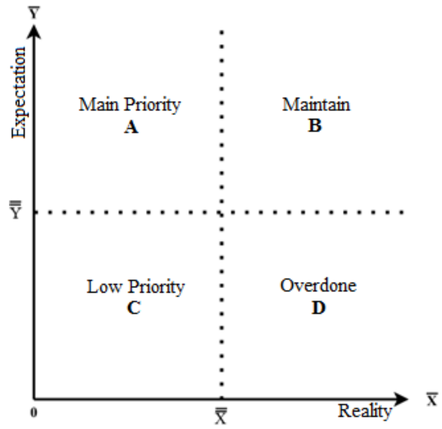

Figure 1. Cartesian diagram

Quadrant B shows that the factors in the questionnaire included in this quadrant have a high level of importance and performance. Customers see that the company is able to meet expectations and satisfy customers. Therefore the company is obliged to maintain the performance attributes in this quadrant to maintain customer satisfaction.

Quadrant C shows that customer expectations in this attribute are low or considered less important and company performance is also low. The company carries out the attributes in this quadrant so it is not satisfactory.

Quadrant D shows that the attributes in this quadrant are less important to customers but the implementation is very satisfying. The company's performance exceeds customer expectations. Companies can reduce the power in this quadrant and allocate resources in quadrant A.

3. RESULTS AND DISCUSSION

3.1 Respondent Profile

The first performed data process was to describe the characteristics of the respondents. The questionnaire was distributed to 40 respondents and it was found that only 36 respondents filled the questionnaire. Table 2 shows the educational, gender, age and position of the respondents. It show that the gender of 33 respondents (92%) were male and 3 respondents (8%) were female. Majority of customers in the field of information technology XYZ in this study were male. There were no respondents in this study were aged less than 26 years. 17 respondents (47%) were in the age range 26-35 years, 12 respondents (33%) were aged 36-45 years and 7 respondents (19%) were over 46 years old. Majority respondents in this study were in the age range 26-35 years. The latest education is 1 respondent (3%) in Diploma 1 (D1), Diploma 2 (D2), Diploma 3 / Associate degree (D3) and Master degree (S2) education. The remaining 32 respondents (89%) had a bachelor degree (S1) education. Majority of customers of PT. XYZ who was the respondent in this study was at the bachelor degree education level.

Table 2. Measurement selected item

Profile	Respondent	Percentage
Gender		
Male	33	92%
Female	3	8%
Total	36	100%
Age		
≤ 25 years	0	0%

26 - 35 years	17	47%
36 - 45 years	12	33%
≥ 46 years	7	19%
Total	36	100%
Educational level		
SD	0	0%
SMP	0	0%
SMA	0	0%
D1	1	3%
D2	1	3%
D3	1	3%
D4 / S1	32	89%
S2	1	3%
S3	0	0%
Total	36	100%

3.2 Questionnaire Validity and Reliability

The 'r' symbol on Table 3 shows the results of the Pearson correlation calculation, which means that the question item has a strong correlation if it is close to 1 or according to the r table for 35 respondents is more than 0.334 (5% significant level) and 'p-values' which means the item is significant if it is less than 0.05. The next step is to test the reliability of the questionnaire with the Cronbach Alpha coefficient. The question in this research is reliable if the Cronbach Alpha value is more than 0.06. Table 4 below is the reliability test results on customer expectations and perceptions of XYZ service quality.

Table 3. Results of the questionnaire validation

Item	Customer Expectation					Customer Perception (Realiity)				
	r hitung	r tabel	P-Value	P < 5%	Inter-pretation	r hitung	r tabel	P-Value	P < 5%	Inter-pretation
P1	0.549	≥ 0.334	0.001	< 0.05	valid	0.755	≥ 0.334	0.000	< 0.05	valid
P2	0.665	≥ 0.334	0.000	< 0.05	valid	0.632	≥ 0.334	0.000	< 0.05	valid
P3	0.748	≥ 0.334	0.000	< 0.05	valid	0.805	≥ 0.334	0.000	< 0.05	valid
P4	0.767	≥ 0.334	0.000	< 0.05	valid	0.776	≥ 0.334	0.000	< 0.05	valid
P5	0.836	≥ 0.334	0.000	< 0.05	valid	0.837	≥ 0.334	0.000	< 0.05	valid
P6	0.873	≥ 0.334	0.000	< 0.05	valid	0.88	≥ 0.334	0.000	< 0.05	valid
P7	0.736	≥ 0.334	0.000	< 0.05	valid	0.733	≥ 0.334	0.000	< 0.05	valid
P8	0.791	≥ 0.334	0.000	< 0.05	valid	0.816	≥ 0.334	0.000	< 0.05	valid
P9	0.846	≥ 0.334	0.000	< 0.05	valid	0.877	≥ 0.334	0.000	< 0.05	valid
P10	0.868	≥ 0.334	0.000	< 0.05	valid	0.810	≥ 0.334	0.000	< 0.05	valid
P11	0.870	≥ 0.334	0.000	< 0.05	valid	0.843	≥ 0.334	0.000	< 0.05	valid
P12	0.867	≥ 0.334	0.000	< 0.05	valid	0.839	≥ 0.334	0.000	< 0.05	valid
P13	0.869	≥ 0.334	0.000	< 0.05	valid	0.863	≥ 0.334	0.000	< 0.05	valid
P14	0.837	≥ 0.334	0.000	< 0.05	valid	0.685	≥ 0.334	0.000	< 0.05	valid
P15	0.851	≥ 0.334	0.000	< 0.05	valid	0.819	≥ 0.334	0.000	< 0.05	valid
P16	0.640	≥ 0.334	0.000	< 0.05	valid	0.537	≥ 0.334	0.001	< 0.05	valid
P17	0.846	≥ 0.334	0.000	< 0.05	valid	0.908	≥ 0.334	0.000	< 0.05	valid
P18	0.842	≥ 0.334	0.000	< 0.05	valid	0.827	≥ 0.334	0.000	< 0.05	valid
P19	0.843	≥ 0.334	0.000	< 0.05	valid	0.801	≥ 0.334	0.000	< 0.05	valid
P20	0.824	≥ 0.334	0.000	< 0.05	valid	0.790	≥ 0.334	0.000	< 0.05	valid
P21	0.935	≥ 0.334	0.000	< 0.05	valid	0.844	≥ 0.334	0.000	< 0.05	valid
P22	0.809	≥ 0.334	0.000	< 0.05	valid	0.864	≥ 0.334	0.000	< 0.05	valid

Table 4. Results of the questionnaire reliability

Item	Cronbach's Alpha		Scale	Interpretation	
	Expectation	Perception		Expectation	Perception
P1	0.974	0.970	≥ 0.06	Reliable	Reliable
P2	0.972	0.971	≥ 0.06	Reliable	Reliable
P3	0.972	0.970	≥ 0.06	Reliable	Reliable
P4	0.971	0.970	≥ 0.06	Reliable	Reliable
P5	0.971	0.969	≥ 0.06	Reliable	Reliable
P6	0.97	0.969	≥ 0.06	Reliable	Reliable
P7	0.972	0.970	≥ 0.06	Reliable	Reliable
P8	0.971	0.970	≥ 0.06	Reliable	Reliable
P9	0.971	0.969	≥ 0.06	Reliable	Reliable
P10	0.971	0.970	≥ 0.06	Reliable	Reliable
P11	0.971	0.969	≥ 0.06	Reliable	Reliable
P12	0.971	0.969	≥ 0.06	Reliable	Reliable
P13	0.971	0.969	≥ 0.06	Reliable	Reliable
P14	0.971	0.971	≥ 0.06	Reliable	Reliable
P15	0.971	0.970	≥ 0.06	Reliable	Reliable
P16	0.973	0.973	≥ 0.06	Reliable	Reliable
P17	0.971	0.969	≥ 0.06	Reliable	Reliable
P18	0.971	0.969	≥ 0.06	Reliable	Reliable
P19	0.971	0.970	≥ 0.06	Reliable	Reliable
P20	0.971	0.970	≥ 0.06	Reliable	Reliable
P21	0.970	0.969	≥ 0.06	Reliable	Reliable
P22	0.971	0.969	≥ 0.06	Reliable	Reliable

3.3 Comparison between Customer Expectations and Perceptions

This section is a comparison between the expectations and reality of service quality on each dimension or variable in the Service Quality method that has been distributed through the statements in the questionnaire. Table 5 below shows the average (mean) comparison between expectations and reality of service quality on each dimension in the Service Quality method.

The average of expectations and reality of tangibility dimension has same value, which is 4.3. There is no gap in this dimension means that the average customer satisfaction is met. Likewise, the empathy dimension has an average expectation and reality of 4.43 respectively. The gap value in the reliability dimension is 0.05, the responsiveness is 0.07, and the assurance has a gap of 0.03. The gap value between expectations and reality are positive, which means that the average customer satisfaction of the three dimensions is fulfilled because it exceeds customer expectations.

Table 5. Average Comparison Results of Customer Expectations and Perceptions

Item	Mean Expectation	Mean Perception	Gap
Tangibility			
P1	4.34	4.37	0.03
P2	4.20	4.43	0.23
P3	4.23	4.17	-0.06
P4	4.34	4.17	-0.17
P5	4.43	4.43	0
Mean Tangibility	4.31	4.31	0
Reliability			

P6	4.29	4.40	0.11
P7	4.34	4.31	-0.03
P8	4.40	4.43	0.03
P9	4.31	4.40	0.09
Mean Reliability	4.34	4.39	0.05
Responsiveness			
P10	4.40	4.49	0.09
P11	4.29	4.37	0.09
P12	4.26	4.37	0.11
P13	4.26	4.34	0.09
P14	4.40	4.40	0.00
Mean Responsiveness	4.32	4.39	0.07
Assurance			
P15	4.51	4.57	0.06
P16	4.37	4.40	0.03
P17	4.34	4.43	0.09
P18	4.51	4.49	-0.03
Mean Assurance	4.44	4.47	0.03
Emphaty			
P19	4.46	4.51	0.06
P20	4.37	4.49	0.11
P21	4.49	4.37	-0.11
P22	4.40	4.34	-0.06
Mean Emphaty	4.43	4.43	0

Although the comparison between the average value of expectations and reality is good, there is a negative gap in the service in certain dimensions which means the quality of that item is still below customer expectations. The two services with the largest negative gap are worth -0.17 and -0.11, respectively, which are listed in "P4 - Complete information on company website / social media" and "P21 - XYZ employees are well communicate ".

After knowing the average customer reality expectations, the data is processed to display a graph as shown in Figure 2. The red line in the middle that intersects the diagram is obtained from the average of all expectations and realities to form four separated areas (quadrants).

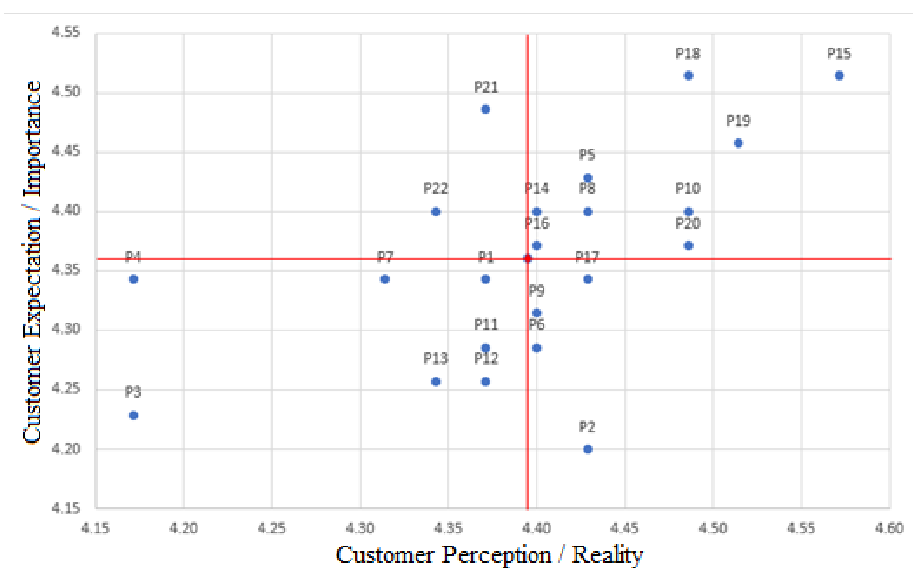

Figure 2. Cartesian diagram

Based on Figure 2, services in quadrant A (top left) are the top priority for improving XYZ services. There are two service factors that are considered very important but not satisfied because the company has not implemented it according to customer expectations. Company must focus on the attributes included in this quadrant to improve customer satisfaction.

First, employees can communicate well with customers, this can be improved by improving social and communication skills. In this case, take regular communication skills training within the company or outside the company if needed. So, the mindset that needed in the job is formed better. Second, understanding the specific needs of customers, this can be improved by improving the technical skills of the job. These technical skills are such as the ability to master the products and services owned and offered as well as similar products considering that technology is developing very fast. Training or introduction to products and services should be carried out regularly so that employees always have the latest information and this information can be useful in understanding specific customer needs.

4. CONCLUSION

Through data analysis processing, results and discussion on customer satisfaction in relation to improving service quality XYZ, the following conclusions are obtained. The *first* research objective is to determine the gap in the perception of the quality of company services received by current customers with customer expectations in terms of ServQual dimensions. The overall result on average between expectations and reality is positive, with a gap value of 0.03, which means that customer satisfaction at XYZ in this research is fulfilled. *Second* is to determine the factors that most influence on customer satisfaction of XYZ company. The four service factors with a high level of importance are: the assurance of the equipment to work properly (assurance), professionally employees (assurance), good communication (empathy), and friendly and polite employees (empathy). *Third* is to know the proposed improvements that must be made to improve the quality of XYZ company services. Proposals for improvements that need to be prioritized according to the Cartesian diagram are improving good communication with customers and being able to better understand customer specific needs. This can be done by involving employees in trainings.

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6. REFERENCES

Alam, M. S., & Mondal, M., (2019). Assessment of sanitation service quality in urban slums of Khulna city based on SERVQUAL and AHP model: A case study of railway slum, Khulna, Bangladesh. *Journal of Urban Management* 8, 20-27.

Boakye, K. G., Natesan, P., & Prybutok, V. R., 2020. A Correlated Uniqueness Model of Service Quality Measurement among Users of Cloud-Based Service Platforms. *Journal of Retailing and Consumer Services* 55.

Ershadi, M. J., Akhavan Niaki, S. T., & Sadeghee, R., (2019). Evaluation and improvement of service quality in information technology department of a detergent production company using the SERVQUAL approach. *International Journal of Services and Operations Management.*

Hartnett, J.L., Schechter, S.H., Kropp, D.H., 1988. Managing Quality: The Strategic and Competitive Edge. *Academy of Management Review* 13, 656–657.

Jamaluddin, J., & Ruswanti, E., 2017. Impact of Service Quality and Customer Satisfaction on Customer Loyalty: A Case Study in a Private Hospital in Indonesia. *IOSR Journal of Business and Management* 19, 23-33.

Kalaja, R., Myshketa, R., & Scalera, F. (2016). Service Quality Assessment in Health Care Sector: The Case of Durres Public Hospital. *Procedia - Social and Behavioral Sciences* 235, 557-565.

KBBI, 2020. Kamus Besar Bahasa Indonesia: Kualitas, [Online], Available: https://kbbi.kemdikbud.go.id/entri/kualitas. [Accessed: 23 Sept 2020]

KBBI, 2020. Kamus Besar Bahasa Indonesia: Jasa, [Online], Available: https://kbbi.kemdikbud.go.id/entri/jasa. [Accessed: 23 Sept 2020]

Kristianto, A. W., (2015), *Analisis Kualitas Pelayanan Terhadap Kepuasan Pelanggan Untuk Meningkatkan Mutu Pelayanan di Retail X Surabaya dengan Pendekatan Metode Service Quality dan Quality Function Deployment*, Thesis, Institut Teknologi Sepuluh Nopember, Surabaya.

Li, M., Lowrie, D. B., Huang, C. Y., Lu, X. C., Zhu, Y. C., Wu, X. H., Lu, H. Z., (2015). Evaluating patients' perception of service quality at hospitals in nine Chinese cities by use of the ServQual scale. *Asian Pacific Journal of Tropical Biomedicine* 5, 497-504.

Miranda, S., Tavares, P., Queiró, R., 2018. Perceived service quality and customer satisfaction: A fuzzy set QCA approach in the railway sector, *Journal of Business Research* 89, 371-377.

Parasuraman, A., Zeithaml, V.A., Berry, L.L., 1985. A conceptual model of service quality and its implications for future research. *Journal of Marketing* 49, 41–50.

Parasuraman, A., Zeithaml, V.A, Berry, L.L., 1988. SERVQUAL: a multiple-item scale for measuring consumer perceptions of Service Quality. *Journal of Retailing* 64, 12-40

Qiong, O.U., 2017. A Brief Introduction to Perception. *Studies in Literature and Language* 15, 18-28.

THE INFLUENCE OF THE USE OF SOCIAL MEDIA ON CUSTOMER ENGAGEMENT : UPSTREAM OILAND GAS ACTIVITIES

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ABSTRACT

Social media is a technology communication media that is used to provide information related to goods or services. Social media is considered successful as a tool to communicate and interact with internet users in a very short period of time. Social media marketing as a strategy for communicating and providing information on individuals and institutions, especially SKK Migas to customers. Social media marketing, especially those related to social media marketing activities, is able to provide information as a form of relationship equity built by SKK Migas to make it easy for customers to understand. Relationship equity is the process of creating a good relationship between the customer and the company in order to understand the various programs and information provided. A good relationship equity can have an impact on a good response from customers, thereby creating a close customer engagement with the company. The purpose of this study was to determine the effect of social media marketing activities on relationship equity, the effect of social media marketing activities on customer engagement and the effect of relationship equity on customer engagement among SKK Migas Official Instagram follower users. This type of research is a quantitative study with a sampling technique, namely purposive sampling technique. The research sample was taken based on certain criteria. The data analysis technique in this study used the Smart PLS statistical tool. This research was conducted by distributing questionnaires through as many as 165 respondents to active Instagram social media users. The results showed that social media marketing activities affect relationship equity, social media marketing activities affect customer engagement and relationship equity affect customer engagement among SKK Migas Official Instagram followers

Keywords: social media marketing activites, customer engagement, relationship equity, oil and gas.

1. INTRODUCTION

Marketing through social media is something that is often researched nowadays, especially with regard to the process of building connection with customers. The impact of social media today, especially Instagram, which is supported by more than 1 billion active accounts. This data shows that a very large social media customer base can be used by the company as a marketing communication medium (Yadav & Rahman, 2016). The majority of companies today, especially SKK Migas, have integrated links on social media sites to communicate and build better relationships with customers (relationship equity) (Choi et al., 2016).

The wide acceptance of social media provides evidence of the fact that more than 50% of Instagram platform users convince companies to get involved and attend to ensure customer opinions through these media channels (Pham & Gammoh, 2015). Companies can analyze the various prospects associated with customers in a variety of different ways. This relates to customer complaints and encourages exclusive communication about the company. Social media is a fast and appropriate media to increase relationship equity. Social media followers by strengthening communication and providing customers with the company's value proposition. Data shows that 40% of social media users get information about various things related to the company (Casey, 2017). Social media has always been a trend with interactivity and relationships to build communication potential (Kwahk & Ge, 2012). Information in dissemination strengthens social communication (Liang et al., 2011).

Social media is considered an important component in communication activities because it provides various facilities for reviews, recommendations, discussion forums as the main goal of communication marketing programs (Hajli, 2015). Social media is able to increase stakeholder value to develop and maintain a strong relationship with customer engagement (Kotler & Keller, 2016). Social media is a technology communication media that is used to provide information related to goods or services. Social media is considered successful as a tool to communicate and interact with internet users in a very short period of time. Social media marketing as a strategy for communicating and providing information on individuals and institutions, especially SKK Migas to customers. Social media marketing, especially those related to social media marketing activities, is able to provide information as a form of relationship equity built by SKK Migas to make it easy for customers to understand. Relationship equity is the process of creating a good relationship between the customer and the company in order to understand the various programs and information provided. A good relationship equity can have an impact on a good response from customers, thereby creating a close customer engagement with the company.

2. LITERATURE

2.1 Social Media Marketing Activities

Social media marketing activities are social media communication technology that is used as a communication facility for information with customers. Social media marketing activities are measured by interactivity, informativeness, word of mouth, personalization and trendiness (Yadav & Rahman, 2016). According to Kotler & Keller (2016) social media is a means for consumers to share text, images, audio and video information between individuals, groups and companies. According to Kaplan & Haenlein (2010) social media is a social networking site such as web- based services that are used by individuals, groups and companies to build profiles with certain systems. Social media marketing activities are marketing practices that effective (Hajli, 2015). Companies are currently required to adjust to business conditions related to marketing activities in the digital era with low cost and effectiveness (Ismail, 2017). Digital technology is able to change marketing activities not only covering technical and practical aspects but there are other aspects, namely internet marketing by reaching target consumers through social media as a place frequently visited by consumers.

2.2 Relationship Equity

Relationship is a connection that is built by two parties in order to form a good communication system so that it is easy to remember and recognize by customers (Kotler & Keller, 2016). Relationship equity is able to build a good two-way communication relationshipbetween both parties providing information and information recipients in order to satisfy consumer needs (Aggarwal, 2004). The indicator for measuring relationship equity according to OU et al (2013) is that the company site knows my requirements, feels like home with this company site and feels committed to this company site. According to Lemon et al., (2001) describing relationship equity as the tendency of customers to stick to a brand is supported by objective and subjective assessments of customers in certain companies. Companies can use strong relationship equity in assessing a prospect to meet customer expectations. The paradigm shift in relationship centered marketing is considered to have a strong brand equity and generate equity value with the aim of retaining customers. Communication relationships are a strong foundation in building engagement programs, community development and reward programs (Rust et al., 2004). The process of building good relationships with customers can increase market share (Palmatier et al., 2006). Increasing market share can increase retention thereby increasing customer engagement (Vogel et al., 2008).

2.3 Customer Engagement

Customer engagement is related to marketing theory and interactive services (Brodie et al., 2011). This relates to the promotion of marketing relationships characterized by interactive and creative experiences between customers and companies and various other stakeholders. Customer engagement according to Van Doorn et al (2010) is a customer behavior construction that combines action focus, psychological dimensions and behavior (Patterson et al., 2006). Customers are often involved in company discussion forums for various reasons related to company information (Brodie et al., 2013). Customer engagement has indicators, namely (So et al., 2014) namely identification, enthusiasm, attention, absorption and interaction. Customer engagement is a multidimensional approach in building a personal relationship between customers and companies in a cognitive, affective and behavioral manner (So & King, 2010). According to So & King (2010) customer engagement as a construction consisting of five order factors, firstly enthusiasm, attention, absorption, interaction and identification, enthusiasm shows a strong level of individual strength with an interest focused on engagement, while consumer attention focuses on the brand. Absorption is characterized by the ease with which the customer understands the information provided. Identification is an individual's perception of a company. Efforts to understand customer engagement in the contribution of relationship equity development so that the relationship is considered quality (Hollebeek, 2011).

3. METHOD

This type of research is quantitative with a causality approach. Causality enhancement, namely a research approach to see the influence of one variable with another (Ferdinand, 2014). Quantitative methods use population research and specific samples with statistical data analysis. This data analysis is intended to answer the problem formulation and test the correctness of the hypothesis (Ferdinand, 2014). This study shows a consequential relationship between exogenous variables and endogenous variables. Research that shows cause and effect is intended to explain the effects of exogenous and endogenous variables. The data were collected through a survey method, namely by distributing research questionnaires. Likert scale used 1-5 (strongly disagree-strongly agree). The number of samples was taken based on the formula of Ferdinand (2014), namely the question item x 5-10 so that (33 x 5 = 165) the respondents were the research sample. Data analyzed by Smart PLS.

4. ANALYSIS

Outer Loading

Convergent validity is the first stage in testing the outer model. The results of data processing from the convergent validity test can be seen through the loading value. Through the loading value, it can be seen the validity of the data to measure the accuracy of the indicator. The measurement results that have been declared valid can be used to carry out further analysis in this study. The indicator is considered valid if the loading value is> 0.70. However, according to Ghozali (2014), if the loading value shows the numbers 0.50 - 0.60 then the indicator is still acceptable. The results of the loading value of each indicator with its construct in this study are shown in the following table:

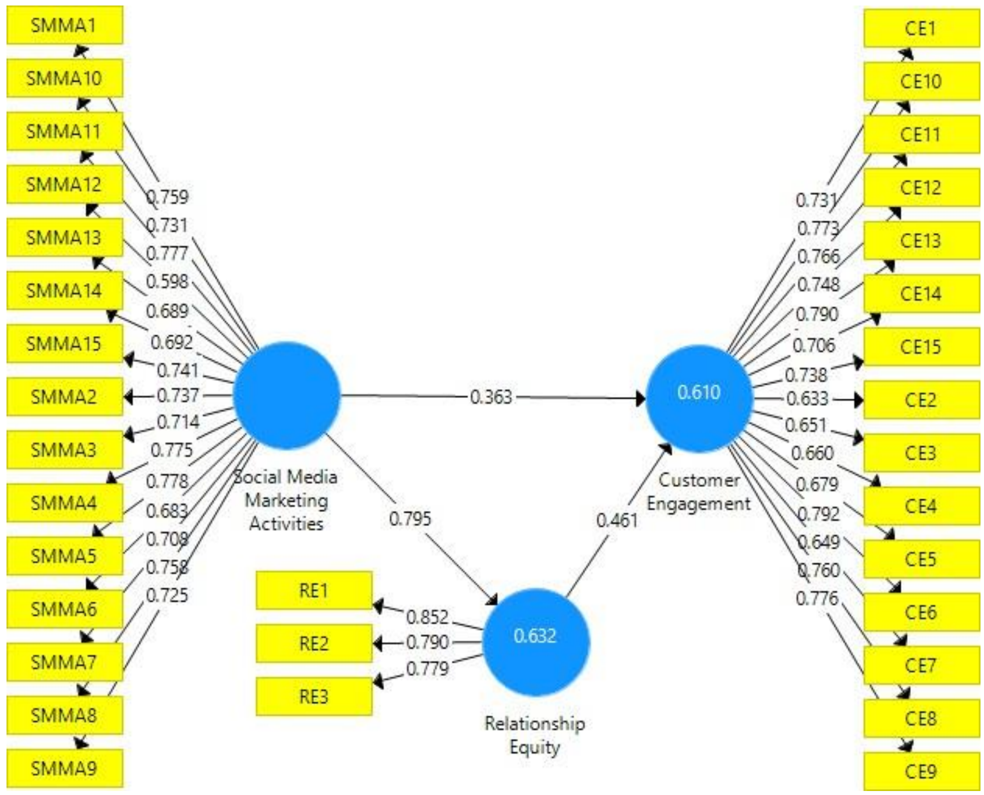

Figure 1. Picture of Outer Model

Table 1. *Outer Loading*

	Customer Engagement	Relationship Equity	Social Media Marketing Activities
CE1	0.731		
CE10	0.773		
CE11	0.766		
CE12	0.748		
CE13	0.790		
CE14	0.706		
CE15	0.738		
CE2	0.633		

CE3	0.651		
CE4	0.660		
CE5	0.679		
CE6	0.792		
CE7	0.649		
CE8	0.760		
CE9	0.776		
RE1		0.852	
RE2		0.790	
RE3		0.779	
SMMA1			0.759
SMMA10			0.731
SMMA11			0.777
SMMA12			0.598
SMMA13			0.689
SMMA14			0.692
SMMA15			0.741
SMMA2			0.737
SMMA3			0.714
SMMA4			0.775
SMMA5			0.778
SMMA6			0.683
SMMA7			0.708
SMMA8			0.758
SMMA9			0.725

Table 1 shows that the loading value of each indicator for each variable, namely social media marketing activities (X), customer engagement (Y) and relationship equity (Z), has an outer loading factor value greater than 0.50. Thus the indicator can be declared valid as a measure of its latent variable, which means that the indicators used are in accordance with the research topic. A construct indicator has a loading value of> 0.70 whereas if the loading value is> 0.50 or> 0.6, it is stated that it can be tolerated (Ghozali, 2014), this is used to measure latent variables.

Discriminant Validity

The second stage of testing the outer model is discriminant validity. This test is also used to see the accuracy of the known indicators based on the cross-loading results. Indicators are said to be valid if the cross-loading value of one construct is greater than other constructs (Ghozali, 2014). Valid which is meant in this test indicates that the indicators used are good. The results of the cross-loading value are shown in the table as follows:

Table 2 Cross *Loading*

	Customer Engagement	Relationship Equity	Social Media Marketing Activities
CE1	**0.731**	0.659	0.611
CE10	**0.773**	0.586	0.552
CE11	**0.766**	0.616	0.585
CE12	**0.748**	0.648	0.618
CE13	**0.790**	0.472	0.545
CE14	**0.706**	0.463	0.417
CE15	**0.738**	0.504	0.465
CE2	**0.633**	0.628	0.515
CE3	**0.651**	0.375	0.411
CE4	**0.660**	0.372	0.448
CE5	**0.679**	0.437	0.521
CE6	**0.792**	0.600	0.607
CE7	**0.649**	0.514	0.479
CE8	**0.760**	0.461	0.503
CE9	**0.776**	0.580	0.546
RE1	0.581	**0.852**	0.770
RE2	0.575	**0.790**	0.583
RE3	0.665	**0.779**	0.560
SMMA1	0.543	0.720	**0.759**
SMMA10	0.530	0.580	**0.731**
SMMA11	0.557	0.589	**0.777**
SMMA12	0.481	0.468	**0.598**
SMMA13	0.528	0.611	**0.689**
SMMA14	0.535	0.569	**0.692**
SMMA15	0.488	0.695	**0.741**
SMMA2	0.474	0.603	**0.737**
SMMA3	0.540	0.582	**0.714**
SMMA4	0.567	0.560	**0.775**
SMMA5	0.581	0.559	**0.778**
SMMA6	0.523	0.509	**0.683**
SMMA7	0.540	0.453	**0.708**
SMMA8	0.540	0.553	**0.758**
SMMA9	0.511	0.552	**0.725**

Table 2 shows that the results of the cross-loading value of each indicator when compared to other topics have a greater value, so that it can be stated that the items are valid. Therefore, there is no need for items to be removed or discarded. Valid indicates that the measuring instruments used in this study are appropriate. Therefore, this data can be used for further testing.

Average Variance Extraced

The final method that can be used to assess the discriminant validity test is to look at the Average Variance Extraced (√) value. Each construct can be considered valid if the AVE value is> 0.50, otherwise if the AVE value is <0.50 it is considered invalid (Ghozali, 2014). The results of the Average Variance Extraced (AVE) value are shown in the table below :

Table 3 *Average Variance Extraced* (AVE)

	Average Variance Extracted (AVE)
Customer Engagement	0.526
Relationship Equity	0.652
Social Media Marketing Activities	0.527

The results of the Average Variance Extraced (AVE) in Table 3 of each variable, namely social media marketing activities (X), customer engagement (Y) and relationship equity (Z) are used to see the correlation of each construct. The AVE results of the three variables have a number of more than 0.50 so that through these results it is known that all variables can be declared valid, which means that they are appropriate, namely the respondent's answer can pass the truth test.

Composite Reliability and Cronbach Alpha

The final stage of the outer model test is composite reliability and croanbach alpha which are used to measure the reliability of a construct. Reliability measurement is used to see the consistency of the constructs used. If the value of composite reliability and croanbach alpha shows a number> 0.70, then the construct is reliable, on the contrary, if the number shows a result <0.70 then the construct is not reliable (Ghozali, 2014). The composite reliability and Croanbach alpha values are shown in the following table

Table 4 *Composite Reliability* and *Cronbach Alpha*

	Cronbach's Alpha	Composite Reliability
Customer Engagement	0.935	0.943
Relationship Equity	0.733	0.849
Social Media Marketing Activities	0.935	0.943

Table 4 shows all values of composite reliability and Cronbach's alpha> 0.70, this indicates that all variables can be declared reliable so that the measuring instrument used can be trusted because of its consistency. Reliability means that research respondents understand and are able to provide answers correctly. Meanwhile, consistency is meant in this case when the answers from the respondent are appropriate and still correct. The indicators used in this study are reliable and their accuracy is trusted so that the answers of respondents are considered to contain truth and reliable accuracy.

Goodness Of Inner Model Evaluation

The results of the Goodness of Inner Model shown through the R-Squares can be shown in the table below:

Table 5 *R Square*

	R Square	R Square Adjusted
Customer Engagement	0.610	0.606
Relationship Equity	0.632	0.630

Based on the results of R Square, the relationship equity is 0.632 or 63.2%, where social media marketing activities can affect the relationship equity by 63.2%. The remaining 36.8% is the contribution of other variables that are not discussed. The R-squares for customer engagement is 0.61 or 61%. This shows that the diversity of social media marketing activities and relationship equity variables can affect customer engagement by 61%. The remaining 39% is contributed by other variables which are not discussed.

Meanwhile, the predictive relevance of Q Square can be measured in the following ways:

Q = 1- (1-R2 relationship equity) x (1-R2 customer engagement)
= 1- (1-0.632) x (1-0.610)
= 1- (0.368 x 0.39)
= 1-0.1435
= 0.8564

The Q Square value in this study is 0.8564 or> 0 so that it can be said that the model has predivtive relevance or indicates that the structural model is proven to be good or relevant.

Hiypothesis Test

The significance test can be found through the t-statistic greater than the critical value (t-table 1.96) in the table below:

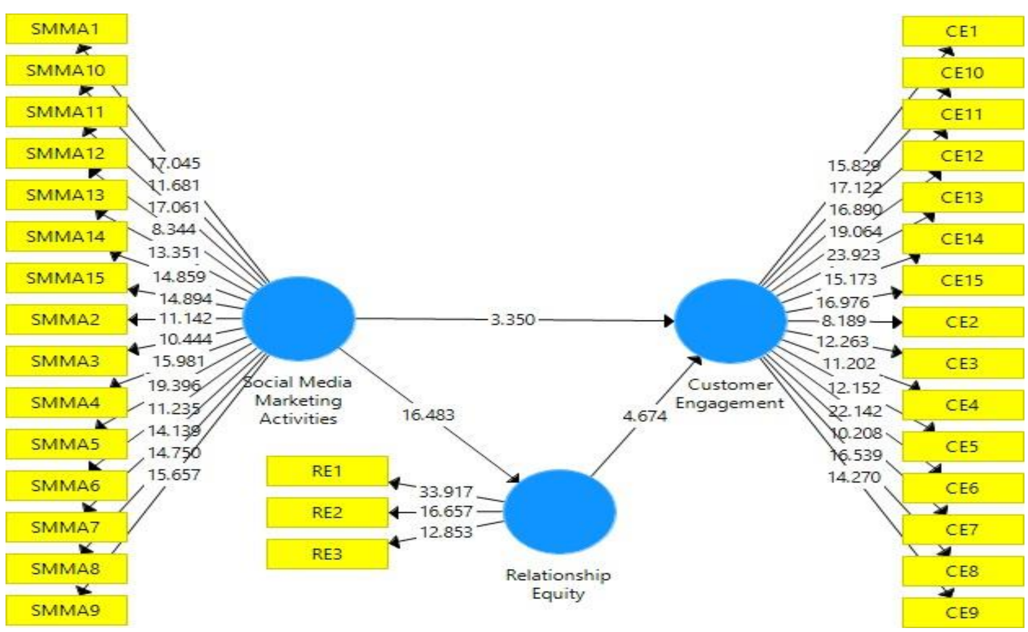

Figure 2 Picture of *Bootsrapping*

Table 6 Path Coefficient

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Relationship Equity -> Customer Engagement	0.461	0.463	0.099	4.674	0.000
Social Media Marketing Activities -> Customer Engagement	0.363	0.357	0.108	3.350	0.001
Social Media Marketing Activities -> Relationship Equity	0.795	0.791	0.048	16.483	0.000

Based on the table, it can be explained that the influence of exogenous variables on endogenous variables is in each of the following hypotheses:

1. Social media marketing has a significant positive effect on relationship equity with a T-statistic value> 1.96, which is 16,483 and a p value of 0,000 <0.05. The first hypothesis in this study is accepted.
2. Social media marketing activities have a significant positive effect on customer engagement with a T-statistic value> 1.96, which is 3,350 and a p value of 0.001 <0.05. The second hypothesis in this study is accepted.
3. Relationship equity has a significant positive effect on customer engagement with a T-statistic value> 1.96, which is 4,674 and a p value of 0.0010 <0.05. The third hypothesis in this study is accepted.

5. CONCLUSION

Based on the research results, it can be concluded that social media marketing activities have an effect on relationship equity, social media marketing activities have an effect on customer engagement and relationship equity have an effect on customer engagement on Instagram followers of SKK Migas Official's followers.

1. Effect Social Media Marketing Activities to Relationship Equity

Through social media marketing activites, the company can provide information related to various quality information and benefits offered. This marketing communication process is related to branding so that consumers can easily remember it (Choi et al., 2016). Marketing via social media marketing activities is considered capable of conveying information about the existence of a company, especially boosting relationship equity so that consumers can easily remember it. Marketing communication via social media marketing activites informs the program so that it can increase the relationship equity so that consumers can understand it according to the target customer the company is aiming for (Hajli, 2015).

2. Effect of Social Media Marketing Activities to Customer Engagement

Social media marketing activities provide information, with the ease of using social media to generate positive customer responses (Kaplan & Haenlein, 2010). This response can be easily and quickly carried out through technological media. Customer management is a form of consumer behavior that provides feedback in the form of acceptance or rejection of the content provided (Brodie, et al., 2011). The process from the customer taking an interest, then being interested, to making a decision is caused by various aspects, one of which is the social media marketing actovities. The influence of social media marketing activities has an impact on consumer response in the form of engagement (Fung So, et al., 2014). Consumers easily access various informationabout the company through social media marketing activities and have an impact on customer engagement (Brodie et al., 2013).

3. Effect *Relationship Equity* to *Customer Engagement*

Relationship equity is important to create because it will stick in the minds of customers, especially with regard to customer relationships about the company (Kotler & Keller, 2016). The relationship equity impression that is created has an impact on the mindset and perception of customers in the process to show behavior in accordance with the mindset they have (So & Sparks, 2014). This behavior is part of customer engagement related to the involvement of customer activities which is due to the influence of relationship equity (Fung So et al., 2014). Relationship equity is able to encourage customers to pay attention to certain companies. Customers tend to show loyalty to the company by paying close attention by showing satisfaction with the benefits of the information content provided so that they recommend the social media content to family, closest friends and colleagues as an option for access to information (So & Sparks, 2014).

6. REFERENCES

Aggarwal, P. (2004). The effects of brand relationship norms on consumer attitudes and behaviour. *Journal of Consumer Research*, 31(1), 87-101

Brodie, R. J., Hollebeek, L. D., Juric, B. and Ilic, A. (2011). Customer engagement: Conceptual domain, fundamental propositions, and implications for research, *Journal of Service Research*,Vol. 14 No. 3,pp. 252-271

Brodie, R. J., Ilic, A., Juric, B. and Hollebeek, L. (2013). Consumer engagement in a virtual brand community: An exploratory analysis, *Journal of Business Research*, Vol. 66 No. 1, pp. 105-114

Casey, S. (2017). 2016 Nielsen Social Media Report.US: Nielsen. Retrieved March 7, 2017, from http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2017-reports/2016-nielsen-social-media-report.pdf

Choi, E. K., Fowler, D., Goh, B., & Yuan, J. (2016). Social media marketing: applying the uses and gratifications theory in the hotel industry. *Journal of Hospitality Marketing & Management*, 25(7), 771-796. doi:10.1080/19368623.2016.110010.

Ferdinand, A. (2014). *Metode Penelitian Manajemen* (5th ed.). Semarang: Badan Penerbit Universitas Diponegoro.

Ghozali, I. (2014). *Partial Least Square (PLS) (4th ed.)*. Semarang: Badan Penerbit Universitas Diponegoro

Hajli, N. (2015). Social commerce constructs and consumer's intention to buy. *International Journal of Information Management*, 35(2), 183-191. doi:10.1016/j.ijinfomgt.2014.12.005

Hollebeek, L. D. (2011). Exploring customer brand engagement: definition and themes, *Journal of Strategic Marketing*,Vol. 19 No. 7,pp. 555-573

Ismail, A. R. (2017). The influence of perceived social media marketing activities on brand loyalty The mediation effect of brand and value consciousness. *Asia Pacific Journal of Marketing and Logistics*, 29(1), 129-144. doi:10.1108/APJML-10-2015-0154

Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of social media. *Business Horizons*, 53(1), 59-68. doi:10.1016/j.bushor.2009.09.003

Kotler, P., & Keller, K. L. (2016). *Marketing Management(15 ed.)*. Noida: Pearson.

Kwahk, K. Y., & Ge, X. (2012). The effects of social media on E-Commerce: A Perspective of Social

Impacty Theory. *45th Hawaii International Conference on System Sciences* (pp. 1814-1823). Hawaii: IEEE

Lemon, K. N., Rust, R. T., & Zeithaml, V. A. (2001). What drives customer equity? *Marketing Mangement*, 10(1), 20-25

Liang, T. P., Ho, Y. T., Li, Y. W., & Turban, E. (2011). What Drives Social Commerce: The Role of Social Support and Relationship Quality. *International Journal of Electronic Commerce*, 16(2), 69-90. doi:10.2753/JEC1086-4415160204

Ou, Y. C., De Vries, L., Wiesel, T., & Verhoef, P. C. (2013). The Role of Consumer Confidence in Creating Customer Loyalty. *Journal of Service Research*, 17(3), 339-354. doi:10.1177/1094670513513925

Palmatier, R. W., Dant, R. P., Grewal, D., & Evans, K. R. (2006). Factors influencing the effectiveness of relationship marketing: a meta-analysis. *Journal of Marketing*, 70(4), 136-153

Patterson, P., Yu, T. and De Ruyter, K. (2006) Published. Understanding customer engagement in services. *ANZMAC 2006: Advancing Theory, Maintaining Relevance, 2006 Brisbane*, QLD 4-6 December. 4-6

Pham, P. H., & Gammoh, B. S. (2015). Characteristics of social-media marketing strategy and customer-based brand equity outcomes: a conceptual model. *International Journal of Internet Marketing and Advertising*, 9(4), 321-337. doi:10.1504/IJIMA.2015.072885

Rust, R. T., Lemon, K. N., & Zeithaml, V. A. (2004). Return on marketing: using customer-equity to focus marketing strategy. *Journal of Marketing*, 68(1), 109-127

So, K. K. F. and King, C. (2010). When experiencematters: building and measuring hotel brand equity: The customers' perspective, *International Journal of Contemporary Hospitality Management*,Vol. 22 No. 5,pp. 589-608

So, K. K. F., King, C. and Sparks, B. A. (2014). Customer engagement with tourism brands: Scale development and validation, *Journal of Hospitality & Tourism Research*,Vol. 38 No. 3,pp. 304-329.

Van Doorn, J., Lemon, K. N., Mittal, V., Nass, S., D., P., Pirner, P. and Verhoef, P. C. (2010). Customer engagement behaviour: Theoretical foundations and reserach directions, *Journal of Service Research*,Vol. 13 No. 3,pp. 253-266.

Vogel, V., Evanschitzky, H., & Ramaseshan, B. (2008). Customer equity drivers and future sales. *Journal of Marketing*, 72(6), 98-108

Yadav, M., & Rahman, Z. (2016). The social role of social media: the case of Chennai rains-2015. *Social Network Analysis and Mining*, 6(1), 101

ANALYZING FACTORS THAT INFLUENCE THE BEHAVIOR INTENTION OF CONSUMERS IN REPURCHASING BLP BEAUTY COSMETIC PRODUCTS

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ABSTRACT

Nowadays cosmetic market in Indonesia is currently making a drastic increase because of the quality of products that local cosmetic industries are getting better. A lot of Indonesian consumers state that the quality of local products now are comparable to the imported cosmetic brands. The Ministry of Industry in Indonesia state that the cosmetic industry now is a main sector that contained in National Industrial Development Master Plan (RIPIN). Cosmetic industry in Indonesia still has huge potential so that a lot of young entrepreneurs take that opportunity to join in that sector. But a lot of competitors in this industry means entrepreneurs have to be able to monitor the consumers behavior, including the buying and repurchasing behavior of cosmetic products. This research uses consumers of BLP Beauty cosmetic as the object of research. This research method will be done by distributing online questionnaires to consumers of BLP Beauty products through makeup and beauty communities and Make Up Artists communities who already tried the products. This research will have 175 respondents. Then the results of the questionnaires will be analized using Structural Equation Modelling (SEM). From the results of this analysis, we found that price, feature and ingredients, influencer's review, and customer's loyality have significants influence to consumer's repurchase intention. This research is expected to provide input for practitioner and academics in preparing a good and exact marketing management strategies in current condition of the market when you know the variables that affects consumer's repurchase intention.

Keywords: Cosmetic, Behavior Intention, Repurchase Intention, Structural Equation Modelling (SEM).

1. INTRODUCTION

The rapid development of technology makes communicating and sharing information nowadays are also getting easier and faster, and we as consumers of various goods can access all information about the goods we use everyday through the internet. Cosmetics and skincare users in Indonesia are increasing rapidly due to the easier access to information about cosmetic and beauty products. There are a lot of experienced people share about things and tell about the good and bad side about cosmetics products. We as consumers certainly want to use the best and safe cosmetic products for our faces, access the website to find out important informations then buy cosmetic products according to recommendations from influencers who we believe in their opinions. The recommended cosmetic products that comply with good quality material standards are usually cosmetic products that need to be imported from abroad. However, we as consumers cannot get it easily in Indonesia, and the local cosmetic products quality in Indonesia at that time were not as good and cannot comparable to the products that they recommend. So what we can do is import these products abroad at relatively high prices. For Indonesian people from the upper to middle class this might not be a problem. However, it is a problem for middle and lower class people who cannot buy these products because of the higher price.

Starting from this problem, and by looking at the potential and opportunities that are still very high in Indonesia, cosmetic companies in Indonesia that have been around for a long time are motivated to improve the quality of their products in terms of products, packaging design, promotions, and so on. However, not only existing cosmetic companies, young entrepreneurs and several Indonesian makeup artists have also started to set up their own cosmetic companies. With the knowledge that has been learned while working as a makeup artist, knowing what Indonesian women need to look beautiful and confident, and knowledge of kind of products that will be suitable for a tropical climate like Indonesia, what colors are suitable for Indonesian women's skin, and so on. So that in 2017 there were 153 new companies appeared in Indonesia, and by the end of 2017 the number of cosmetic companies in Indonesia reached 760, around 95% are small to medium scale cosmetic companies, and only the remaining about 5% are large scale industries. The Ministry of Industry in Indonesia has designated the cosmetics industry as a main sector in the National Industrial Development Master Plan 2015 to 2035.

Data obtained from the Ministry of Industry states that the growth of the local cosmetic industry has increased rapidly in recent years, it means that more competitors appeared but all of them targeting the same market. Cosmetics companies will be confused to determine their consumers because with the increasing number of new cosmetic brands, consumers will have a sense of curiosity to try all kinds of products in the market. Cosmetics companies that are just starting their business will find it difficult to monitor, understand, and analyze consumers behavior in buying cosmetic products, because many factors influence consumer behavior in buying back their cosmetic products, and the behavior of each consumer is different. Cosmetics companies are required to be able to monitor consumer behavior, including consumer behavior in choosing and buying a product. Therefore, this research was conducted by taking several factors that influence consumer behavior in repurchasing a cosmetic product, such as Product Quality, Packaging Design, Feature and Ingredients, Price, and Influencer’s Review, Customer Satisfaction, and Customer Loyality.

2. METHOD

2.1 Literature findings and derived hypotheses

This research was conducted to determine what factors influence consumers in repurchasing a cosmetic product, and in this study we use BLP Beauty cosmetic brand for research. The first step in the research is to review the literature studies to find out what factors can influence repurchase intention of cosmetic products and then form a research hypothesis. This intention can be influenced by attitudes toward performing the behavior (Ajzen, 1991). Purchase behavior can be predicted by purchase intention (Morrison, 1979) Repurchasing intention cosmetic products hasbeen analyzed in previous studies (Ali, 2019); (Ariffin et al., 2016); (Setyorini, 2016). This study has shown the influence of several predictors of purchase intention with respect to cosmetic products. In line with this study, we aim to find relevant predictors for purchase intentions of cosmetic products. Considering the literature review findings, we can come up with seven hypotheses.

There are several studies about the influence of product quality on repurchase intention. Product quality is a potential strategic weapon that companies have to beat competitors. (Kotler, 2016) explained that product quality is the ability of a product to satisfy consumer needs. This means that to satisfy consumer needs, the company must control the quality of the product. Because before buying, consumers will always see the quality of the product first, whether it is in according to their expectations or not. The better the quality of the products made by the company, the more consumer will be interested in repurchase a product. Products that have guaranteed quality will make consumer trust in a brand, and this will make consumers no longer doubt and look for similar products in the brand.

Hypothesis 1. (H1) Product quality has a significant effect on consumer behavior intention in repurchasing BLP Beauty cosmetic products.

Based on (Kotler, 2016), good packaging must have functional and aesthetic components that match and make a good impression from a brand. Functionally, packaging must be able to protect the contents of the product, by taking into account production costs and other factors in the marketing of a product. Aesthetically, the design must pay attention to the color of the packaging, the size of the fonts used, the size of the packaging and the shape of the packaging. Packaging is an important factor because it relates directly to consumers and is the key to the initial assessment of consumers whether they like one product or not. Good packaging can encourage consumers to buy a product. Packaging can also affect the product experience of consumers after trying the product. Even some good product packaging can be used as a display.

Hypothesis 2. (H2) Product packaging has a significant effect on consumer behavior intention in repurchasing BLP Beauty cosmetic products.

Defined by (Kotler, 2016), the ingredients that the company uses to make a product can be a special attraction for consumers and can be a plus point in the consumer's consideration in buying a product. BLP Beauty sells cosmetic products that ingredients are safe for skin and dermatology tested. Some of the features displayed by these brands such as transparency list of ingredients and "dermatology tested" claim that can attract consumers to repurchase their products.

Hypothesis 3. (H3) Product feature and ingredients has a significant effect on consumer behavior intention in repurchasing BLP Beauty cosmetic products.

Price, as defined by (Kotler, 2016), is one of the factors that consumers consider when they want to buy a product. The company must consider a pricing based on the market they are trying to target. Companies usually develop products that can be purchased in pairs so that they can be offered for a bundling price that is more affordable than single purchases.

Hypothesis 4. (H4) Product price has a significant effect on consumer behavior intention in repurchasing BLP Beauty cosmetic products.

Based on (Kotler, 2016), one example of online reviews (word of mouth) is social media. Word of mouth (WOM) is a very powerful marketing tool. There have been many companies made from the basis of good WOM. WOM has been proven to increase sales. Viral marketing is a form of online WOM. When people or influencers we trust give reviews of a product, our perception of that product will tend to change based on their reviews. Good reviews given by influencers will have certain effect and become one of the consumers judgment to choose and buy a product because they trust the reviews given by that influencers.

Hypothesis 5. (H5) Influencer's review has a significant effect on consumer behavior intention in repurchasing BLP Beauty cosmetic products.

Basically, customer satisfaction is a feeling of pleasure or disappointment that arises from comparing a product or service with someone's expectations. If the performance of a product or service is far below expectations, someone will feel disappointed, and if a product or service matches or even exceeds someone's expectations, the individual will feel satisfied. If a consumer of cosmetic products has experience in trying one product and feels it matches the appearance and feels beautiful when using it, or does not cause certain allergic effects, it can be said that the consumer is satisfied with a product (Kotler, 2016).

Hypothesis 6. (H6) Customer satisfaction has a significant effect on consumer behavior intention in repurchasing BLP Beauty cosmetic products.

Loyalty can be defined as a high commitment to repurchase or resubscribe to a product or

service even though there are environmental influences and certain situations or changes in marketing rules in the future. Individual loyalty to a product or brand is generated because of the impression when using a product or feeling a service from that brand. Loyalty to a product or brand can affect an individual's intention to repurchase a product, for example a cosmetic product.
Hypothesis 7. (H7) Customer loyality has a significant effect on consumer behavior intention in repurchasing BLP Beauty cosmetic products.

2.2 Survey: variables, scale, and data

Research data were collected through an online access panel at mid December 2020 to the end of December 2020 and distributed to associations of beauty enthusiasts and makeup artists throughout Indonesia, as well as consumers of BLP Beauty cosmetic products. The target is women age 16 or older, and have already repurchased the cosmetic products for more than three times. With 7 independent latent variables and 1 dependent latent variable (repurchase intention), the minimum number of samples to analyze is 5 times the number of latent variables plus their indicators, which is approximately 160 respondents. For this purpose, 189 respondents have been collected who filled out the questionnaire but 14 respondents did not meet the requirements so that only 175 respondents were included in the analysis (Table 1). Data that has been collected then processed using Structural Equation Model (SEM). Data analysis was performed using SPSS and AMOS.

The study uses latent variables and Structural Equation Model (SEM) can provide informations about the simultaneous causal relationship between variables used. SEM is also provide the information about loading factor and measurement error(Sumargo, 2018). Based on (Zeng et al., 2020) SEM is very appropriate to answer questions driven by theory and to examine hypotheses regarding direct or indirect effects between latent variables. In our case, all eight latent variables are measured by three observed indicators variables.

Table 1. Demographic data of sample (in %)

Age	Survey Sample
16-20	6%
21-25	21 %
26-30	68 %
31-35	6%

Table 1. Demographic data of sample (in %) (continued)

Where respondents live	
Bandung	3%
Bekasi	1%
Jakarta	37%
Kediri	2%
Malang	2%
Padang	5%
Palembang	1%
Pekanbaru	1%

Semarang	1%
Sidoarjo	1%
Surabaya	42%
Tangerang	2%
Yogyakarta	3%
Education	
Student	26%
Non-Student	74%
Job Status	
Worker	87%
Non-Worker	13%

Where respondents live	
Bandung	3%
Bekasi	1%
Jakarta	37%
Kediri	2%
Malang	2%
Padang	5%
Palembang	1%
Pekanbaru	1%
Semarang	1%
Sidoarjo	1%
Surabaya	42%
Tangerang	2%
Yogyakarta	3%
Education	
Student	26%
Non-Student	74%
Job Status	
Worker	87%
Non-Worker	13%

3. RESULT

3.1 Descriptive Results

The loading factor of each indicator of the latent variables are above 0.6, this indicates that the model is already fit for each of latent variable (Table 2).

Table 2. Result of Confirmatory Factor Analysis (CFA)

Variabel	Indicator	Loading Factor
Repurchase Intention (RI)	RI1	1,00
	RI2	1,65
	RI3	1,48
Quality (Q)	Q1	1,00
	Q2	1,14
	Q3	1,46

Table 2. Result of Confirmatory Factor Analysis (CFA) (continued)

Variable	Indicator	Loading Factor
Packaging (P)	P1	1,00
	P2	0,97
	P3	1,19
Feature & Ingredients (FI)	FI1	1,00
	FI2	0,67
	FI3	0,60
Price (PP)	PP1	1,00
	PP2	1,42
	PP3	1,36
Influencer's Review (IR)	IR1	1,00
	IR2	1,03
	IR3	1,05
Customer's Satisfaction (CS)	CS1	1,00
	CS2	1,7
	CS3	1,47
Customer's Loyality (CL)	CL1	1,00
	CL2	3,63
	CL3	1,67

3.2 Measurement Model Result

The results of the Goodness of Fit (GoF) test show that all values have approached the cut off value so that the model is considered fit (Table 3).

Table 3. Result of Goodness of Fit

No.	Goodness of Fit Measurement	Cut off Value	Default Model	
		Absolute Fit Indices		
1	GFI	close to 1,00	0,727	Fit
2	AGFI	close to 1,00	0,634	Fit
3	RMR	close to 0	0,051	Fit

Table 3. Result of Goodness of Fit (continued)

No.	Goodness of Fit Measurement	Cut off Value	Default Model	
		Incremental of Indices		
4	NFI	close to 1,00	0,728	Fit
5	CFI	close to 1,00	0,665	Fit
6	IFI	close to 1,00	0,778	Fit
7	RFI	close to 1,00	0,722	Fit
8	TLI	close to 1,00	0,774	Fit
		Parsimony Fit Indices		
9	PRATIO	close to 1,00	0,812	Fit
10	PNFI	close to 1,00	0,519	Fit
11	PCFI	close to 1,00	0,628	Fit

From the results of the above, it can be seen that all of the measurement indicators already meet the specified values so that the model can be said to be fit model. After taking GoF we can continue the analysis to the next step.

3.3 SEM Result

Table 4. Result of Goodness of Fit

No.	Goodness of Fit Measurement	Cut off Value	Default Model	
		Absolute Fit Indices		
1	GFI	close to 1,00	0,531	Fit
2	AGFI	close to 1,00	0,526	Fit
3	RMR	close to 0,00	0,176	Fit
		Incremental of Indices		
4	NFI	close to 1,00	0,489	Not Fit
5	CFI	close to 1,00	0,519	Fit
6	IFI	close to 1,00	0,524	Fit
7	RFI	close to 1,00	0,424	Not Fit
8	TLI	close to 1,00	0,459	Not Fit
		Parsimony Fit Indices		
9	PRATIO	close to 1,00	0,888	Fit
10	PNFI	close to 1,00	0,534	Fit
11	PCFI	close to 1,00	0,561	Fit

From the results of the above, it can be seen that some of the measurement indicators do not meet the specified values but some of them have already met the requirements. In addition, other Goodness of Fit (GoF) tests have met the test so that the model can be said to be quite fit. In the principle of parsimony and rules of tumb it is said that if there are one or two goodness of fit criteria that have met, then the model is said to be good (Affandi, 2018).

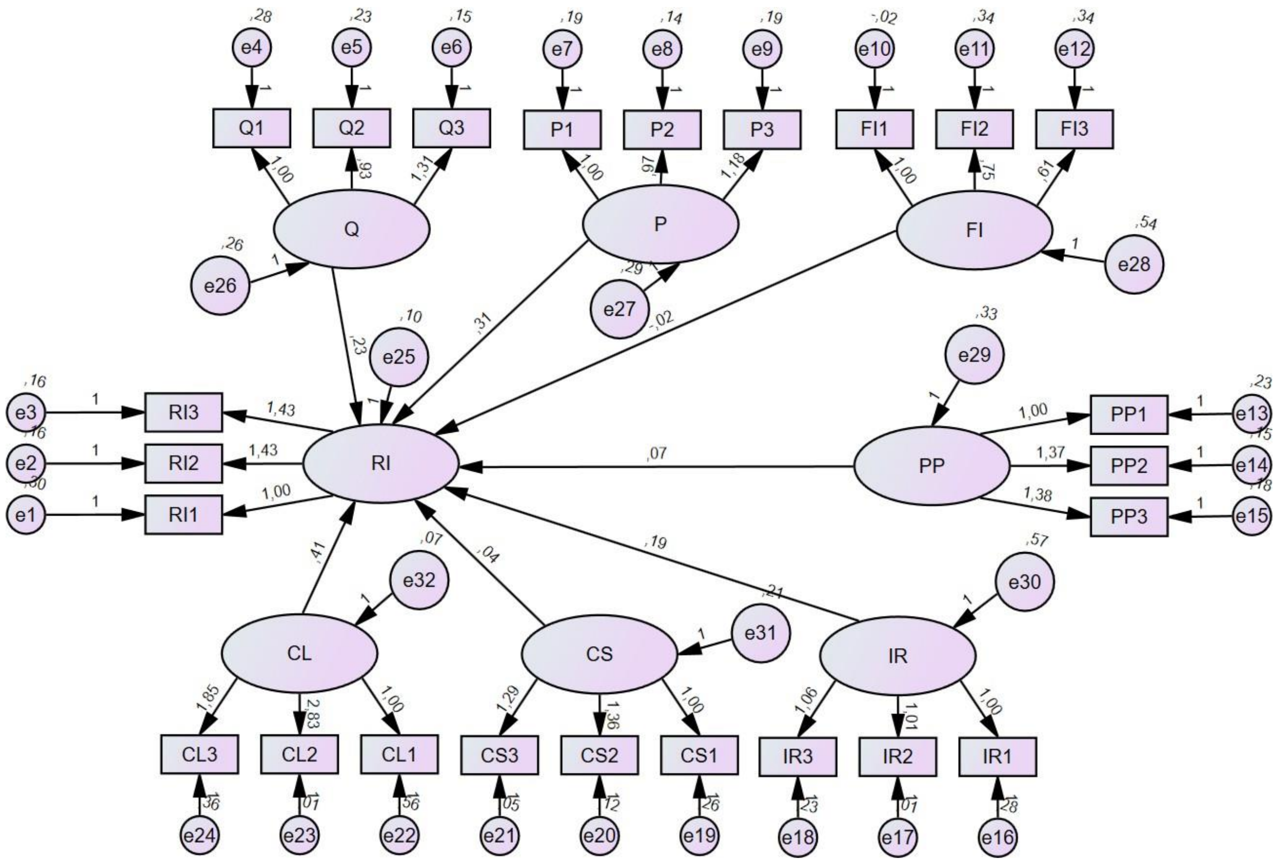

Figure 1. Structural Equation Model Path

The range of standardized loadings for each latent variables and observed scales as follow: 0,93-1,31 for product quality, 0,97-1,16 for product packaging, 0,61-1,00 for feature and ingredients, 1,00-1,38 for product price, 1,00-1,06 for influencer's review, 1,00-1,36 for customer satisfaction, and 1,00-2,83 for customer loyality. All loads exceed the 0.40 limit, indicating that the latent variables are measured adequately with the observed subscales.

4. DISCUSSION

4.1 Hypotheses

Table 5. Hypotheses Test Result

Correlations between Variables			CR	Probability (p)	
Intention	<---	Quality	2,022	0,052	Not Significant
Intention	<---	Packaging	1,98	0,08	Not Significant
Intention	<---	Price	2,112	0,038	Significant
Intention	<---	Ingredients	-2,63	0,005	Significant
Intention	<---	Influencer	4,447	0,002	Signicant
Intention	<---	Satisfaction	0,49	0,663	Not Significant
Intention	<---	Loyality	2,645	0,004	Significant

In the table above, it can be seen that the relationship between the exogenous latent variables feature and ingredients, price, influencer's review, and customer loyalty towards the endogenous latent variable repurchase intention obtained a p-value < 0.05, which means they have significant effect toward repurchase intention. This was also found in previous studies such as (Putri, 2018), (McCormick, 2016), (Basyarahil, 2017), and (Kasbella, 2017). Meanwhile, the exogenous variables quality, packaging, and customer satisfaction with the endogenous variable repurchase intention have a p-value > 0.05, which means they have no significant effect to endogenous latent variable repurchase intention.

4.2 Limitations

The limitation of this study is online respondents that can be collected for this research because of the time limited time for data collection. This research could be more appropriate if the respondents used in the research are a lot more than we currently used in the analysis. Another limitation is that the respondents are only female, because there are also men that may use BLP Beauty cosmetic products, so there must be bias in this study. There are only seven factors (latent exogenous variables) used in this study according to the researcher are the factors that give most influence to repurchase intention of a cosmetic product. Based on (Klein et al., 2019) intention is still a strong predictor but bias in actual behavior is possible and cannot be completely excluded. So we conclude that this results provides a reliable picture of possible repurchase intention behavior related to cosmetic products and essential predictors.

5. CONCLUSIONS

In this study, researcher found that the conclusion from the results of the analysis and discussion of this research is that the factors that influence consumers in the interest in repurchasing cosmetic products in terms of the Theory of Planned Behavior include: (1) Initial respondents from this study amounted to 189 people with 14 respondents who made repurchases less than 3 times, and 175 respondents had made repeat purchases more than 3 times so that the final respondents used in this study were 175 people; (2) Factors include: feature and ingredients (FI), price (PP), influencer's review (IR), and customer loyalty (CL) are factors that affect repurchase intention (RI) or consumer interest in repurchasing a product cosmetics; (3) Among the four factors that influence consumers to repurchase cosmetic products are sorted based on the value of the coefficient and the highest to lowest significance level are as follows: influencer's review (IR) with a value of CR = 4.447 and probability (p) = 0.002, customer loyalty (CL) with a value of CR = 2.654 and probability

(p) = 0.004, feature and ingredients with a value of CR = -2.63 and probability (p) = 0.005, and price (PP) with a value of CR = 2.112 and probability (p) = 0.038; (4) Other factors, namely quality (Q), packaging (P), and customer satisfaction (CS) are proven not to affect consumers' intention to re-purchase cosmetics.

6. REFERENCES

Affandi, M. A., (2018). *Faktor-Faktor yang Memengaruhi Niat Partisipasi Milenial dalam Mega Event Project Asian Games 2018*.

Ajzen, I., (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*. https://doi.org/10.1016/0749-5978(91)90020-T

Ali, A., & Bhasin, J., (2019). Understanding Customer Repurchase Intention in E-commerce: Role of Perceived Price, Delivery Quality, and Perceived Value. *Jindal Journal of Business Research*, *8*(2), 142–157. https://doi.org/10.1177/2278682119850275

Ariffin, S., Yusof, J. M., Putit, L., & Shah, M. I. A., (2016). Factors Influencing Perceived Quality and Repurchase Intention Towards Green Products. *Procedia Economics and Finance*, *37*(16), 391–396. https://doi.org/10.1016/s2212-5671(16)30142-3

Basyarahil, M. A., (2017). *Analisis faktor-faktor yang mempengaruhi minat beli kosmetik pria pada mahasiswa fakultas ekonomi dan bisnis universitas brawijaya*. Brawijaya University.

Kasbella, W. P., & Madiawati, P. N., (2017). Issn : 2355-9357. *E-Proceeding of Management*, *4*(1), 660–669.

Klein, F., Emberger-Klein, A., Menrad, K., Möhring, W., & Blesin, J. M., (2019). Influencing factors for the purchase intention of consumers choosing bioplastic products in germany. *Sustainable Production and Consumption*, *19*, 33–43. https://doi.org/10.1016/j.spc.2019.01.004

Kotler, P., & Keller, K. L., (2016). *Marketing Management*. Pearson Education Limited.

McCormick, K., (2016). Celebrity endorsements: influence of a product-endorser match on millennials attitudes and purchase intentions. *Journal of Retailing and Consumer Services*, *32*, 39–45. https://doi.org/10.1016/j.jretconser.2016.05.012

Morrison, D. G., (1979). Purchase intentions and purchase behavior. *Journal of Marketing*. https://doi.org/10.2307/1250742

Putri, E. D. R., (2018). Pengaruh Kualitas Produk dan Harga Terhadap Keputusan Pembelian Melalui Minat Beli. In *Director*. Sanata Dharma University.

Setyorini, R., & Nugraha, R. P., (2016). The effect of trust towards online repurchase intention with perceived usefulness as an intervening variable: A Study on KASKUS Marketplace Customers. *The Asian Journal of Technology Management*, *9*(1), 1–7.

Sumargo, B., & Novalia, T., (2018). Structural equation modelling for determining subjective well-being factors of the poor children in bad environment, *Procedia Computer Science*. https://doi.org/10.1016/j.procs.2018.08.156

Zeng, S., Hu, X., Zhao, H., & Stone-MacDonald, A. K., (2020). Examining the relationships of parental stress, family support and family quality of life: A structural equation modeling approach. *Research in Developmental Disabilities*.https://doi.org/10.1016/j.ridd.2019.103523

ANALYSIS OF THE FACTOR OF PROMOTION AND CONSUMER IMAGE ON PURCHASE INTENTION IN COFFEE PURCHASE APPLICATION USING TECHNOLOGY ACCEPTANCE MODEL 2 (TAM2)

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ABSTRACT

The development of technology is in the fourth phase of the industrial revolution, namely Industry 4.0 which is growing rapidly throughout the year. The current industrial revolution 4.0 has a significant impact especially on the coffee industry. Moreover, the coffee shop business in Indonesia is at a tipping point. However, pioneering the coffee business in this era is not easy to run so that each businessman highlights their own advantages. PT. Fore Kopi Indonesia is one of the coffee shops that not only attaches importance to physical outlets, but also provides coffee ordering apps that are presented on iOS & Android devices. The coffee purchase app on PT. Fore Kopi Indonesia has a very important role to support the customer purchasing process and help the company in marketing the product because it is directly connected to the app. The company's top priority is to understand customer needs and determine how to deliver a much better service to customers. However, the ease and effect of promotion on purchasing interests has never been measured before on the company. The coffee purchase application must be analyzed to find out the perception of acceptance and benefits felt by customers. This study was conducted to identify the influence of sales promotion on purchasing interest in coffee buying apps as well as what factors can make consumers have a buying interest when they make a coffee purchase. So that the company can review the sales promotion strategy that will be carried out on the application. Researchers use Slovin formula to determine the number of samples. using n as the sample size to be searched, N as the population size and e as the margin of error which is the amount of error expected or specified. The researcher collected data using an online questionnaire that was distributed to 100 respondents then the questionnaire results were obtained as many as 121 respondents. The data generated from the questionnaire then processed using SPSS software. Technology Acceptance Model 2 (TAM 2) method is the most suitable method to be used as an analysis of application acceptance adoption based on several constructs contained in TAM 2. Further testing using Structural Equation Modeling (SEM). The result of this study is an analysis of factors that influence Promotion and Intention to use in the use of coffee purchase applications.

Keywords: Coffee Purchasing Application, Technology Acceptance Model 2, Perceived Ease of Use, Promotion, Purchase Intention, Structural Equation Modelling.

1. INTRODUCTION

Based on data compiled in Statista (2019), (Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)(Statista, 2019)the number of e-commerce users in Indonesia in 2017 reached 139 million users, and then rose 10.8% to 154.1 million users in 2018. In 2020, e-commerce users rose by 8.7% to 181.5 million. Based on data collected in Data Reportal (2020),there are 80% of e-commerce users who make online purchases through mobile *devices.* When viewed from the population in Indonesia, social media can be used as a liaison with others and can facilitate access to information. It is then widely used by businesspeople as one of the effective marketing media to be used as a promotional media. The application of promotions on social media is also widely used by some businesspeople in Indonesia. One of them is in the coffee business in Indonesia which can be seen from the number of coffee shops in the corners of the city of Indonesia. Along with the many demands and needs of coffee businesses in Indonesia, many coffee shop businesses are vying to attract new consumers, one of which is by providing innovations in technology. This is driven by the growth of the middle class and lifestyle changes in Indonesian society. When looking at the development of technology in the last three years, many Indonesians are increasingly sensitive to the level of service in a coffee shop as measured by the speed of service and instant service in the process of purchasing coffee.

The rise of coffee business in Indonesia, makes each businessman highlight their respective advantages. Fore Coffee is one of the coffee shops that not only attaches importance to physical outlets, but also provides coffee ordering apps that are presented on iOS & Android devices. In 2018, Fore Coffee is the only coffee shop in Indonesia that has an app for ordering coffee. With this application, consumers who want to order coffee or know what promo information is going on, consumers can see it directly in one hand, using the Fore Coffee application. When compared with other coffee shop applications, the application of this Fore Coffee company has many advantages. Previously, Fore Coffee carried an online-to-offline (O2O) concept in which the concept integrates between mobile applications and offline stores. Another difference is, other applications only emphasize the application as a member gathering media. While the application owned by Fore Coffee, consumers can make transactions directly from the application. So, the application can facilitate and minimize the queue in offline stores.

In a study conducted by Chung & Hyeuk (2016) proved by using TAM methodology to know the influence of brand engagement and resulted in the conclusion that the Starbucks application can show that consumers voluntarily and can actively engage with Starbucks only through its mobile app. This research was conducted to find out the effect of sales promotion on purchasing interest in coffee buying apps as well as what factors can make consumers have a buying interest when they make a coffee purchase. So that the company can review the sales promotion strategy that will be carried out on the application. In addition, this research is very important to prove the existing theory. there is still no research that examines the relationship between sales promotion and interest in purchasing coffee through the Fore Coffee application. In TA M 2 method, researchers use four substances, namely *Perceived Ease of Use* that can be used to know the perception or belief that the information technology used is easy to use, *Perceived Usefulness* that can be used to know the perception of consumer confidence that the information technology used can provide benefits, *Attitude Toward Using* can be used to give confidence to users to be able to use information technology that is then connected with *Behavioural Intention of Use* that can know consumer behavior in order to be consistent in using information technology and Usage *Behavior* that can know the behavior of users when using information technology. The next step taken by researchers is to conduct an analysis using Structural Equation *Modeling* (SEM) to find out more certainty the influence and factors that influence the promotion and buying interest of consumers when making coffee purchases.

2. METHOD

2.1 Literature review

The determinants of online purchasing were popularized by one of the most popular frameworks, namely the Technology Acceptance Model (1992) who first developed TAM in order to identify the factors that generally affect computer use. TAM contains two main variables, namely Perceived Usefulness and Perceived Ease of Use (2000). Each of these variables is a major factor in TAM which is expected to influence a person's attitude to use the system, which is expected to provide perceived benefits, and can clarify the possible interest of users in implementing the system (Legris et al., 2003). In addition to these main variables, there is research by Richard Ye (2014) which includes the sales promotion variable as an external variable to measure the relationship between sales promotion, TAM, and consumer-to-customer (C2C) purchase interest (2014). So, the variables used in this research are sales promotion, image, purchase interest, perceived ease of use, perceived usefulness, image, and purchase interest.

2.1.1 Technology Acceptance Model

Based on Legris (2003) *Technology Acceptance Model* (TAM) is a development of TRA *(Theory of Reasoned Action)* which in 1986 was introduced by Davis and subsequently redeveloped by several scientists, one of whom was Venkatesh and Davis. TAM is a model used for the acceptance of a technology that can be used to identify the level of technological acceptance of an individual. According to Davis, the main purpose of TAM is to explain what are the factors that can influence the acceptance of Information Technology with the user population. In TAM2, there are some moderator variables that are optional and do not have a significant influence on the problems experienced by researchers.

2.1.2 Structural Equation Modeling (SEM)

According to Gefen (2002)Structural Equation Modeling or commonly referred to as SEM is a multivariate analysis method that can then be used to describe the linear relationship between observation variables (indicators) and variables that cannot be measured directly or commonly referred to as latent variables. SEM is a technique developed to be further used widely in some static research. The models contained in it include path analysis, regression analysis, and confirmaatory factor analysis. This SEM can be used as a stronger modeling alternative when compared to multiple regression methods, factor analysis, covariant analysis and time series analysis. From some definitions mentioned above, SEM tends to be used to determine whether a model used is valid compared to using SEM to be able to determine whether the model used matches or not with the analyzed.

2.2 Respondents

Researchers use Slovin formula to determine the number of samples. using n as the sample size to be searched, N as the population size and e as the margin of error which is the amount of error expected or specified. The researcher collected data using an online questionnaire that was distributed to 100 respondents then the questionnaire results were obtained as many as 121 respondents. The data generated from the questionnaire then processed using SPSS software. One hundred and twenty one participants completed the survey. The final sample resulted in a questionnaire filled out by 72 female respondents, 49 male respondents, the age range of the respondents was 26-40 years old, the education level of respondents was mostly filled with undergraduate students, and the respondents who filled in the most were students.

Table 1. Descriptive results

Variables	n	Percentage (%)
Gender		
Male	49	40.50%
Woman	72	59.50%
Age		
15-25 years old	50	41%
26-40 years old	63	52%
>41 years old	8	7%
Education		
Magister	24	20%
Bachelor	46	38%
Junior High School	36	30%
Senior High School	14	12%
Occupation		
Housewives	6	5%
Employees	9	8%
Student	97	81%
Enterpreneur	9	7%
Understand how to use the application		
Yes	80	66%
No	41	34%
Purchase Amount		
0-1 kali per minggu	69	57%
2-3 kali per minggu	40	33%
4-6 kali per minggu	10	8%
>6 kali per minggu	2	2%

3. RESULT

3.1 Model Specification

This study uses Structural Equation Modeling (SEM) analysis which is used to examine the relationship between complex variables, which is tested recursively and non-recursively which is used to obtain a comprehensive picture of the results of the overall model. This study uses Structural Equation Modeling (SEM) analysis which is used to examine the relationship between complex variables, which is tested recursively and non-recursively which is used to obtain a comprehensive picture of the results of the entire model. In this study, SEM analysis was used to determine the relationship between variables in which there are independent variables and dependent variables contained in a model. The modeling in this study is based on the Technology Acceptance Model (TAM) theory. From the model created, it can determine a system that interacts in accordance with a series of flow paths that can explain the relationship between variables.

Before estimating, it is mandatory to make an initial model formation using a structural model. At this stage, the researcher must be able to conceptually define the construct being studied.

Table 2. Variable Specification

Subscructure	Dependent Variabel	Independent Variabel
1.	Image	Perceived usefulness
2.	Perceived Ease of Use	Intention to Use
3.	Promotion	Minat Beli

Before interpreting the results of hypothesis testing, there are several steps that must be taken to ensure that the approved model has a good fit with the object being observed through the data obtained. The next step is to analyze the goodness-of-fit model. This is done to determine that the analyzed model has a good fit.

3.2 SEM Results

3.2.1 Measurement Model

Measurement Model is a process of CFA test or confirmatory factor analysis. CFA is used to identify whether the indicators used are constructs from the research variables which are then tested on each indicator. The CFA test can be carried out on the exogenous and endogenous extracts used. This measurement test is used to ensure that whether there are variables that are not correlated, apply to endogenous or exogenous constructs. When the correlation between exogenous and endogenous constructs is combined, it will produce a high correlation.

This analysis can be used to assess the validity of convergents and the validity of diskriminants that can be measured by looking at composite reliability (CR), factor loadings (FL), and average variance extracted (AVE). Composite reliability is used to measure the reliability of the model created. The function of CR is almost the same as Cronbach's αlpha, which can provide a more precise estimation value by using factor loadings in the research model. While Factor loadings are used to show the correlation value and weighting of each questionnaire variable as an observed indicator. If the resulting FL value is large, it indicates the presence of dimension factors in the research model. Average variance extracted (AVE) is the sum of the average variants in the observed variable (Putri & Noer, 2017). The test criteria can be seen from seeing a CR value greater than 0.7; FL is greater than 0.6; and AVE at least 0.5 (Lin et al., 2017). If all questionnaire variables meet the criteria, then the factors or variables in this study have adequate validity.

In this study, there are eight variables, namely Image, Perceived Usefulness, Perceived Ease of Use, Intention to Use, Promotion and Purchase Interest. The relationship between variables is associated with covariance as shown below:

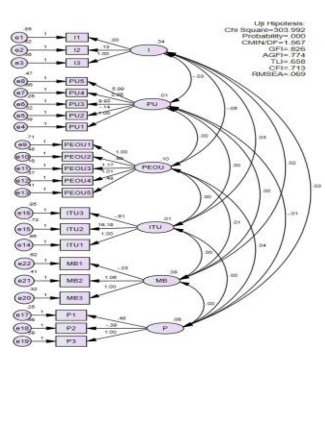

Figure 1. Measurement Model

After modeling between variables, the next step is to analyze the goodness-of-fit on the measurement results of the model. Goodness of fit is used to ensure that the resulting model has a good suitability or not through the data obtained.

Table 3. Goodness of Fit Measurement Model

No.	Goodness of Fit Measurement	Cut off Value	Model Default Value	Description
1.	Chi Square		303.9922	**Not Fit**
2.	Cmin/df	≤ 2,00	1,567	**Fit**
3.	Probabiliy	≥ 0,05	0,0000	**Not Fit**
4.	RMSEA	≤ 8,00	0,0687	**Fit**
	Absolute Fit Indices			
4	GFI	< 9,00	0,8264	**Fit**
5.	AGFI	< 9,00	0,7735	**Fit**
6.	RMR	< 9,00	0,0554	**Marginal Fit**
	Incremental of Indices			
7.	NFI	< 9,00	0,5053	**Marginal Fit**
8.	CFI	< 9,00	0,7132	**Marginal Fit**
9.	IFI	< 9,00	0,7384	**Marginal Fit**
10.	RFI	< 9,00	0,4109	**Not Fit**
11.	TLI	< 9,00	0,6585	**Marginal Fit**
	Parsimony Fit Indices			
12.	PRATIO	< 9,00	0,8398	**Fit**
13.	PNFI	< 9,00	0,4243	**Fit**
14.	PCFI	< 9,00	0,5989	**Marginal Fit**

The results of the calculation above show that in Absolute Fit Indices and Parsimony Fit Indices provide a conformity index that has met the recommended limits. In the principle of parsimony & rule of tumb, it is explained that if there are one or two criteria of goodness of fit that have been met, then the model can be said to be good (Solimun, 2005). With six fit assumptions on this model, the model used is considered fit and there is no need to modify the index. And if the goodness of fit has met the cut-off-value, then the model used is acceptable and the model in this study is good.

3.2.2 Structural Model

After the measurement stage of the model is fulfilled. the next stage is the creation of structural models by connecting endogenous variables and exogenous variables. Where, the exogenous variables in this study are Perceived Ease of Use, Image and Promotion. While endogenous variables in this study are Perceived Usefulness, Intention to Use and Buy Interest. Structural models in this study, illustrated in Figure 2:

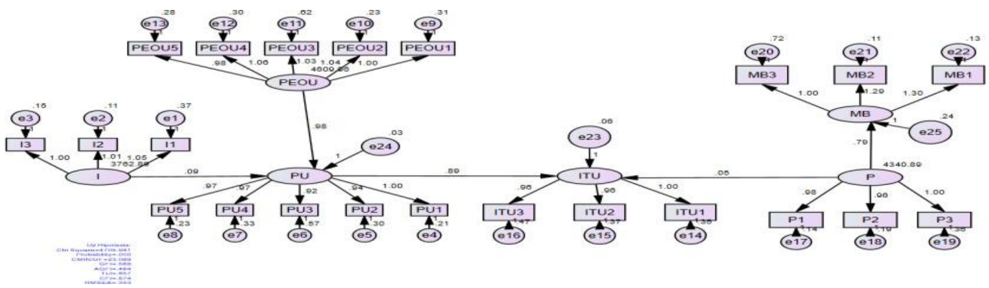

Figure 2. Structural Model

The suitability of the model studied is the degree of conformity of the estimated model examined. If the model conformity test has not been met, then the model modification must be done. To ensure that there are no indicators that exceed the limit or are not appropriate, then can look at the structural results described in table 4:

Table 4. Goodness of fit structural Model

No.	*Goodness of Fit Measurement*	*Cut off Value*	*Nilai Default Model*	*Keterangan*
1.	Chi Square		228,2490	**Not Fit**
2.	Cmin/df	≤ 2,00	1,7696	**Fit**
3.	Probabiliy	≥ 0,05	0,0000	**Not Fit**
4.	RMSEA	< 9,00	0,0801	**Fit**
		Absolute Fit Indices		
4	GFI	< 9,00	0,8034	**Fit**
5.	AGFI	< 9,00	0,7573	**Fit**
6.	RMR	< 9,00	0,0543	**Fit**
		Incremental of Indices		
7.	NFI	< 9,00	0,4125	**Not Fit**
8.	CFI	< 9,00	0,5932	**Marginal Fit**
9.	IFI	< 9,00	0,6190	**Marginal Fit**
10.	RFI	< 9,00	0,3380	**Not Fit**
11.	TLI	< 9,00	0,5932	**Marginal Fit**
		Parsimony Fit Indices		
12.	PRATIO	< 9,00	0,8874	**Fit**
13.	PNFI	< 9,00	0,3361	**Not Fit**
14.	PCFI	< 9,00	0,5264	**Marginal Fit**

The results of the calculation above show that in Absolute Fit Indices and Parsimony Fit Indices provide a conformity index that has met the recommended limits. In the principle of parsimony & rule of tumb, it is explained that if there are one or two criteria of goodness of fit that have been met, then the model can be said to be good (Solimun, 2005). With six fit assumptions on this model, the model used is considered fit and there is no need to modify the index. And if the goodness of fit has met the cut-off-value, then the model used is acceptable and the model in this study is good.

4. DISCUSSION

After the modeling done above and the model produced fit, the next step is to analyze the factors that influence the promotion of consumer buying interest in Fore Coffee. This step is done by analyzing the relationship of each variable from the results mentioned in table 4. This analysis can also be done to be a reference hypothesis that has been predetermined.

After the criteria of goodness of fit in structural models have been estimated and can be met, then the next stage is the analysis of structural relationship models that are subsequently tested hypothetically. The relationship between constructs in this hypothesis is indicated in the regression weights value. Hypothesis testing was conducted by analyzing the significance of causality relationships between constructs used in the model seen from the p-value of the existing structural relationship results. In table 5, an arrow (➐) indicating the direction of influence between variables. Standardized regression weight values that indicate positive values mean the relationship of the two variables that have a positive relationship direction. While the test of relationship significance is done by looking at the p-value of each relationship. If the resulting p-value is less than 0.1, then the relationship of the two variables is significant. The table below shows the regression weights of the variables that have been tested causality relationships.

Table 5. Hypotesis Result

Variabel Relations			**Estimate**	**S.E.**	**C.R.**	**P**	**Description**
image	<-->	peou	-.0110	.0099	-1.1147	.2650	Rejected
image	<-->	pu	.0558	.0322	1.7308	.0835	Accepted
image	<-->	itu	.0584	.0510	1.1462	.2517	Rejected
image	<-->	mb	.1049	0.435	2.4130	.0158	Accepted
peou	<-->	pu	.0176	.0115	1.5313	.1257	Rejected
promotion	<-->	image	-.2086	.0686	-3.0432	.0023	Accepted
peou	<-->	itu	.0602	.0366	1.6427	.1004	Rejected
pu	<-->	mb	.0153	.0112	1.3692	.1710	Rejected
promotion	<-->	mb	.0507	.0295	1.7158	.0862	Accepted

After the hypothetical analysis, it was produced that of the 9 hypotheses proposed, there were 4 accepted hypotheses and 5 rejected hypotheses. Accepted hypotheses are variables that have an influence on other variables. Whereas, if the rejected variable is a variable that has no influence on other variables.

a. Image (I) **to Perceived** *Ease of Use (PEOU)*

The analysis of structural model shows that there is an insignificant *relationship between Image (I) and Perceived Ease of Use (PEOU) with* probability value of 0.2650 more than 0.1 (α=10%). Thus, it shows that the hypothesis for H1 is rejected.

From these results, it can be said that the user or customer is not affected by others or people around him who have a high degree in making transactions. The results of this study are different from the conclusion of Randy Pradana (2019), stated that the influence of others or people closest to him can make customers or customers think about making purchases through the application.

b. Image (I) **to** *Perceived Usefulness (PU)*

The results of structural model analysis showed that there is an insignificant *relationship between Image (I) and Perceived Usefulness* with a probability value of 0.0835 less than 0.1 (α=10%). Thus, it indicates that the Hypothesis for H2 is accepted.

From these results, it can be said that the influence of others or people around him who have a high degree of influence significantly on the purchasing process on the customer. Which, the influence of others can help customers in choosing the menu of products to be purchased and will accelerate the customer transaction process because there is help from others in explaining what information and promotions are contained in the Fore Coffee application.

c. Image* terhadap *Intention to Use

The analysis of structural model shows that there is an insignificant relationship *between Image (I)* and Intention to Use *with probability* value of 0.2517 more than 0.1 (α=10%). Thus, it shows that the hypothesis for H3 is rejected.

From these results, it can be said that the influence of others or people around them who have a high degree does not have a significant effect on how often customers make purchases through the application. Where, buyers more often make transactions through the application, but there is no influence from others in making such transactions. It is known that buyers make transactions more often through the app, out of personal desire and without being influenced by others.

d. *Image (I)* to Buying Interest

The results of structural model analysis show that there is an insignificant *relationship between Image (I)* and Buy Interest with a probability value of .0158 less than 0.1 (α=10%). Thus, it indicates that the Hypothesis for H4 is accepted.

From these results, it can be said that the influence of others or people around him who have a high degree have a significant effect on the buying interest of customers. It can be noted that the consumer's buying interest is not influenced by the words or solicitation of others in making transactions through the application. Consumers who want to make transactions, are interested to buy if there is influence from people around him who have a high status like an influencer.

e. Perceived Ease of Use to Perceived Usefulness

The results of structural model analysis showed that there is *an insignificant relationship between Perceived Ease of Use and Perceived Usefulness* with a probability value of 1,257 more than 0.1 (α=10%). Thus, it shows that the Hypothesis for H5 is rejected.

From these results, it can be said that the user's perception of the ease of use of the Fore Coffee application has no real or significant influence on the user's perception of the usefulness or benefits of using the Fore Coffee application in making purchase transactions. The results of this study are similar to the conclusion of Randy Pradana (2019) who stated that the perception of ease of use of applications has a significant influence on the perception of the usefulness of the use of Fore Coffee application.

f. Promotion to Image

The results of structural model analysis showed that there is an insignificant *relationship between Promotion* and *Image* with a probability value of 0.0023 which is less than 0.1 (α=10%). Thus, it indicates that the Hypothesis for H6 is accepted.

From these results, it can be said that user promotion has a significant effect on *the image or* view of the user in making a purchase through the application. It can be noted that in the Fore Coffee app, there are many promotions in one application that require customers to purchase promotional products through the app.

g.* Perceived *Ease of Use to Intention to Use

The results of structural model analysis showed that there is *an insignificant relationship between Perceived Ease of Use* and Intention to Use *with probability* value of .1004 where more than 0.1 (α=10%). Thus, it shows that the hypothesis for H7 is rejected.

From these results, it can be said that the user's perception of ease of use of the application has no significant effect on the interest in using the application. It can be concluded that buyers who find it easy to make transactions through the application, are not necessarily interested in continuing to use the application in the transaction process. The results of this study are different from the conclusion of Randy Pradana (2019) who stated that the perception of ease of user can influence the interest in using the application.

h. Perceived *Usefulness* to Buying Interest

The results of structural model analysis show that there is an insignificant *relationship between Perceived Usefulness* and *Buy Interest* with a probability value of 0.1710 where more than 0.1 (α=10%). Thus, it shows that the Hypothesis for H8 is rejected.

From these results, it can be said that the perception of ease of using the application, has a significant effect on customers' buying interest in making transactions through the application. From this hypothesis, it can be explained that customers have little interest in continuing to use the application in making transactions. While in the process of using it, Fore Coffee application is considered *more user friendly* and easy to use when making transactions. The results of this study are different from the conclusion of Randy Pradana (2019) who stated that users are more interested in using the application,

i. *Promotion Relationship* to **Buy Interest**

The analysis of structural model shows that there is an insignificant relationship *between Promotion* and *Buy Interest* with probability value of 0.0862 which is less than 0.1 (α=10%). Thus, it indicates that the Hypothesis for H9 is accepted.

From these results, it can be said that the ongoing promotion on the application, significantly affects the user's purchase interest. It can be noted that customers are more interested in making in-app purchases because the promotions provided by Fore Coffee tend to encourage users to make purchases through the app than to make purchases directly in the store. The results of this study are similar to the conclusions of Imas Nurhazanah, who stated that users are more interested in using the application (2018).

5. CONCLUSION

After analyzing the effect of promotion and image on purchase intention, the following conclusions are obtained. After analyzing the effect of promotion and image on purchase intention, the following conclusions are obtained. There is a significant relationship in the Image and Perceived Usefulness variables, it is known that consumers who want to make a purchase transaction are more likely to want to buy because of their own desires and not because of the influence of others. In addition, Promotion and Image also provide significant results and promotions on applications can affect user views in making transactions. Meanwhile, Image and Perceived Usefulness also provide significant results with the conclusion that the view of the user if there are people around him who have a high profile value using the application in the purchase process can have an influence on other customers Promotion and Purchase Interest also provide significant results, and it can be seen that customers are more interested in making purchases in the application because the promotions on Fore Coffee App tend to encourage users to make purchases through the application compared to making purchases directly in the store.

6. REFERENCES

Adams, D. A., Nelson, R., Todd, P. A., & Nelson, R. R., (1992). Perceived Usefulness, Ease of Use, and Usage of Information Technology: A Replication Increasing Systems Usage Perceived Usefulness, Ease of Use, and Usage of Information Technology: A Replication. *Source: MIS Quarterly*, *16*(2), 227–247.

Gefen, D., (2002). Customer Loyalty in e-Commerce Settings.pdf.crdownload. *Journal of the Association for Information Systems*, *3*(1), 27–51. https://pdfs.semanticscholar.org/00f2/f77fe6480f66c2982010a091e8c76c61b7ff.pdf

Kemp, S. (n.d.). *DIGITAL 2020: INDONESIA*. Retrieved June 25, 2020, from https://datareportal.com/reports/digital-2020-indonesia

Legris, P., Ingham, J., & Collerette, P., (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information and Management*, *40*(3), 191–204. https://doi.org/10.1016/S0378-7206(01)00143-4

Lin, S.-C., Nadlifatin, R., Amna, A., Persada, S., & Razif, M., (2017). Investigating Citizen Behavior Intention on Mandatory and Voluntary Pro-Environmental Programs through a Pro- Environmental Planned Behavior Model. *Sustainability*, *9*(7), 1289. https://doi.org/10.3390/su9071289

Nurzanah, I., & Sosianika, A., (2018). Promosi Penjualan dan Minat Beli: Penerapan Modifikasi Technology Acceptance Model di E-Marketplace Shopee Indonesia. *Industrial Research Workshop and National Seminar*, 706–714.

Putri, A. T. K., & Noer, B. A., (2017). Information Richness, Retailer Brand, Extended Offers pada Niat Beli Konsumen Menggunakan T-Cash. *Jurnal Sains Dan Seni ITS*, *6*(1). https://doi.org/10.12962/j23373520.v6i1.21317

September, R., & January, A., (2016). Consumer brand engagement by virtue of using Starbucks's Branded Mobile App based on grounded theory methodology. *International Journal of Asia Digital Art and Design*, *19*(4), 91–97. https://doi.org/10.20668/adada.19.4_91

Solimun, (2005). *Structural Equation Modelling (SEM): Aplikasi Software AMOS*. Malang: Fakultas MIPA dan Pasca Sarjana.

Statista, (2019). *Tren Pengguna E-Commerce 2017 - 2023*.
https://databoks.katadata.co.id/datapublish/2019/10/10/tren-pengguna-e-commerce-2017- 2023#

Suryani, E., Teknologi, D. M., Bisnis, F., & Manajemen, D, (2019). *ADOPSI APLIKASI EDMODO SEBAGAI MEDIA PEMBELAJARAN DENGAN MENGGUNAKAN TECHNOLOGY ACCEPTANCE MODEL 2 (TAM 2)*.

Venkatesh, V., & Davis, F. D, (2000). Theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. *Management Science*, *46*(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926

Ye, L. R., & Zhang, H., (2014). Sales Promotion and Purchasing Intention: Applying the Technology Acceptance Model in Consumer-To-Consumer Marketplaces. *International Journal of Business, Humanities and Technology*, *4*(3), 1–5. http://www.ijbhtnet.com/journals/Vol_4_No_3_May_2014/1.pdf

INVESTIGATION OF SERVICE INNOVATION AND EMPLOYEE PERFORMANCE ON CUSTOMER SATISFACTION AND LOYALTY: CASE STUDY PT. PLN (PERSERO) UP3 PAMEKASAN

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ABSTRACT

Performing business, which in a competitive and dynamic era, requires companies that continous applied service innovations and improved employee performance in work station. In line with that, this study further discuss about service innovation and employee performance in relation with satisfaction and loyalty. This study attemps to analyze the effect of service innovations and employee performance on customer loyalty. This study choose PT PLN (persero) UP3 Pamekasan as the object to analyze the effect of service innovations and employee performance on customer loyalty. Using information gathered by questionnaires from PLN customer's in Bangkalan district within 6600 VA to 197 kVA, this study attemps to better understand about the correlation between innovation, employee performance, customer satisfaction and customer loyalty in recent condition. Not only the effect, this study analyze also how significant impact of the eksogen variables to the endogen variables. For help reaching a large coverage area, this study has also used *Google form* to gather the essential information from the subject. The questionnaire and the *google form* prepared in 14 indicators variables which are developed from 4 latent variables, i.e Employee Performance (EP), Service Innovation (I), Customer Satisfaction (CS), and Customer Loyalty (L).

This study was developed through *Confirmatory Factor Analysis* (CFA) approach by confirming similar theories and research that have been done before. The sample data analysis method used the Structural Equation Modeling (SEM) approach, which is using some *Goodness of Fit* (GOF) criteria to ensure the research model is fit. The results of this study obtained that service innovation and employee performance have a positive influence on the customer satisfaction. However, the employee performance has a significant one. This is based on critical ratio and probability values that calculated using AMOS 22. In addition, this study indicated that the customer satisfaction has a positive and significant impact to customer loyalty. The results of this study are expected to contribute the company managements in decision making and it's being the new literature in marketing.

Keywords: Customer Loyalty, Customer Satisfaction, Employee Performance, *Structural Equation Modelling.*

1. INTRODUCTION

Customer loyalty is defined as "on going commitment to buy or reuse products or services in the future" Oliver (1997). Generally recognized as a reflection of long-term customer purchasing behavior. From a number of theories related to customer satisfaction and loyalty, the concept of expectation-confirmation theory (ECT) is the dominant one used to model repetitive purchasing behavior and recommendations in marketing research (Oliver, 1981). Two affective factors, namely expectations and confirmation, are used to explain customer satisfaction in ECT concept (Hossain and Quaddus, 2012; Olson and Dover, 1979). Because satisfaction and loyalty have a substantial impact on customer retention and company profits (Crosby et al., 1990), the serviced industry strives to encourage and increase customer satisfaction and loyalty.

PT. PLN (Persero) UP3 Pamekasan, a state-owned company in the field of supplying and distributing electricity energy in Madura islands, continuously innovate to improve customer satisfaction, as well as increase the company's customer loyalty. In quality development should focus on customer satisfaction, so it is necessary to understand the components related to customer satisfaction. It is necessary to know what is customer expectations in a services then compare with existing service in the company. Then, there will be a service gap between the customer expectations and the existing services. That is the role of this study which is analyzing how the components (innovation and employee performances) meets customer behavior's (satisfaction and loyalty).

2. METHODS

This study based on increasing customers expectations for the quality of company product's and services amid limited company resources . This study hypothesizes employee innovation and performance as part of meeting customer expectation. To support these hypotheses, a test through theory and historical data approach is required. So, a comprehensive study was conducted by compiling hypotheses, as an effort to approach the problems faced. In this study, five hypotheses will be tested through theoretical approaches and historical data collected through questionnaires.

2.1 Variables

The study was developed based on four latent variabels, two exogenous and two endogenous. In this section are described each variabel, based on the previous literature. Determining variable indicator is important because it will help as a shaper of question items or statements in questionnaires. The following is presented table 1, which contains each variable and the determination of variable indicators used in this study.

Table 1. Variables and the Indicators

Variables	Code	Indicators
		derstanding (EP$_1$)
		mitment (EP$_2$)
Employee Performance	EP	cus (EP$_3$)
		owledge (EP$_4$)
		st services (EP$_5$)
Service Innovation	I	line service (I$_1$)
		odern (I$_2$)
		sy and fast (I$_3$)
		ovative (I$_4$)
		ormative (I$_5$)
Customer Satisfaction	CS	isfied (CS$_1$)
		eat (CS$_2$)
		mfortable (CS$_3$)
Customer Loyalty	CL	commend (CL$_1$)
		gh trust (CL$_2$)

2.2 Model and hypotheses

Based on a review of the relevant literature, the relationship between the latent variables are presented in figure 1 and the hypotheses that are tested in this study are listed below. Analysis and testing of models and hypotheses using Structural Equation Modelling (SEM) methods. The variables and hypotheses are predetermined based on literature and adapted to research object (CFA analysis)

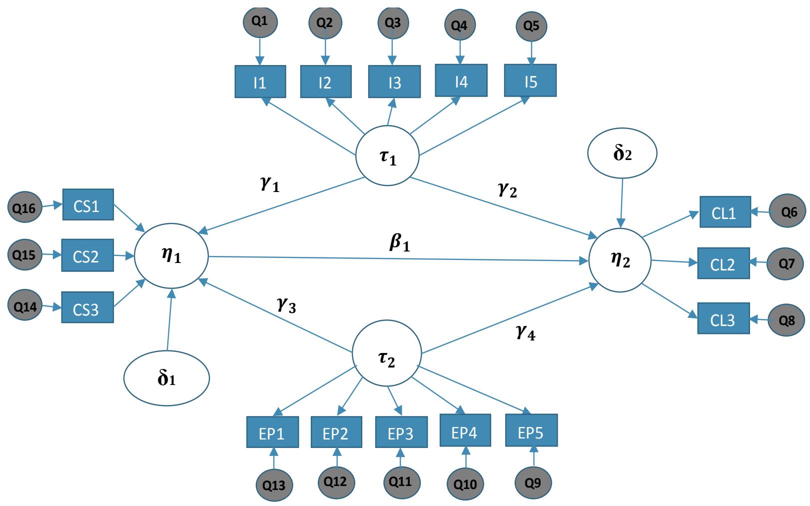

Figure 1. Research Model of relationship between laten variables

Structural equations based on the research model can be formulated as follows:

$$\boldsymbol{\eta_1 = \gamma_1\tau_1 + \gamma_3\tau_2 + \delta 1} \quad (1)$$

$$\boldsymbol{\eta_2 = \gamma_2\tau_1 + \gamma_4\tau_2 + \beta_1\eta_1 + \delta 2} \quad (2)$$

η : Value of endogenous

τ : value of exogenous

γ : coefficient path between exogenous and endogenous

β : coefficient path between both of endogenous

δ : residual path of endogenous

Hypotheses are tested in these study are listed below:

H_1: Innovation has a positive and significant impact on customer satisfaction

H_2: Innovation has (directly) significant impact on customer loyalty

H_3: there is significant influence of customer satisfaction on customer loyalty.

H_4: there is (directly) significant influence of employee performance on customer satisfaction.

H_5: Employee performance has a significant (directly) impact on customer loyalty.

2.3 Population and research samples

Number of customers industry and business within 6600 VA to 197 Kva at PLN UP3 Pamekasan as many as 3.570 customers, which is spread in four district i.e bangkalan, Sampang, Pamekasan and Sumenep. In this study, Bangkalan has selected to being study case. This based on the ease of researchers in reaching prospective respondents. In addition, Bangkalan has the largest spread of industrial and business customer's that is about 1.062 customers.

Table 2. Number of The industrial and business customer's distribution

Segment	District			
	Bangkalan	**Sampang**	**Pamekasan**	**Sumenep**
Business	912	553	716	747

Gambar 3.2 Model Penelitian

Sumber: Esin Sadikoglu dan Cemal Zehir, 2007; Bunga Budi Utami dan Sri Wartini, 2015) diolah oleh peneliti

Industrial	150	170	210	112

Sampling technique use the *simple random sampling* to determining number of samples, as the equations below:

$$\text{n} = \frac{N_{pq}}{(N-1)D+pq} \quad \textbf{(3) where:}$$

P = 0.5 $\quad$ $D = \frac{B^2}{4}$

q = 1 – p

description:
N : amount of population
n : amount of minimum sample
B : level of estimate error (B = 0,1)
p : proportion of the population (p = 0,5)

then, the minimum samples can be determined by calculated below:

Business

$q = 1 - 0.5 = 0.5 \qquad D = \frac{(0.1)^2}{4} = 0.0025$

$$\text{n} = \frac{(921)(0.5)(0.5)}{(150-1)0.0025+(0.5)(0.5)} = \frac{228}{2.527} = 90.22$$

Industri

$q = 1 - 0.5 = 0.5 \qquad D = \frac{(0.1)^2}{4} = 0.0025$

$$\text{n} = \frac{(150)(0.5)(0.5)}{(150-1)0.0025+(0.5)(0.5)} = \frac{37.5}{0.6225} = 60.24$$

According the calculation above, the minimum value of business samples is 91 samples and the minimum value of industrial samples is obtained 60 samples.

2.4 Data processing and analysis

By conducting data processing, this study uses several statistical approaches to test the sample so that it becomes an information produced in this study. It begins from processing using descriptive statistics technique to know the demographics of respondents until the use of SEM techniques to analyze the relationship between the variables. SEM uses three analytical approaches, factor analysis, path analysis and structural model. But before doing the analysis, there are assumptions that must be met before conducting data analysis, i.e data must be normally distributed for univariate cases and multivariate normal distribution. In this study used AMOS to conducting normality tests. The determination based on *critical ratio* (C.R.) skewness and *critical ratio* (C.R) kurtosis values. Here is an example of normality test output using AMOS, with three variable indicators along with the equation used.

Table 3. Output of AMOS normality test

Variables	Skew.	C.R	Kurtosis	C.R
Indicator 1	-	-	-	-
Indicator 2	-	-	-	-
Indicator 3	-	-	-	-
Indicator n	-	-	-	-
Multivariate			-	-

where :

- Sign (-) : output value.
- Skew : the skewness sample and the slope calculation is obtained from the formula:

$$\propto = \frac{\sum_{i=1}^{N}(x_i - \bar{x})^n}{NS^3} \quad (4)$$

where:

α : skewness value
N : count of data
S : standard deviation
x_i: observation value
$\bar{x}$: average of observation value
n : count of indicator variable

- $C.R_{skew}$: *critical ratio* skewness, obtained from skewness samples divided with standard of error ($\sqrt{6/N}$, $\bar{x} = 0$).
- Kurtosis : a kurtosis sample whose taper is obtained from:

$$\propto = \frac{\sum_{i=1}^{N}(x_i - \bar{x})^4}{NS^4} - n \quad (5)$$

where :

α : skewness value
N : count of data
S : standard deviation
x_i: observation value
$\bar{x}$: average value

n : count of indicator variable

- $C.R_{kur}$: the critical ratio obtained from kurtosis samples divided by standard error ($\sqrt{24/N}$, $\bar{x} = 0$).
- The multivariate label at the end of table row contains mardia's coefficient on the kurtosis multivariate, with the following formula;

$$\frac{1}{N}\sum_{i=1}^{N}\left[(x_i - \bar{x})'\hat{S}^{-1}(x_i - \bar{x})\right]^2 - \frac{p(P+2)(N-1)}{N-1} \quad (6)$$

where:

x_i : observation value

$\hat{S}^{-1}$: estimates of covarians matrix
N : count of data.

A multivariate *critical ratio* value is a value that indicates that the meets the normal multivariate distribution or not. Data is normally distributed multivariate when the value of c.r is an interval 0f ± 2,58, with a significance rate of $p < 0,01$ (khine, Science and Mathematics Education Centre, Curtin University, 2013).

2.5 Model testing parameter

The model developed in this study through several evaluations so that the model can be said to be good (fit). The evalution is as follows:

- Chi-Square (X^2)

The smaller chi square value, the better models obtained (because in the chi-square different test, $X^2 = 0$ means there is absolutely no difference, H_0 accepted) and received on a probability basis with a cut-off value of $p > 0,05$ or $p > 0,10$ (Hulland et al, 1996).

- *Goodness of Fit Index* (GFI)

GFI determined by the following equations :

$$GFI = 1 - \frac{F_k}{F_0} \qquad (7)$$

where:

F_k : *fit function* minimum value

F_0 : *fit function* value, if all parameter is 0

A high value in the GFI index indicates a better *fit*. When the GFI value ≥ means good fit, while the value of $0,80 \leq GFI \leq 0,90$ is often called marginal fit (Hair JR et al.,2010).

- *Adjusted Goodness of Fit IndexI* (AGFI)

Recommended acceptance rate if AGFI has a value equal to or greater than 0,90 (Hair et al.,1995), this index obtained by the following formula:

$$AGFI = 1 - (1 - GFI)\frac{d_b}{d} \qquad (8)$$

where :

$$d_b = \sum_{g=1}^{g} p^{*(g)} = jumlah\ sampel\ momen$$

d = degrees of freedom

- *Root Mean Square Error of Aproximate* (RMSEA)

RMSEA is one of the formative indices in SEM. RMSEA value ≤ 0,05 indicates close fit, while $0,05 \leq RMSEA \leq 0,08$ indicates good fit (Brown, 2006).

$$RMSEA = \sqrt{\frac{d}{df}} \qquad (9)$$

Dengan d = value obtained from formula $\frac{\chi^2 - df}{(N-1)}$

χ^2 : analyzed test χ^2 statistic values

df : degree of freedom testing of analyzed models

N : count of samples

- CMIN/DF or Relative X^2

CMIN/DF is one of the indicators to measure the fit level of a model, generated for Chi-square statistic (CMIN) divided by *Degree of Freedom* (DF).

After testing the validity data, reliability of research instruments, data normality test and testing of research models by *Goodness of FIT* criteria, then further testing of the research hypotheses. The first hypotheses test is a test of the type of relationship between variables (positive or negative). this test is based on standardized estimate coefficient values obtained from data processing using AMOS.

Table 4. Standardized estimate coefficient value for test the direction of the relationship

Relation between variables			Standardized estimate
EP	--->	**CS**	0,445
I	--->	**CS**	0,258
CS	--->	**CL**	0,519
I	--->	**CL**	0,310
EP	--->	**CL**	0,071

From the table above, it appears that the standardized estimates value for each relationship between variables is positive. This indicates that each variable positively influences each other. Furthermore, the test of significance of the relationship between variables based on critical ratio and probability values. Determination of significance using rules if the value of C.R ≥ 1,988 then the relationship of the variable is significant. The value 1,988 is obtained from t-table with df = 84 and α = 0,05. In addition, it can use the terms of the probability value P, ie if P ≤ 0,05then the relationship of two variables is significant, whereas if the P ≥ 0,05 then the relationship of two variables is insignificant.

Table 5. Output of AMOS significant test

Relationship between variables			Estimate	S.E.	C.R.	P	Ket.
CS	<---	EP	0,489	0,232	2,105	0,035	significant
CS	<---	I	0,223	0,18	1,237	0,216	Insignificant
CL	<---	CS	0,539	0,119	4,54	0,000	Significant
CL	<---	I	0,278	0,198	1,406	0,16	insignificant
CL	<---	EP	0,081	0,258	0,313	0,754	insignificant

By the five relationships between the variables above, there are two relationships that have a significant effect, it is employee performance (EP) to customer satisfaction (CS) and customer satisfaction to customer loyalty. Furthermore, by using table 3 and table 4, it can be known the results of the research hypothesis.

Table 6. The results of hypotheses test

	Hypotheses	Results
H_1	Innovation has a positive and significant impact on customer satisfaction	**Rejected**
H_2	Innovation has (directly) significant impact on customer loyalty	**Rejected**
H_3	There is significant influence of customer satisfaction on customer loyalty.	**Accepted**
H_4	There is (directly) significant influence of employee performance on customer satisfaction.	**Accepted**
H_5	Employee performance has a significant (directly) impact on customer loyalty	**Rejected**

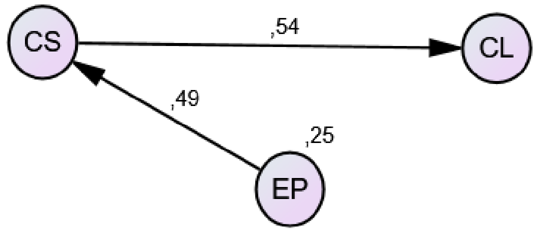

Figure 2. final model of the relationship between the variables

4. CONCLUSION

Here are some things that are inferred from this study:

- Employee performance and service innovation have a positive impact on customer satisfaction, in case at PLN UP3 Pamekasan customer's of business and industrial within 6600 VA to 197 Kva. However, only employee performance had a significant impact, based on critical ratio value 2,105 (C.R ≥ 1,988) and a probability value 0,035 (p < 0,05).
- Customer satisfaction has a significant impact on customer loyalty, based on critical ratio value 4,54 (C.R > 1,988) and probability value 0,000 (p < 0,05). The results of this study reinforce previous research on the theory of satisfaction-loyalty.

The results of this study should be implications on managerial policy. It should be used as one of the references by the company management in determining the priorities that should take precendence. From table 4 and figure 2, it can be inferred that employee performance has a positive and significant impact on customer satisfaction, in case of business and industrial within 6600 VA to 197 kVA. Therefore the management of PLN UP3 Pamekasan needs to strengthen human resources in the downstream unit by following actions :

- Conducting a review of labour formation in downstream units that is in line with the realization of customer additions and the higher of customer expectations for electricity services.
- Provide the employee skills certification for downstream units to improve the competence and understanding of the employees about the company's business process.

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6. REFFERENCE

Suchánek, Petr and Maria Králová. 2015. "Effect of Customer Satisfaction on Company Performance." *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis* 63(3):1013–21.

Williams, Paul and Earl Naumann. 2011. "Customer Satisfaction and Business Performance: A Firm-Level Analysis." *Journal of Services Marketing* 25(1):20–32.

Oghuma, Apollos Patricks, Christian Fernando Libaque-Saenz, Siew Fan Wong, and Younghoon Chang. 2016. "An Expectation-Confirmation Model of Continuance Intention to Use Mobile Instant Messaging." *Telematics and Informatics* 33(1):34–47.

Nanda, Neena, Shelja Jose Kuruvilla, and B.V.R.Murty. 2013. "Role of Service Innovation in Customer Satisfaction and Customer Loyalty : A Study on Organized Retail in India." *International Journal of Business Insights & Transformation* 6(2):53–63.

Jiang, James J. and Gary Klein. 2009. "Expectation-Confirmation Theory: Capitalizing on Descriptive Power." *Handbook of Research on Contemporary Theoretical Models in Information Systems* 384–401.

Fu, Xue mei, Jiang hua Zhang, and Felix T. S. Chan. 2018. "Determinants of Loyalty to Public Transit: A Model Integrating Satisfaction-Loyalty Theory and Expectation-Confirmation Theory." *Transportation Research Part A: Policy and Practice* 113(May):476–90.

Sugiyono, 2007.*Statistik Penelitian*. Bandung: ALFABETA Bandung.

Brown, Susan A., Viswanath Venkatesh, Jason Kuruzovich, and Anne P. Massey. 2008. "Expectation Confirmation: An Examination of Three Competing Models." *Organizational Behavior and Human Decision Processes* 105(1):52–66.

ANALYSIS OF FACTORS AFFECTING CONSUMERS IN USING THE MARKETPLACE SERVICES IN INDONESIA FOR SERVICE IMPROVEMENT RECOMMENDATIONS

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ABSTRACT

The massive growth of internet users has created a new pattern in Indonesian society or is commonly known as online shopping. Online commerce is called electronic commerce (e-commerce) which continues to grow, projected to continue to grow up to five times by 2022. One example of the use of e-commerce is the marketplace. Since the implementation of "Pembatasan Sosial Berskala Besar" (PSBB) as a result of the Covid-19 outbreak, transactions in the marketplace have increased. Seeing the increasingly competitive marketplace service competition, especially during the pandemic, the background for this research is to be able to find factors that influence consumers in using marketplace services in Indonesia.

In this study, the unified theory of acceptance and use of technology 2 (UTAUT2) is used as a research model with the addition of trust variables and structural equation modeling (SEM) as a method for analysis. This study used a survey method to collect data by distributing online questionnaires based on the variables and indicators of UTAUT2 with the addition of the trust variable. There are 31 question item questions, with a scale of 1-5, and the survey results obtained 179 respondents. The processing is done using SPSS and AMOS software. The results of this data processing show that in this study the effort expectancy, habit, facilitating conditions, and trust variables also affect the interest and use of marketplace services.

Keywords: Marketplace, UTAUT2, Trust, SEM

1. INTRODUCTION

Based on data recorded over the last 20 years, the growth of internet users in Indonesia has grown by 8,560% compared to 2000, wherein Q4 of that year internet users are estimated to be 2,000,000 users (Group, 2019)The invention of the internet with its growing users creates a new pattern in society when shopping, namely by shopping online. Bank Indonesia recorded that in 2019 the number of transactions in online trade-in Indonesia each month reached 13 trillion rupiahs (Hendartyo, 2020). In 2018, consulting firm McKinsey & Company published a research article entitled "The digital archipelago: How online commerce is driving Indonesia's economic development". In the report, McKinsey & Company said that the e-commerce market in Indonesia is projected to grow about eight times from 2017 to 2022. One example of the use of e-commerce is the electronic commerce marketplace or perhaps more commonly known as the marketplace in Indonesia. The marketplace is one of the branches of e-commerce where this system involves at least three stakeholders, namely sellers, buyers as parties who carry out buying and selling activities also operators of the marketplace who act as a third party that brings together the seller and the buyer (Maier & Wieringa, 2020).

The Covid-19 pandemic has become a new momentum in helping accelerate people's transaction patterns to shop online. Various ways have been done by marketplace service providers to keep users shopping during especially during this pandemic, such as providing fresh categories, providing discounts and promos, as well as various other ways so that people become interested and use the marketplace services to shop. Seeing the competition for marketplace services in Indonesia which is getting hotter day by day coupled with the momentum of the pandemic which is increasingly increasing the consumption pattern of people in online shopping, the background of this research is to be able to look for factors that influence consumers in using marketplace services in Indonesia. The results of this study can provide theoretical and practical contributions to understanding user behavior, especially during a pandemic, so that marketplace service providers can continue to improve their services.

The impact of the high volume of transactions that occur on online purchasing services is accompanied by an increase in the potential for problems that occur. It is evident from the report issued by the National Consumer Protection Agency that during 2020 there were 295 complaints such as refund problems, pishing problems, purchase of problematic items, cashback that was not obtained, voucher problems, and warranty problems that could not be fulfilled. Therefore, to overcome and resolve these problems, marketplace service providers must continue to improve services and pay attention to aspects of trust so that consumers believe that the marketplace can fulfill their responsibilities and solve existing problems. Trust can be defined as the belief of an individual that a party will fulfill its responsibilities in achieving a goal.

Technology acceptance can be used to find out how much acceptance of a system is for its users (Nurfitriyani, 2020). In research to determine technology acceptance from mobile internet users is carried out using several models of technology acceptance, UTAUT2 provides an advantage in explaining technology acceptance by at least 26% better than other technology acceptance models such as TAM, TRA, or UTAUT (Rondan-Cataluña et al., 2015). Besides, UTAUT2 is a refinement of UTAUT which is more aimed at organizations, in UTAUT2 this model is made to be more inclined towards consumers or users of a technology (Venkatesh et al., 2012). So that from these advantages UTAUT2 was chosen as a model in this study.

2. METHOD

2.1 Marketplace

The marketplace is a medium for virtual transactions. If the conventional market requires a physical place for sellers and buyers to meet, it is different from a marketplace that makes virtual media a place for transactions to occur (Pratolo, 2020). Another definition of a marketplace is an information system that allows several sellers, buyers, and other stakeholders to communicate and transact dynamically in a place supported by additional services (Stockdale & Standing, 2004). In the marketplace, it involves at least three stakeholders, namely sellers and buyers as parties conducting exchanges and operators of the marketplace as third parties that facilitate the exchange (Maier & Wieringa, 2020).

2. 2 Unified Theory of Acceptance and Use of Technology 2 (UTAUT2)

Over the years the development of models of technology acceptance has developed rapidly. According to its function, technology acceptance was created to find out how much user acceptance of a system (Nurfitriyani, 2020). Until now, many models have been created as models in technology acceptance, one of which is the Unified Theory of Acceptance and Use of Technology (UTAUT). Four main variables significantly play a role as determinants of user acceptance and usage behavior, namely Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions (Venkatesh et al., 2003).UTAUT is more aimed at technology acceptance in the context of use in organizations so that in 2012 UTAUT2 emerged as a model in the context of use in consumers. Three additional variables make up UTAUT2, namely Hedonic Motivation, Price Value, and Habit.

2.3 Trust

Trust can be defined as an individual's belief that other parties will fulfill their responsibilities in achieving their goals (Widodo et al., 2019), in this study the individual in question is a user of marketplace services. From this definition, there is a risk when giving trust to other parties. Some risks can be obtained in using the marketplace, such as making transactions with unknown parties and service users who are unable to identify products directly (Aristyana Dewi et al., 2017). Research that looks for factors that influence the adoption of digital wallets in Indonesia shows that trust is one of the factors that influence behavioral intention to use digital wallets in Indonesia (Widodo et al., 2019), In other studies, trust is also one of the main factors affecting the use of mobile banking in Ghana (Owusu Kwateng et al., 2019).

2.4 Structural Equation Modeling (SEM)

In analyzing and processing data, there are several techniques that researchers can do, one of which is to use Structural Equation Modeling (SEM) or which is also known as structural equation modeling. SEM technique, which is a multivariate analysis technique, can be used to analyze complex relationships between variables. The main requirement in using SEM techniques is to build a hypothetical model consisting of a structural model and a measurement model in the form of a path diagram. In use, SEM can be used to test a series of relationships at the same time.

SEM is a combination of two concepts in statistics, namely the concept of factor analysis which is included in the measurement model and the regression concept using a structural model. The difference between these two models is that the measurement model explains the relationship between variables and their indicators, while the structural model explains the relationship between variables (Irwan & Idris, 2014).

2.5 Initial Identification and Methodology Determination Stage

Through this stage, the initial identification of the research will be carried out including the identification of problems as outlined in the research background in Chapter 1. At this stage, the methodology will also be determined obtained from literature studies and also from previous research. The choice of UTAUT2 as a model in this study was due to its 26% ability to explain technology acceptance compared to other models such as TAM, TRA, and also UTAUT (Rondan- Cataluña et al., 2015). Besides, UTAUT2 is made with attention to the consumer context, while UTAUT is more aimed at the organizational context (Venkatesh et al., 2012).

The addition of the trust variable cannot be separated from the role of previous research. Trust can be defined as an individual's belief that other parties will fulfill their responsibilities in achieving goals. Research on the factors that influence digital wallet adoption in Indonesia finds that trust is one of the factors that influence behavioral intention (Widodo et al., 2019). Trust is also one of the main factors affecting the use of mobile banking in Ghana (Owusu Kwateng et al., 2019).

Structural Equation Modeling (SEM) is a technique for analyzing and processing data. SEM technique, which is a multivariate analysis technique, can be used to analyze complex relationships between variables (Irwan & Idris, 2014). In conducting SEM analysis, there are many software that can be used to analyze, one of which is AMOS. AMOS software is gaining popularity because of its user-friendly advantages, making it easy to operate even among beginners (Diniaty & Alpian, 2020).

2. 6 Data Collection and Processing Stage

After making the initial identification and also determining the methodology to be used, the data collection and processing stages will be carried out using SPSS and AMOS software.

2.7 Data Analysis Stages

At this stage, an analysis will be carried out of the results of the data processing that has been carried out in the previous process. The value generated in the data processing process will be related to the theory in the literature study on technology acceptance using the UTAUT2 model with the addition of the trust variable. The results of the analysis will be translated into a descriptive analysis to facilitate the reading of the results. Through this analysis, the two trust variables will also explain whether they affect the user interest in using marketplace services. The results of this analysis will be used as a basis for concluding and also suggestions for research at the next stage.

2.8 Conclusion and Suggestion Stage

After data analysis is carried out, the next stage is the stage of providing conclusions and research suggestions, with the following details:

- Conclusion
  At the conclusion stage, the results are given containing the process of whether the variables in the UTAUT2 model with additional trust affect users in using marketplace services.
- Suggestion
  At the suggestion stage after drawing conclusions, suggestions, input, and recommendations regarding developments that can be carried out are given. These suggestions can be used as a reference for future research and the marketplace service provider industry.

3. RESULTS AND DISCUSSION

3.1 Initial Stage of Analysis

Data collection is done by distributing questionnaires that have been designed in the previous chapter through the WhatsApp application and also Instagram. The questionnaire is distributed using google form. Respondent data will be processed in MS Excel and continued with processing from the assumption test in the SPSS application. Testing of the Structural Equation Model (SEM) was carried out using the AMOS 26 application.

Furthermore, a descriptive analysis was conducted which was divided into two parts, namely a descriptive demographic analysis and a descriptive statistical analysis. The demographic analysis of 179 existing respondent data was carried out to know the composition of characteristics of all respondents based on gender, age, current employment status, latest education, and marketplaces that have been used. Furthermore, statistical analysis was carried out to determine which indicators of each variable were the most chosen.

The process is continued by processing the data in the software as an assumption test analysis with the help of SPSS software. Four tests were carried out on the assumption test process, namely testing the validity, reliability, normality, and correlation between variables. After that, the data processing stage will be continued using AMOS 26 software.

3.2 Analysis of Structural Equation Model (SEM)

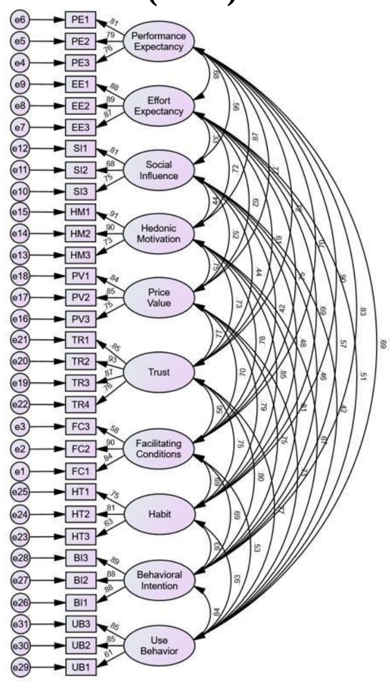

Figure 1. Measurement model

At this stage, a measurement model is made by connecting the indicators to the research variables, then the variables will be connected with the covariance as shown in Figure 1. In this study, there are 10 variables with each variable having 3 indicators and 4 indicators. on the variable trust. Measurement model testing is done with the help of AMOS software.

Table 1. Goodness of fit results from measurement models

No	Goodness of Fit Measures	Cut off value	Score	Information
Absolute Fit Indices				
1	CMIN/DF	≤ 3.00	2.713	Acceptable Fit
2	GFI	≥ 0.8	0.723	Marginal Fit
3	RMR	≤ 0.08	0.059	Good Fit
4	RMSEA	≤ 0.08	0.098	Marginal Fit
Incremental of Indices				
5	AGFI	≥ 0.8	0.647	Poor Fit
6	NFI	≥ 0.8	0.795	Marginal Fit
7	TLI	≥ 0.8	0.83	Good Fit
8	CFI	≥ 0.8	0.858	Good Fit
Parsimony Fit Indices				
9	PNFI	0.6 - 0.9	0.655	Good Fit
10	PGFI	0.5 - 1.0	0.567	Good Fit

- **Absolute Fit Indices**
  There are four measuring instruments used in absolute fit indices, namely CMIN / DF, GFI, RMR, and RMSEA. The first measuring instrument is the minimum sample discrepancy function (CMIN) divided by the degree of freedom (DF) or what can be seen as CMIN / DF shows a value of 2.713 where this value is less than 3.00 and is included in the acceptable fit category (Ferdinand, 2002). GFI shows the number 0.723, which means the value is close to 0.8 so that this value falls into the marginal fit criteria. RMR shows the number 0.059 which means it is still below the value of the RMR measurement so that it is included in the good fit category. The last measurement is to look at the RMSEA where the number is 0.098 with an expected value of less than 0.08 so that this measurement can be said if it is categorized as marginal fit.
- **Incremental of Indices**
  Measurement of incremental indices does not use the value of the chi-square as its raw form but it compares the chi-square value and the model. The first measurement is from the AGFI value which is close to the value of 0.8 which is equal to 0.647 so that it is included in the marginal fit criteria. NFI has a value of 0.795 which means it is also included in the marginal fit category. TLI has a value of 0.83 which means it has exceeded
  0.8 so that it is included in the good fit criteria. Finally, CFI has a value of 0.858, which means that the value is included in the good fit category because it is more than 0.8.
- **Parsimony Fit Indices**
  Furthermore, there is parsimony of fit indices which has two measurements, namely PNFI and PGFI. The first measurement was found to be 0.655, which means that it is included in the good fit criteria because the value is 0.6 - 0.9. Furthermore, PGFI measurement obtained a value of 0.567 which means that it is included in the good fit criteria because the value is in the range 0.5 - 1.

Table 2. CR & AVE calculation results

Variable	CR ≥ 0.7	AVE ≥ 0.5
PE	0.828	0.615
EE	0.910	0.771
SI	0.790	0.558
FC	0.824	0.616
HM	0.885	0.721
PV	0.855	0.664
HT	0.777	0.540
TR	0.916	0.733
BI	0.913	0.777
UB	0.819	0.607

Based on table 2 it can be seen that all values on CR have exceeded 0.7 and on AVE have exceeded 0.5. This can be interpreted if all variables already have a good level of consistency because the value on CR is sufficient and meets the requirements.

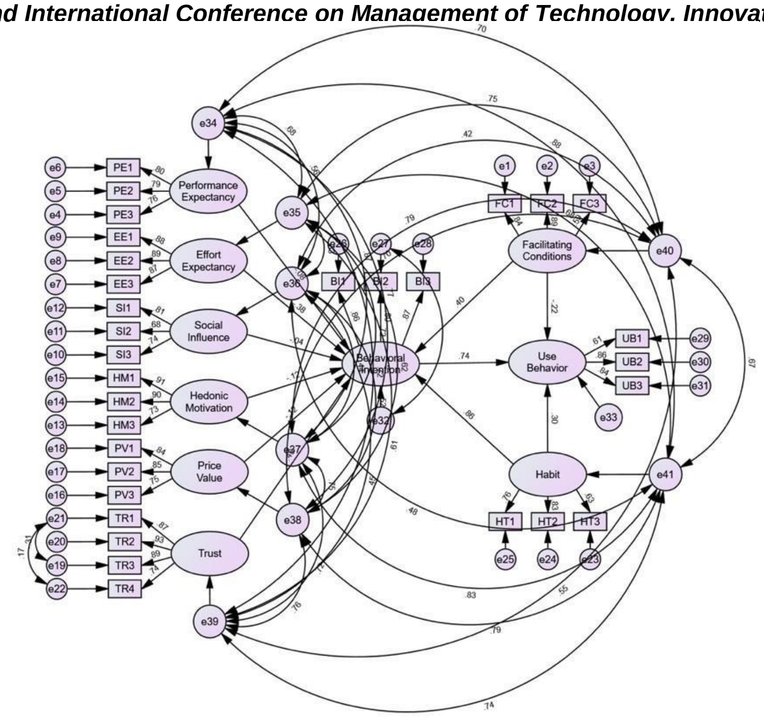

Figure 2. Structural model

The next step after the measurement model is carried out is to carry out structural modeling, structural modeling which is made according to what has been designed in the previous chapter. There are 10 variables, namely performance expectancy, effort expectancy, social influence, hedonic motivation, price value, habit, trust, perceived risk, behavioral intention, and use behavior. These variables will be connected according to the model that has been designed so that they appear like a structural model as shown in Figure 2.

Each variable will have 3 indicators and the trust variable will have 4 indicators. Then each variable and indicator will have its respective error. Furthermore, the results of the structural model will be tested by comparing them with the existing criteria for goodness of fit.

Table 3. Goodness of fit results from structural model

No	Goodness of Fit Measures	Cut off value	Score	Information
Absolute Fit Indices				
1	CMIN/DF	≤ 3.00	2.686	Acceptable Fit
2	GFI	≥ 0.8	0.722	Marginal Fit
3	RMR	≤ 0.08	0.061	Good Fit
4	RMSEA	≤ 0.08	0.097	Marginal Fit
Incremental of Indices				
5	AGFI	≥ 0.8	0.649	Poor Fit
6	NFI	≥ 0.8	0.795	Marginal Fit
7	TLI	≥ 0.8	0.832	Good Fit
8	CFI	≥ 0.8	0.859	Good Fit
Parsimony Fit Indices				
9	PNFI	0.6 - 0.9	0.67	Good Fit
10	PGFI	0.5 - 1.0	0.571	Good Fit

- **Absolute Fit Indices**

There are four measuring instruments used in absolute fit indices, namely CMIN / DF, GFI, RMR, and RMSEA. The first measuring instrument is the minimum sample discrepancy function (CMIN) divided by the degree of freedom (DF) or what can be seen as CMIN / DF shows a value of 2,686 where this value is less than 3.00 and is included in the acceptable fit category (Ferdinand, 2002). GFI shows the number 0.722, which means the value is close to 0.8 so that the value falls into the marginal fit criteria. RMR shows the number 0.061 which means it is still below the value of the RMR measurement so that it is included in the good fit category. The last measurement is to look at the RMSEA where the number is 0.097 with an expected value of less than 0.08 so that this measurement can be said if it is categorized as marginal fit.

- **Incremental of Indices**
  Measurement of incremental indices does not use the value of the chi-square as its raw form but it compares the chi-square value and the model. The first measurement is from the AGFI value, which is still below 0.8, which is 0.649, so it is included in the poor fit criteria. NFI has a value of 0.795 which means it is also included in the marginal fit category. TLI has a value of 0.832 which means it has exceeded 0.8 so that it is included in the good fit criteria. Finally, CFI has a value of 0.859, which means that the value is included in the good fit category because it is more than 0.8.
- **Parsimony Fit Indices**
  Furthermore, there is parsimony of fit indices which has two measurements, namely PNFI and PGFI. The first measurement was found to be 0.67, which means that it is included in the good fit criteria because the value is 0.6 - 0.9. Furthermore, PGFI measurement obtained a value of 0.571 which means it is included in the good fit criteria because the value is in the range 0.5 - 1.

Table 4. CR & AVE calculation results

Variable	**CR $\geq$ 0.7**	**AVE $\geq$ 0.5**
PE	0.828	0.616
EE	0.910	0.771
SI	0.790	0.558
FC	0.824	0.616
HM	0.885	0.721
EE	0.910	0.772
HT	0.777	0.540
TR	0.916	0.733
BI	0.913	0.777
UB	0.819	0.607

This test is done by measuring construct reliability (CR) to measure the consistency of the indicators contained in the variables. Besides, a measurement of the average extracted variant (AVE) is carried out to measure the convergence (merger/integration) level of the indicator. The details of the test can be seen in table **4.** In table 4, it is found that all variables meet the measurement of CR, which exceeds 0.7 and all variables also meet AVE, which is more than 0.5. It can be concluded that all variables and indicators have a good consistency and a good convergence rate.

3. 3 Hypothesis test

Hypothesis testing is carried out to determine whether the independent variable affects the dependent, hypothesis testing is also aimed at measuring whether or not this effect is significant. Testing is done by looking at the CR and P values, with the criteria that CR ≥ 1.96 or CR ≤ -1.96. Besides, to see the significance of the variables that need to be seen is the P-value which is said to be significant if the P-value is ≤ 0.05. The hypothesis of this test is as follows:

H_0: The independent variable is not directly related and does not have a positive effect on the dependent variable

H_1: The independent variable is directly related and has a positive effect on the dependent variable

The results of hypothesis testing are found if seven hypotheses are rejected and four hypotheses are accepted, with details of the hypothesis that can be seen in table 5.

Table 5. Hypothesis test results

H-	Hypothesis Explanation	CR	P	Decision
H1	Performance expectancy is directly related and has a positive influence on behavioral intention	-0.41	0.682	Reject H1 (Not significant)
H2	Effort expectancy is directly related and has a positive influence on behavioral intention	-3.904	***	Accept H2 (Significant)
H3	Social influence is directly related to and has a positive influence on behavioral intention	-0.58	0.562	Reject H3 (Not significant)
H4	Hedonic motivation is directly related and has a positive influence on behavioral intention	-0.722	0.47	Reject H4 (Not significant)
H5	Price value is directly related and has a positive influence on behavioral intention	-0.899	0.368	Reject H5 (Not significant)
H6a	Facilitating conditions is directly related and has a positive influence on behavioral intention	3.121	0.002	Accept H6a (Significant)
H6b	Facilitating conditions are directly related and have a positive effect on use behavior	-2.482	0.013	Accept H6b (Significant)
H7a	Hedonic motivation is directly related and has a positive influence on behavioral intention	3.708	***	Accept H7a (Significant)
H7b	Habit is directly related and has a positive effect on use behavior	1.792	0.073	Reject H7b (Not significant)
H8	Behavioral intention is directly related and has a positive effect on use behavior	4.266	***	Accept H8 (Significant)
H9	Trust is directly related and has a positive influence on behavioral intention	4.936	***	Accept H9 (Significant)

4. Conclusions and Recommendations

4.1 Conclusion

The analysis process begins with distributing questionnaires to data processing which is broadly divided into several stages. The first stage is to conduct descriptive analysis which is divided into two stages, namely descriptive analysis which discusses more deeply the demographics of the respondents, and descriptive statistical analysis which discusses the characteristics of the respondents' answers in general. The next stage is to test the assumptions which consist of testing the validity, reliability, normality, and correlation between variables.

After the assumption testing analysis phase is met, the next process is to perform structural equation model (SEM) data analysis. This stage will discuss the results of the measurement model, structural model, and also modification of the structural model. In this analysis, a measuring tool is used to test whether the model is fit by comparing the test results with the goodness of fit table. The conclusion shows if the model is fit so that research hypothesis testing is carried out as designed in the previous chapter.

In this study, the results of testing and analysis are factors that influence user interest in using marketplace services with the help of the UTAUT2 model and additional trust variables. Conclusion details are as follows:

- Of the several variables used from the UTAUT2 model, four variables influence behavioral intention, namely effort expectancy, facilitating conditions, habit, and trust. Besides, behavioral intention also affects use behavior. All of these variables have a positive influence on the increase in the dependent variable, which means that by increasing the value of the independent variable, the dependent variable will also increase.
- An additional variable, namely trust, is proven to be able to influence the use of marketplace services, especially during this pandemic, when there was a significant increase in reports of problems in the use of marketplace services.

4. 2 Suggestion

The suggestions that can be given after this research are as follows:

- The choice of question indicators in the UTAUT2 model needs to be reviewed to produce even better values, besides that, the good variables must always be developed so that other better indicators can be found.
- The development of other influencing variables can also be added to expand the UTAUT2 model in analyzing the factors that influence marketplace use.
- Marketplace service providers can apply tested variables to their services.
- Based on the test results, three variables affect behavioral intention, so that if the value of these three variables is increased, it will increase the use behavior. One of the ways to increase the value is to pay attention to indicators that are still considered less good in value, with the following details:
    - In the trust variable, if it refers to the lowest average indicator value, marketplace service providers need to increase the level of problem-solving when users experience problems. For example, increasing security in the marketplace service system, so that personal data does not leak to parties other than marketplace service providers.
    - In the habit variable, if it refers to the lowest average indicator value, marketplace service providers need to increase their dependency on marketplace services. For example, always improving the user experience of the marketplace, to improve the experience of the user.
    - In facilitating conditions, if it refers to the lowest average indicator value, marketplace service providers need to pay more attention to the ease of getting assistance. For example, by opening up many avenues to get assistance, such as adding access to facilitate the communication process with customer service.

5. REFERENCES

Aristyana Dewi, M. A., Hidayanto, A. N., Shihab, M. R., & Zhu, Y. Q. (2017). Trust transfer and its effects on the continuance usage of mobile service in B2C E-marketplaces. *Proceedings Ot the 21st Pacific Asia Conference on Information Systems: "'Societal Transformation Through IS/IT'", PACIS 2017*.

Diniaty, D., & Alpian, I. D. (2020). Pengaruh Pengetahuan, Sikap, dan Tindakan Masyarakat Terhadap Keberadaan Rumah Kelola Sampah Menggunakan Metode SEM. *Jurnal Teknik Industri: Jurnal Hasil Penelitian Dan Karya Ilmiah Dalam Bidang Teknik Industri*. https://doi.org/10.24014/jti.v5i1.6120

Ferdinand, A. (2002). Structural Equation Modelling Dalam Penelitian Manajemen: Aplikasi Model-Model rumit dalam penelitian untuk tesis magister dan disertasi doktor. *BP Universitas Diponegoro.*

Group, M. M. (2019). *Top 20 Countries With The Highest Number Of Internet Users*. https://www.internetworldstats.com/top20.htm

Hendartyo, M. (2020). *Bank Indonesia Perkirakan Inflasi Oktober 0,04 Persen*. https://bisnis.tempo.co/read/1396647/bank-indonesia-perkirakan-inflasi-oktober-004-persen

Irwan & Idris, A. (2014). Analisis Structural Equation Modelling dan Terapannya. *Jurnal Teknosains, 8 Nomor 2*, 137–151.

Maier, E., & Wieringa, J. (2020). Acquiring customers through online marketplaces? The effect of marketplace sales on sales in a retailer's own channels. *International Journal of Research in Marketing*. https://doi.org/10.1016/j.ijresmar.2020.09.007

Nurfitriyani, S. J. (2020). *Mengenal UTAUT2 Sebagai Salah Satu Technology Acceptance*. https://sis.binus.ac.id/2020/07/20/mengenal-utaut2-sebagai-salah-satu-technology- acceptance/

Owusu Kwateng, K., Osei Atiemo, K. A., & Appiah, C. (2019). Acceptance and use of mobile banking: an application of UTAUT2. *Journal of Enterprise Information Management*. https://doi.org/10.1108/JEIM-03-2018-0055

Pratolo, S. (2020). Bedukmawa: Marketplace and Fintech Design for Student Entrepreneurship in the Industrial Revolution 4.0 Era. *Journal of Accounting and Investment*. https://doi.org/10.18196/jai.2101141

Rondan-Cataluña, F. J., Arenas-Gaitán, J., & Ramírez-Correa, P. E. (2015). A comparison of the different versions of popular technology acceptance models a non-linear perspective. *Kybernetes*. https://doi.org/10.1108/K-09-2014-0184

Stockdale, R., & Standing, C. (2004). Benefits and barriers of electronic marketplace participation: An SME perspective. In *Journal of Enterprise Information Management*. https://doi.org/10.1108/17410390410548715

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly: Management Information Systems*. https://doi.org/10.2307/30036540

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly: Management Information Systems*. https://doi.org/10.2307/41410412

Widodo, M., Irawan, M. I., & Sukmono, R. A. (2019). Extending UTAUT2 to explore digital wallet adoption in Indonesia. *2019 International Conference on Information and Communications Technology, ICOIACT 2019*. https://doi.org/10.1109/ICOIACT46704.2019.8938415

FACTORS DETERMINING INDONESIAN CONSUMER BEHAVIOR IN PRODUCT PURCHASE INTENTION VIA ONLINE MARKETPLACES DURING THE COVID-19 PERIOD: AN APPROACH OF INFORMATION ACCEPTANCE MODEL

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ABSTRACT

During a pandemic as the present days, daily activities to fulfill the needs, for instance, shopping, can be carried out effortlessly. With the presence of online marketplaces especially in Indonesia, buying and selling activities can still be done and are no longer choices but goals for some people. One of the parties that benefited from online shopping is the Small and Medium-sized Enterprises (SMEs), in which the increase in their turnover can help stabilize the economy in Indonesia. This study further analyzes the determining factors of consumer behavior in Indonesia regarding their intentions to purchase products via online marketplaces. The analysis was performed employing the Information Acceptance Model (IACM) approach, which combined two existing theories, namely the Theory of Reasoned Action (TRA) and the Information Adoption Model (IAM), as well as trust as the additional variable. The data was obtained through a questionnaire distributed to online marketplace users who have purchased from SMEs via best-selling online marketplaces in Indonesia. The 210 obtained data were further processed using Structural Equation Modelling (SEM). This study found three IACM hypotheses, Information Quality with Information Usefulness, Information Credibility with Information Usefulness, and Adoption Information with Purchase Intention which were not proven to have positive effect during the Covid-19 pandemic. The findings of the present study are thus expected to deliver new insight and big pictures that can be beneficial for enterprises, thereby they can survive and thrive especially in difficult times like the present.

Keywords: Purchase Intention, Pandemic, IACM, Online Marketplace

1. INTRODUCTION

Amid the increasing number of the Covid-19 virus spread currently occurring, the world economic situation becomes difficult (Puspasari, 2020). An infectious disease outbreak like this can easily impend the monetary and regional security, as proven by the previous outbreaks of HIV, H1N1, H5N1, as well as epidemic and pandemic SARS (Verikios, Sullivan, Stojanovski, Giesecke, & Woo, 2011). The data of the study is valuable since it was taken in the pandemic era, unlike the usual studies with similar methods in the normal condition. In setting the determining factors in purchase intention, the current study employs the Information Acceptance Model (IACM) approach developed by Erkan and Evans (2016) and adds trust as the additional variable as one of the crucial factors in transacting via e-commerce and online marketplace (Pavlou, 2003).

The present study aims at identifying the determining factors of Indonesian consumers in their intention to purchase products via the online marketplace in the Covid-19 pandemic period.

The Central Bureau of Statistics (BPS) claimed that Indonesia experiences a recession in the third quarter, which is mainly caused by the Covid-19 pandemic. During this pandemic era, the implementation of large-scale social restrictions (PSBB) has an impact on the domestic factor, namely the decline in public consumption that causes bankruptcy for several companies due to deficits, which, in turn, increases the number of unemployed. One of the government's efforts to revive Indonesia's economy is supporting the Small and Medium-sized Enterprises (SMEs) by conducting digital training, that is the marketplace utilization and online marketing. In this pandemic era, Indonesian e-commerce companies record an increase in sales volume due to a shift in market behavior from offline to online. Covid-19 has made the online marketplace a destination, no longer an option, due to its convenience for the consumers to meet their daily needs.

During the pandemic crisis, e-WOM benefits the businessmen and the potential consumers since it offers a win-win solution, in which the businessmen take advantage of the honesty of consumer reviews while the potential consumers are benefited by not buying goods and services with bad ratings and reviews. For such rationale, the present paper employs Indonesia's largest online marketplaces based on the survey conducted by iPrice Group (2020) in the first quarter of 2020.

2. RESEARCH METHOD

Information Acceptance Model (IACM) is a new theory introduced by Erkan and Evans (2016). IACM is the development of two existing theories, namely the Information Adoption Model (IAM) (Sussman & Siegal, 2003) and the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975), which includes e-WOM characteristics from IAM and consumer behavior toward e-WOM information from TRA. IACM extends the adoption of information using consumer behavior and identifies how this process affects the consumers' behavioral intention. This paper also added trust as a variable since, according to Alsajjana and Dennis (2010), trust can influence purchase intention. Consumers who trusted online services would acquire a positive attitude toward the services and tend to repurchase things through them. The following is IACM hypothesis model.

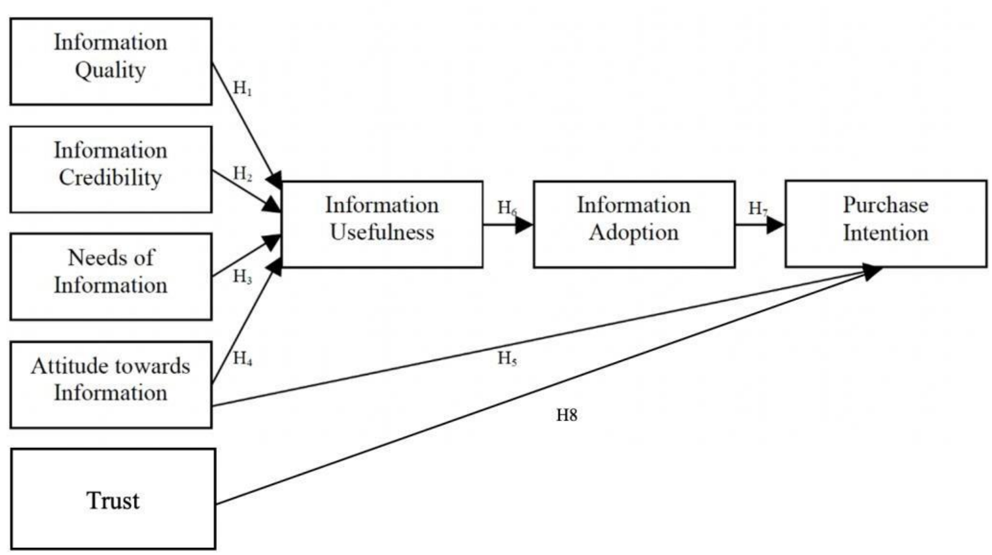

Figure 1. The hypothesis model of the Information Acceptance Model (IACM)

The current paper comprises eight hypotheses as follows:
H1: The quality of e-WOM information has a positive relationship with the usefulness of e-WOM information.
H2: The credibility of e-WOM information has a positive relationship with the usefulness of e-WOM information.
H3: The need for e-WOM information has a positive relationship with the usefulness of e-WOM information.
H4: The attitude toward e-WOM information has a positive relationship with the usefulness of e-WOM information.
H5: The attitude toward e-WOM information has a positive relationship with the purchase intention.
H6: The usefulness of e-WOM information has a positive relationship with the adoption of e-WOM information.
H7: The adoption of e-WOM information has a positive relationship with the purchase intention.
H8: Trust has a positive relationship with the purchase intention.

From these hypotheses, a questionnaire was created by referring to the IACM method, which was then utilized to collect the primary data of the study. The questionnaire was made in Google Form and spread online to reach more and wider respondents. This study employed a 5-point Likert scale since the respondents were considered able to choose, which showed differentiation per point (Awang, Afthanorhan, & Mamat, 2016). The 5-point Likert scale in the questionnaire also simplified the respondents to answer the questions and adjusted each of their needs. The measurement scale of this study only applied to the survey design employing an online questionnaire. The population of the study was the consumers of the Indonesian online marketplace. The minimal sample size required in the online survey questionnaire method based on the rule of thumb in the Structural Equation Model (SEM) analysis was 30 multiplied with 7, which achieved 210 as the total respondents (Ramirez & Cox, 2012). Before calculating the SEM, the classical assumption test and model evaluation were conducted to then be analyzed with the SEM method.

3. FINDINGS AND DISCUSSION

3.1 Demographics

The present study obtained the data from 210 respondents, comprising 127 women and 83 men spread across several major cities in Indonesia. The age range with the most respondents was 18-43 years old (112 respondents), while 37 respondents were under 18 years old and 61 respondents were over 43 years old. 134 respondents had a monthly shopping frequency of more than three times, while the rest 76 shopped less than three times a month. Based on the survey, most of the online marketplace consumers worked as government and state-owned enterprise employees, followed by private employees, entrepreneurs, students, and housewives.

3.2 Data Analysis

In the present study, the data was tested using SPSS AMOS 20 to conduct the validity and reliability tests before continuing to the further step. A construct validity test was conducted to discover whether every single indicator can explicate the current constructs. The indices employed as the variable standard were the ones with a p-value of less than 0.05 and a loading factor of more than 0.5. Meanwhile, the indicators with a p-value of more than 0.05 and a loading factor of less than 0.5 were disposed of the model.

Ghozali (2016) suggested that what must be observed was the standardized loading factor (the estimate) value. If the value was less than 0.50, then the indicator was dropped since it was invalid to measure the latent construct. The standard of both tests can be seen in Table 1 and the findings of reliability and validity tests can be observed in Table 2.

Table 1. The standard of validity and reliability tests

Convergent Validity	Minimal Value
Loading factor	0.5
Average Variance Extracted (AVE)	0.5
Cronbach's alpha	0.6
Construct Reliability (CR)	0.7

The following table presents the findings of the reliability and validity tests.

Table 2. The results of reliability and validity tests

Variables	Loading Factors	Loading Factors^2	Errors	CR	AVE	Cronbach's Alpha
IQ	0.679	0.461	0.539	0.872	0.579	0.909
	0.675	0.456	0.544			
	0.791	0.626	0.374			
	0.797	0.635	0.365			
	0.846	0.716	0.284			
IC	0.857	0.734	0.266	0.827	0.546	0.781
	0.730	0.533	0.467			
	0.663	0.440	0.560			
	0.691	0.477	0.523			
NOI	0.684	0.468	0.532	0.853	0.594	0.806
	0.823	0.677	0.323			
	0.848	0.719	0.281			
	0.716	0.513	0.487			
ATI	0.677	0.458	0.542	0.880	0.598	0.869
	0.685	0.469	0.531			
	0.744	0.554	0.446			
	0.931	0.867	0.133			
	0.801	0.642	0.358			
IU	0.884	0.781	0.219	0.847	0.735	0.684
	0.830	0.689	0.311			
AI	0.888	0.789	0.211	0.843	0.577	0.832
	0.787	0.619	0.381			
	0.697	0.486	0.514			
	0.645	0.416	0.584			
PI	0.921	0.848	0.152	0.880	0.649	0.837
	0.687	0.472	0.528			
	0.787	0.619	0.381			

	0.810	0.656	0.344			
TI	0.775	0.601	0.399	0.808	0.679	0.752
	0.870	0.757	0.243			

The test results indicated that the data collection instrument used in the present study had described each variable, with all items obtained good score in the loading factor, CR, AVE, and Cronbach's alpha. The tested variables were said to meet the convergent validity and variable reduction was not required; thus, they could proceed to the SEM analysis.

Before continuing the hypothesis test, the Goodness of Fit (GOF) test was required to be conducted. The model was said to be fit if it met at least five indicators of a good fit. As seen in Table 3, all category had met the requirement of cut-off values except the chi-square. The overall result of this model was fit even if there was a GOF type that did not meet the cut-off value.

Table 3. The results of the Goodness of Fit test

No.	GOF Types	Cut-off Values	Results	Information
Absolute Fit Indices				
1	Chi-Square	>0.05	0.00	Did not meet the requirement
2	GFI	≥ 0.7	0.77	Met the requirement
3	AGFI	≥ 0.7	0.73	Met the requirement
4	RMR	≤ 0.1	0.05	Met the requirement
5	RMSEA	< 0.1	0.08	Met the requirement
Incremental Fit Indices				
6	NNFI	≥ 0.7	0.74	Met the requirement
7	CFI	≥ 0.7	0.83	Met the requirement
8	IFI	≥ 0.7	0.83	Met the requirement
Parsimony Fit Indices				
9	PNFI	0.60–0.90	0.66	Met the requirement
10	PGFI	0.50–1.00	0.65	Met the requirement

In this hypothesis test, the relationship significance among variables was observed using the p-value. The relationship was significant if the p-value was less than 0.05; otherwise, the relationship was not significant. Meanwhile, β value was employed to discover the positivity of the relationships. If the β value is positive, the relationship between variables was positive, and vice versa.

Table 4. The results of the hypothesis test based on the SEM analysis

Hypotheses	Impacts			β	p-values	Results
H1	Information quality	→	Information usefulness	-0.09	0.293	Not significant
H2	Information credibility	→	Information usefulness	0.051	0.436	Not significant
H3	Needs of information	→	Information usefulness	0.152	0.014	Significant
H4	Attitude towards information	→	Information usefulness	0.902	0.000	Significant
H5	Attitude towards	→	Purchase	0.327	0.000	Significant

	information		intention			
H6	Information usefulness	→	Adoption of e-WOM information	0.636	0.000	Significant
H7	Adoption of e-WOM information	→	Purchase intention	0.165	0.229	Not Significant
H8	Trust	→	Purchase intention	0.420	0.000	Significant

According to the test findings of the SEM examination, the hypothesis H3, H4, H5, H6, and H8 were positively related and had significant values, unlike H1, H2 and H7. The analysis test results demonstrated that information quality affected information usefulness negatively and insignificantly; hence, H1 was rejected. This indicated that the information value gained by the consumers did not affect their purchase intention in the pandemic era. Meanwhile, from H2, information credibility gave a positive impact yet not significant toward information usefulness; therefore, H2 was also rejected. It means that the information received by the consumers was considered not reliable and this did not make the information useful for the purchase intention in the Covid-19 pandemic period. H7 was rejected. This indicated that information adoption has no effect on consumers' purchase intention during the Covid-19 pandemic, thus consumers figured sellers or merchant contribution did not affect their purchase intention.

4. CONCLUSION

Based on the findings and discussion in the previous section, it can be concluded that, out of eight hypotheses, the results employing the SEM method to identify the factors determining purchase intention via online marketplace during the Covid-19 period generate five positively related hypotheses. Meanwhile, the three others are not proved to have significant relation being tested in the Covid-19 period. With such results, it can be deduced that e-WOM certainly affects the product purchase intention in the pandemic era. Consumers no longer regard a product's quality and credibility; they can instead use the internet to exchange information as one of the powerful ways in noticing the current trend. Besides quality and credibility, affordable price with good merchant services, in which the consumers can ask and order something anytime with excellent response, is also what they concern. The urgent situations and conditions also allow the SMEs to jump on the bandwagon by selling the high-demand goods. In this condition, SMEs can rise by following the trend, improve their service quality in the merchants, and even create their own trends to be followed by other businesses in the future.

5. REFERENCES

Alsajjana, B., & Dennis, C. (2010). Internet banking acceptance model: Cross-market examination. *Journal of Business Research* 63 (9–10), 957 – 963.

Awang, Z., Afthanorhan, A., & Mamat, M. (2016). The Likert scale analysis using parametric based structural equation modeling (SEM). *Computational Methods in Social Sciences* 4 (1), 13 – 21.

Erkan, I., & Evans, C. (2016). The influence of eWOM in social media on consumers' purchase intentions: An extended approach to information adoption. *Computers in Human Behavior* 61, 47 – 55.

Fishbein, M. A., & Ajzen, I. (1975). *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*, Addison-Wesley, Massachusetts.

Ghozali, I. (2016). *Aplikasi Analisis Multivariete Dengan Program IBM SPSS 23*, 8th Edition, Badan Penerbit Universitas Diponegoro, Semarang.

iPrice Group. (2020). Peta e- commerce Indonesia. *iPrice Insights*, https://iprice.co.id/insights/mapofecommerce/

Pavlou, P. A. (2003). Consumer acceptance of electronic commerce: Integrating trust and risk with the technology acceptance model. *International Journal of Electronic Commerce* 7 (3), 101 – 134.

Puspasari, R. (2020). Pemerintah waspada dampak pandemi Covid-19 terhadap ekonomi Indonesia. Kementerian Keuangan Republik Indonesia. *The Ministry of Finance Republic of Indonesia*, https://www.kemenkeu.go.id/publikasi/siaran-pers/siaran-pers-pemerintah-waspada-dampak-pandemi-covid-19-terhadap-ekonomi-indonesia/

Ramirez, A., & Cox, C. (2012). Improving on the range rule of thumb. *Rose-Hulman Undergraduate Mathematics Journal* 13 (2), 1 – 13.

Sussman, S. W., & Siegal, W. S. (2003). Informational influence in organizations: An integrated approach to knowledge adoption. *Information Systems Research* 14 (1), 47 – 65.

Verikios, G., Sullivan, M., Stojanovski, P., Giesecke, J., & Woo, G. (2011). The global economic effects of pandemic influenza. *Proceedings of The 14th Annual Conference on Global Economic Analysis*, Venice, Italy, 1–41.

DEVELOPMENT OF OMNICHANNEL SYSTEM FOR COMPLAINT MANAGEMENT IN PUBLIC SERVICE: A CASE STUDY AT SURABAYA CITY COUNCIL OF POPULATION AND CIVIL REGISTRATION

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ABSTRACT

In developing countries like Indonesia, it is a fact that most of public services still need service quality improvement. Even though not many government institutions are keen to improve their service quality, Surabaya City Council of Population and Civil Registration (Dinas Kependudukan dan Pencatatan Sipil/Dispendukcapil of Surabaya City) as part of Surabaya City Governments take different set in their endeavours to improve its service quality. Driven by the awareness that this era requires better, more transparent, and more accountable services, Dispendukcapil is trying to provide omnichannel system to facilitate community to ask queries regarding completion time, requirement of particular services, even to express feedback and complaints. Dispendukcapil realizes that complaints or queries mishandling would potentially go to media, damage the reputation, and create mistrust.

In the current pandemic era, when face-to-face service counters are reduced and online services are boosted, community needs a channel for asking questions or making complaints that previously could be raised in person at the service counter. Dipendukcapil understands that the reduction of service at counters and the use of internet in submitting request are not easy to be adapted by all elements in the community. Therefore, the dis-satisfaction and complaints that are potentially increased in this situation need to be handled properly.

This paper describes the initiative in implementing omnichannel system in Dispendukcapil Surabaya, its Key Performance Indicators (KPIs), and the monitoring mechanism. The implementation of the initiative evidently increases the response time from 7 x 24 hours to 38.16 hours (1.59 days) for call centre channel and 123.54 hours (5.15 days) for service desk website.

Keywords: public services, call centre, omnichannel, customer relationship management, complaint management.

1. INTRODUCTION

In public service, customer satisfaction is one of the vital things. One strategy that an organization must implement if it wants to minimize customer loss after receiving a complaint is to provide feedback to the customer either by telephone, written text, and other media which shows that the organization will resolve the problem and its handling procedures (Lovelock & Wirtz, 2004).

As a non-profit organization that provides services, *Dispendukcapil* cannot underestimate customer complaints, namely citizens who need population administration services. Indeed, residents cannot switch to other institutions to obtain services for obtaining e-KTP, Family Cards, Birth Certificates, Death Certificates, and others which are considered better because those who have the mandatory of the Law are only the Municipal/Regency *Dispendukcapil* where the resident resides and is registered. However, service dissatisfaction that is not properly handled can lead to citizen tweeting in media which can lead to a decline in public trust in the *Dispendukcapil* and government in general. What needs to be considered is the high potential for dissatisfaction in public services as such (Best & Andreasen, 1977) mentioned that customers experience more dissatisfaction with services than the goods offered by a company.

Tragically, many companies neglect the handling of complaints that come to them. The results of research on the voices of readers in *Kompas* daily at a certain time, of the total 168 written complaints, less than 2% of organizations responded to these complaints and only 6% of the problems were declared resolved (Refiana, 2012).

The biggest reason customers experience dissatisfaction with service is due to careless and unprofessional human resources (Day & Bodur, 1978). Also, an organization optimizes the performance of its human resources, especially those who handle complaints from the public to be more polite in dealing with customers and apologize if there are procedural errors occur (Lovelock & Wirtz, 2004).

The easiest way to handle complaints from the public is to use a toll-free complaint phone number (Bateson & Hoffman, 1999). However, with the increasing expectations of citizens regarding the quality of complaint handling, it is not sufficient if the organization only relies on one channel to accommodate customer complaints. Times have changed and today it is different, for example, consumer behavior enjoys dozens of possible brand communication routes and 73% of them choose to connect and shop at more than one (Manners, 2019). Based on these findings, the omnichannel communication option is the best alternative as the basic operation of an organization's complaint service.

The omnichannel principle is to integrate all communication channels between the company and its customers so that there is an equal sharing of data in each channel (W. Yanuardi et al., 2016). The follow-up at the end of the complaint process will be delivered by the complaint service crew to the applicant through the same channel when complaining (W. Yanuardi et al., 2016). Delivering that in the multichannel era, if the communication channels of customers are not integrated, customers who call from one channel cannot forward them through another channel. The customer must start his journey again by repeating the information he has given on another channel. This certainly reduces the quality of the customer experience. Some steps are trying to be completed with a cross-channel communication mechanism, where customers can access various channels owned by the company because it allows customers to switch from one channel to another during the customer journey, but between channels, the data is not integrated. Usually, this shift is done because the characteristics of the channel are more suitable for the next action the customer needs, for example by printing communication and checking QR codes to meet customer preferences. Furthermore, by scanning the QR code, customers can continue their digital journey if they wish (Xribe, 2019).

In contrast to the two, according to (W. Yanuardi et al., 2016), with omnichannel communication, the customer can interact with the company through any communication channel he wants, without having to repeat information when he switches channels. This is one of the strategies in creating a seamless, flawless customer experience.

For government organizations, guidance has been given in the form of statutory regulations, namely Presidential Decree 76 of 2013 concerning the management of public service complaints, the contents of which have regulated, among others, the right of the applicant to submit complaints on public services, provision of complaint facilities for vulnerable groups or with special needs, data protection, and performance appraisal of the public service complaint unit.

So, it is time for public service complaints to be better managed. The follow-up impact of the high quality of service complaints is an increase in community satisfaction as customers.

The final objective in handling public complaints is to research the quality of complaint handling, so that feedback from customers regarding complaint handling becomes mandatory so that organizations can find out customer satisfaction (Filip, 2013).

2. METHODOLOGY

When compared with similar services owned by other government agencies, the complaint service system at *Dispendukcapil* is far superior. Almost all media center services in other government agencies are one-way only except for 112 emergency calls, but the Surabaya *Dispendukcapil* develops two-way services. Incoming complaints will be responded to directly and explained that the complaints will be immediately followed up by the *Dispendukcapil*.

Table 1. Incoming Complaints

Party	Address	Media	Communication Direction
Pemerintah Kota Surabaya	112	Call	2 way
Kementrian Kesehatan RI	1500567	Call	1 way
Dirjen Dukcapil Kemendagri RI	1500537	Call	1 way
Kementrian Tenaga Kerja dan Transmigrasi RI	08001503001	Call	1 way
KEMENPAN RB	https://www.lapor.go.id/	Written Complaints Site	1 way
Disdukcapil Kota Surabaya	031-99254200	Call	2 way
	Instgram @dispendukcapil.sby, twitter @DispendukcapilS	Social Media	
	Whatsapp 081931519587		
	Service Desk https://servicedesk.disdukcapilsurabaya.id/login/index.php	Written Complaints Site	
	Counselor	Face to face service at *Dispendukcapil* Office	
	dis_dukcapil@surabaya.go.id	E-mail	

The call center when it was first developed in March 2020 was not yet what it is today. Only a few telephone lines are available. Over time, this service has received a lot of input from various parties and is increasingly refined so that all stakeholders are comfortable using it.

Table 2. Milestone of Call Center Service Changes

Timeline	Events
March 2020	Launching call center via telephone channels
April 2020	*Disdukcapil* social media has begun to actively act as a call center for millennials
October 2020	The launching of a face-to-face call center is limited to applicants who need direct guidance
	Launching whatsapp group as a call center with Dispendukcapil partners that includes wards and district services for technical complaint means adminduk
November 2020	Launching an application service desk and a team of quality control to ensure smooth handling of the public complaints process

One of the strengths of the complaint service developed by the *Dispendukcapil* is the pioneering pattern of integration between many channels in one system called omnichannel communication. The applicant can complain about the problems they face through one of the communication channels provided. Regarding the incoming complaint, the data internally moves to the line of service for its execution without being noticed by the applicant. The applicant can also complain about his problem by coming to the *Dispendukcapil* office, but the final follow-up is in the form of a WhatsApp notification from the complaint system to the applicant's number. This kind of mechanism can be done because the data that enters each type of communication channel is connected in an integrated service system. This omnichannel mechanism makes it easy for the applicant to get updated information on what was reported in this integrated complaint service. The call center when it was first developed in March 2020 was not yet what it is today. Only a few telephone lines are available. Over time, this service has received a lot of input from various parties and is increasingly refined so that all stakeholders are comfortable using it.

The difference in the concept of communication between multichannel and cross-channel with omnichannel communication can be explained as shown below.

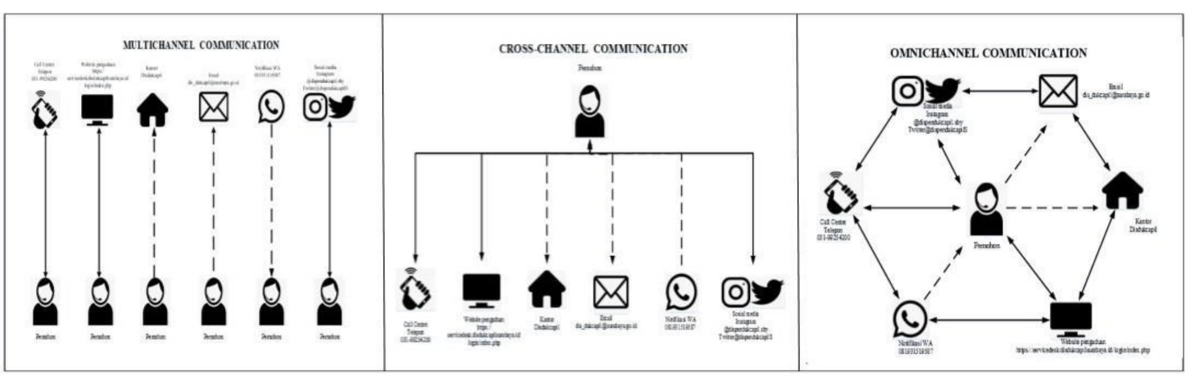

Figure 1. Business Flow System Complaints

3. RESULTS AND DISCUSSION

3.1 Statistics Service Complaints in *Dispendukcapil* Surabaya

The number of incoming complaints on average per day from the time of the pandemic (April 2020) to the beginning of 2021 is around 525 people. The complaint service, which initially took the form of a call center by telephone (1 channel), has become a mainstay channel for city residents to submit complaints because they find it difficult to access population administration services which have changed fully online since the pandemic era. However, after time has passed, it is suspected that residents have started to get used to accessing the online public administration service and the number of complaints that have been submitted shows a trend of gradually decreasing.

In the end, other communication channels such as social media, websites, e-mails and paper bases, and complaint mechanisms by coming to the office were also developed. However, on average, the most data on complaints that come in is from telephone lines. Randomly taken data at the end of 2020 and early 2021 shows that about 59% of complaints from incoming calls can be answered and answered.

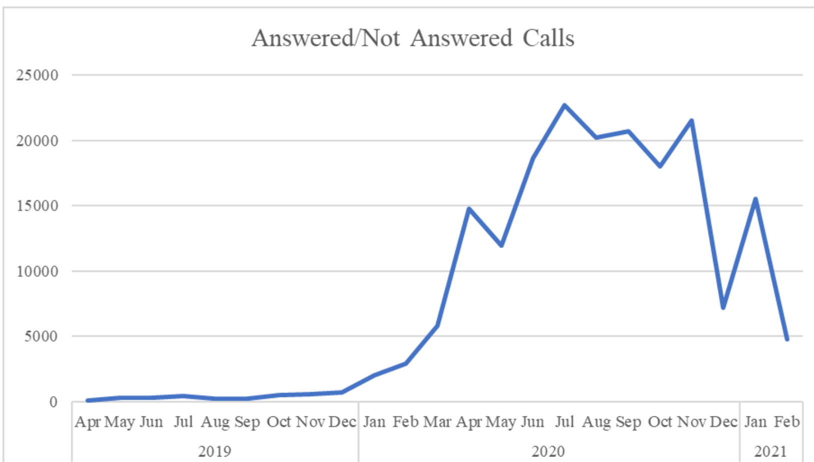

Figure 2. Number of Incoming Calls

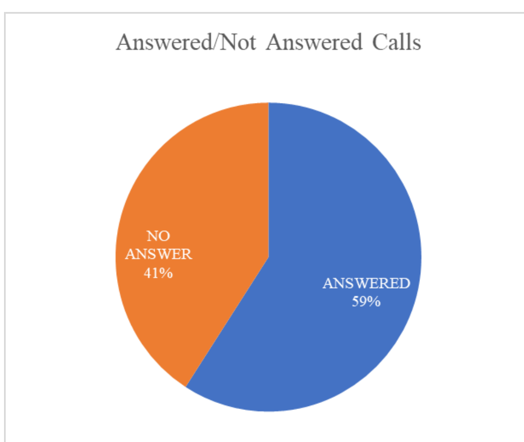

Figure 3. Proportion of Answered and Not Answered Calls

The second-largest number of complaints were received through the web site (including incoming mail in the form of paper-based or people coming to the *Dispendukcapil* office to complain about services), which were approximately 67 per day. Complaints that come through social media are not as many as complaints that come in by telephone and web site / come to the office, namely Average Daily Request (Instagram) = 41 per Day and Average Daily Request (Twitter) = 11 per Day.

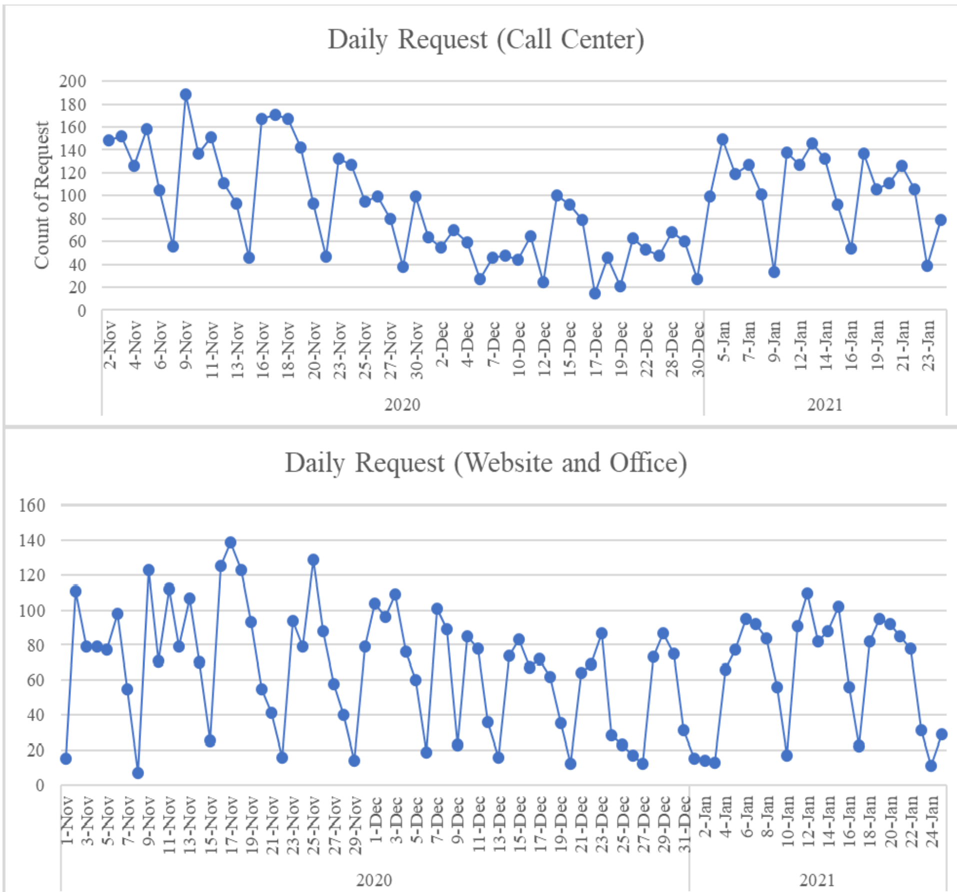

Figure 4. Daily Request of Complaints

3.2 Continuous Efforts to Improve the Performance of Integrated Call Center System (Omni-Channel)

3.2.1 Crucial Point Business Process Evaluation System Complaints

(Trappey et al., 2010) said that the effects of good complaint handling include not being left behind by customers who have a bad experience of company services, upholding a good impression on the company, and turning angry customers into loyal customers. According to him, complaints that are not handled properly without the certainty of time or the time lag between the entry of complaints and the resolution recommendations that are too large will cause customer dissatisfaction. Trappey provides concepts about important aspects to improve the performance of a performance service system, namely an integrated customer complaint framework, a handling system including complaint reporting, compensation diagnosis, complaint search, and complaint analysis. While (Boshoff, 1997) mentioned that the time delay will be negatively related to the increased level of customer satisfaction after service recovery. In other words, the sooner therecovery occurs, the higher the level of improvement in customer satisfaction is likely to occur, after service recovery.

Furthermore, *Dispendukcapil* reviewing these four important aspects for the improvement stage with the aim of achieving an increase in the speed of response time and resolution of complaints that entry.

Table 3. Improvement of *Dispendukcapil*

No	Aspects	Improvement of *Dispendukcapil*
1	Integrated customer complaint framework	Prepare SOP
2	Handling system including complaint reporting	Build a service desk application that can integrate all information from all service channels in one data base. Data will be sent to other applications regarding the execution of the settlement and the update will be sent to the complainant via the same channel or other channel requested.
3	Compensatory diagnosis	Provides a frequently ask question feature in the Service Desk application for officers handling complaints to minimize errors in execution steps and speed up the execution process.
4	Complaint search	Provide a unique complaint ticket code for all service channels, making it easier to find complaints that have entered and check the progress status of their completion on the Service Desk application.
5	Complaint analysis	A feature is provided in the Service Desk application for special officers (quality control team) who can observe all the progress of incoming complaints.

The outline of the process is as shown below:

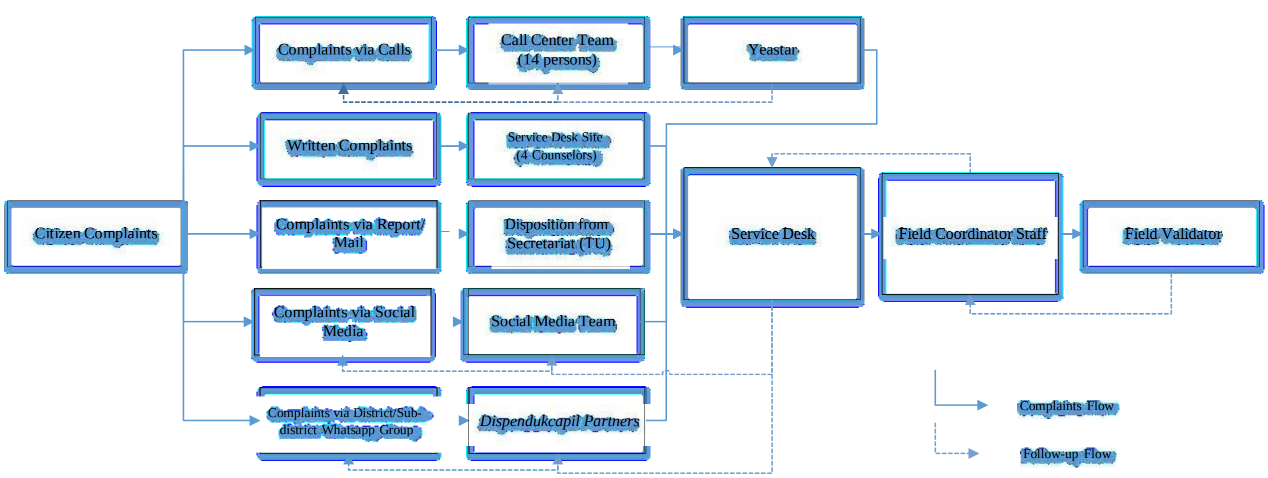

Figure 5. Integrated Complaints Processing System

3.2.2 Determination of Key Performance Indicators

To ensure that all service process points can carry out their functions properly according to the SOP, Key Performance Indicators (KPI's) were developed for all officers in the complaint service system process chain. KPIs were developed by referring to the speed of the handling process and the accuracy of taking steps to handle incoming complaints. So Performance = function (time, accuracy of execution).

3.2.3 Quality Control Team

The quality control team was specially formed to ensure 2 things, namely, the execution process did not exceed the standard time for settlement of complaints and the execution steps taken by the executor did not violate the provisions.

3.3 Service Performance in Integrated Call Center System *Dispendukcapil*

On average, the problems that were complained of can be resolved in less than 1 day by 70% for those who go through the phone channel and 30% for those who go through the website channel. Settlement within 1 day means that if a complaint comes in one day at 9 am, then at around 9 the next morning the problem has been resolved, and the information has been submitted back to the complainant of the problem.

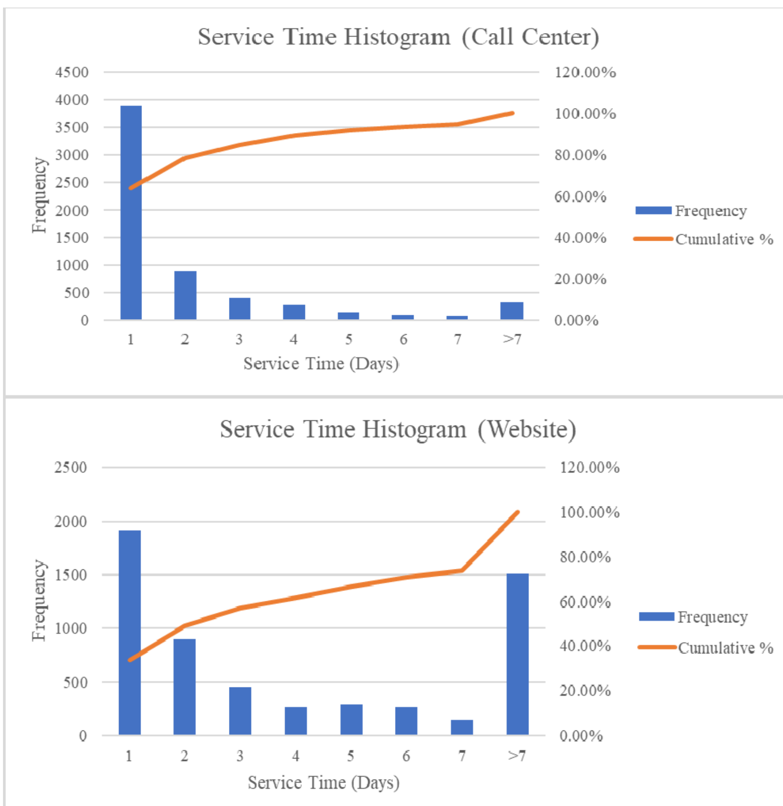

Figure 6. Website and Call Center Service Time Distribution

Recognition of the complaint service integrated performance with the omnichannel pilot mechanism in the *Dispendukcapil* was published by the Surabaya City Government Organization Section in the 2020 Community Satisfaction Survey report with an index that increased significantly by 15.87 points compared to 2019, from a score of 82.36 to 98.23.

4. CONCLUSION

Seeing that in the future all matters in the private and public sectors will rely heavily on digital channels for communication with customers, the performance of the integrated complaint service with this omnichannel pilot must continue to be improved. It is planned to develop the frequently ask question feature with a machine learning-based knowledge management system so that it can help officers who handle complaints to respond more quickly but accurately.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Bateson, J. E. G., & Hoffman, K. D., (1999). *Managing Services Marketing: Text and Readings*, Dryden press. https://books.google.co.id/books/about/Managing_Services_Marketing.html?id=R1ctAQAAMAAJ&redir_esc=y

Best, A., & Andreasen, A. R., (1977). Consumer response to unsatisfactory purchases: a survey of perceiving defects, voicing complaints, and obtaining Redress. *Law & Society Review*, *11*(4), 701. https://doi.org/10.2307/3053179

Boshoff, C. (1997). An experimental study of service recovery options. *International Journal of Service Industry Management*, *8*(2), 110–130. https://doi.org/10.1108/09564239710166245

Day, R. L., & Bodur, M., (1978). Consumer response to dissatisfaction with services and intangibles. *ACR North American Advances*, *NA-05*. https://www.acrwebsite.org/volumes/9433/volumes/v05/NA-05/full

Filip, A., (2013). Complaint management: a customer satisfaction learning process. *Procedia - Social and Behavioral Sciences*, *93*, 271–275. https://doi.org/10.1016/j.sbspro.2013.09.188

Lovelock, C., & Wirtz, J. (2004). *Services Marketing: People, Technology, Strategy*, (7th ed.).

Manners, J., (2019, October 21). *How To Plan Effective Omnichannel Communications*.

NapoleanCat. https://napoleoncat.com/blog/omnichannel-communications/

Refiana, L., (2012). Qualitative analysis about consumer complaint response through reader's letter column in Kompas.com. *Procedia - Social and Behavioral Sciences*, *65*, 83–87. https://doi.org/10.1016/j.sbspro.2012.11.095

Trappey, A. J. C., Lee, C. H., Chen, W. P., & Trappey, C. V., (2010). A framework of customer complaint handling system. *2010 7th International Conference on Service Systems and Service Management, Proceedings of ICSSSM' 10*, *July*, 879–884. https://doi.org/10.1109/ICSSSM.2010.5530119

W. Yanuardi, A., Indah P., Y., Wahyudi, W. T., & Nainggolan, B., (2016). Analisis omnichannel customer experience maturity di pt. telekomunikasi indonesia. *Jurnal Manajemen Indonesia*, *16*(2), 81. https://doi.org/10.25124/jmi.v16i2.314

Xribe., (2019, May 16). *What is the difference between cross-channel & multichannel communications? - Xribe*. https://www.xribe.eu/what-is-the-difference-between-cross-channel-multichannel-communications/

INTEREST ANALYSIS OF THE USE OF ZOOM APPLICATION AS ONLINE LEARNING MEDIA IN PRIVATE UNIVERSITY STUDENTS IN SURABAYA FOR INCREASING EDUCATION QUALITY

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ABSTRACT

The development of information technology in modern times is growing rapidly. The COVID-19 pandemic accident forces people to carry out activities without crowding causing education ranging from basic education to higher education to be carried out remotely. With the online meeting application zoom can allow lectures and teaching and learning processes to occur remotely. Universities need to continue to improve the quality of education even in the teaching and learning process indirectly or directly remotely or online.

The formulation of the problem and the objectives of this study are expected to provide an empirical analysis of understanding related to the influence of factors, namely interest in use, perception of ease, perceived usefulness, behavior when using, quality of instructors, quality of education system, quality of information, experience and job relevance in use. zoom application as an online learning medium to improve the quality of education with the Technology of Acceptance Model (TAM) approach.

The sample in this study were 125 private university students in Surabaya who were still active in their studies and used the zoom application as an online learning medium. Tests are carried out using the Structural Equation Model (SEM). Implication by theoretical, methodological and opportunities for further research are discussed in the discussion.

Based on the results of testing and analysis, it was found that the quality of instructors, the quality of the education system and the quality of information had a positive effect on interest in use. Job and experience relevance has a positive effect on perceived usefulness. Perceived ease does not have a positive effect on interest in use. Points of information quality, quality of instructors, and quality of the education system are important points in improving the quality of education.

Keywords: E-Learning, Zoom, Surabaya University, Technology Acceptance Model 2.

1. INTRODUCTION

The advancement of information technology in modern times is rising rapidly and many things can be achieved remotely with the aid of information technology. Information technology is supposed to be useful in supporting IT-supported activities, and information technology will build a mechanism of support for decision-making and be effective in activities such as industry, economics, social policy, and education. (James A. O'Brien & Marakas, 2017). The teaching and learning process has not been spared from the development of information technology and creates a solution for carrying out the teaching and learning process remotely. Distance learning / via online itself has the aim of meeting education standards by utilizing the development of information technology using computer media or gadgets that can be connected to each other between students and teachers so that through the use of technology the learning and teaching process can be carried out properly The use of information technology is expected to be able to overcome the learning and teaching process with distance limitations so as to enable the implementation of a good teaching and learning process considering that Indonesia is a very large country and the internet infrastructure is adequate. Digital Reports 2020 which was released at the end of January 2020, which states that almost 64 percent of Indonesia's population is connected to the internet, so it can be said that internet users in Indonesia have reached 175.4 million people out of the total population of Indonesia which is approximately 272.1 million. (Hootsuite, 2020). At this time, many universities in Indonesia implemented e-learning method. This is created because e-learning is one of the innovations that can be used for the learning process, not only in the delivery of lecture material but also in the changes in the abilities of various competences of students. With the existence of e-learning, students not only listen to material descriptions from educators but are also active in observing, doing, demonstrating and so on. So that educators are expected to be able to virtualize teaching materials in various formats so that they can provide a more interesting and dynamic learning experience so that they can attract interest and motivate students to further participate in the learning process.

2. METHOD

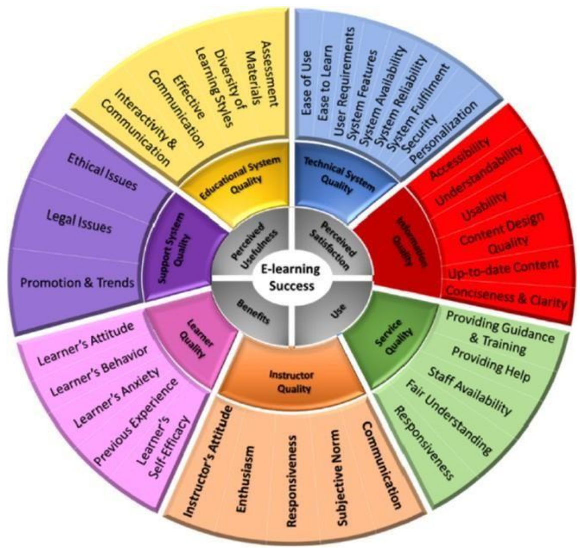
2.1 E-Learning

E-Learning is a communication and information technology to enable students to study anytime and anywhere, Dahiya (Hartanto, 2016). Two modes of e-learning are available, synchronous e-learning and asynchronous e-learning. Synchronous e-learning refers to the teacher and students performing the learning process at the same time. Synchronous e-learning allows for direct online interaction between educators and students. In the implementation of synchronous e- learning, educators and students are required to access the internet simultaneously or online in another way at the same time. Educators can provide learning materials directly via the internet in the form of papers, presentations or presentations. Students can also communicate with the teacher by directly asking questions or offering comments that can be facilitated through chat windows or verbally. Synchronous e-learning is a form of real but virtual (virtual) class visualization, so teachers and students are linked online. Virtual classrooms are also often referred to as synchronous e- learning. Asynchronous means that the process of learning does not occur at the same time or indirectly. The teaching and learning process can be carried out by students doing asynchronous e- learning at a different time from the time the teacher offers the subject matter. In the online teaching and learning method, asynchronous e-learning is very common because students can access learning content anywhere and at any time. Students may also think about the timetable that their teacher sets at their own pace. Reading, animation, simulation, video presentations, educational games, pop- quiz, tests and assignments can take the form of asynchronous e-learning.

2.2 E-Learning Success and Satisfaction Rates

In the context of information systems, a model is developed to assess this in order to identify performance and satisfaction in electronic learning (E-learning). The model is split into six variables, namely System Efficiency, Quality of Knowledge, Usage, User Satisfaction, Individual Impact and Organizational Impact. (2020, Al-Fraihat et al.). In the new modeling carried out by Al- Fraihat et al., it was found that aspects needed several aspects to measure the level of performance and satisfaction in online learning, namely quality of the educational system, quality of the technical system, quality of content, quality of service, quality of teacher, quality of learner and quality of support system. These things can be measures of online learning's progress. Where each of the indicators has a link that can demonstrate the progress of online learning.

Figure 1. Multidimensional Conceptual Model for Evaluating E-Learning System Success Model



2.3 Management of Quality Education

Instructors in learning play an important role in the teaching and learning process, the ability of instructors to manage learning, namely the ability to plan, evaluate students and implement the learning process. Selection of the right learning model will greatly determine student interest and participation in the teaching and learning process. With a good and precise learning model, students are expected not only to gain knowledge about the areas of interest being taught but also to have a deep impression of the learning material, thus encouraging students' interest in implementing the concepts and values of course material in everyday life.

There are several things that the instructor/teacher needs to have for basic professional skills: Mastery of lecture or lesson materials, Program management learning and teaching each course, Classroom management by arranging classroom layouts that create an appropriate learning climate, Use of learning resource media, Management of teaching and learning interactions, Mastery of educational foundations, Management of program and counseling functions in tertiary institutions, Introduction and administration of higher education, Understanding of the principles and interpretation of educational results, Assessment of student achievement for teaching purposes.

2.4 Zoom

Zoom is a meeting application with high definition quality for free with video conferencing and screen sharing for more than 1 person. Zoom is a communication application focused on online meetings using video. Zoom can also be used by various devices, including cellphones, computers, room systems to conventional telephones.

Through Zoom, distance learning online can be more effective, this is because Zoom provides a conference that can be reached by all participants in this case, students and lecturers. Zoom also has a video recording feature so that data security is maintained and the results of the conference and the results of the recordings can be downloaded by participants who may directly have network problems during the conference. (Brahma, 2020).

2.5 Technology Acceptance Model (TAM)

Fred Davis first unveiled TAM, or the Technology Acceptance Model, in 1989. There are several models, including the Theory of Justification (TRA), Technology Acceptance Model (TAM), End User Computing Satisfaction (EUCS) and Task Technology Fit (TTF) Study, that can be used to test the acceptance of information systems. (2019, Mambu, Jonathan, Rumawouw & Liem). In order to increase the efficiency of an individual or organisation, TAM can be trusted to assess the use of information systems so that it can make it easier for the wearer to complete work. (In 2014, Devin & Suaratana). TAM is supposed to assist in the process of predicting the attitude and acceptance of technology of a person and can provide the requisite basic information on the factors that drive the attitude of the individual (Mandailina, et al, 2019).

TAM 2, which is one of the most common and appropriate methods for calculating the advantages and convenience of information technology that was first used by application users, is the approach used in this study. (Lemay et al., 2017). Any of the build variables found in the method of TAM 2 can be modified according to the researcher's needs and can be regarded as the best way to describe user behavior when using information systems. The level of technology acceptance can be measured by distributing questionnaires that are distributed offline and online, wherein each respondent's perceptions can be obtained from the results of the questionnaires. (Lee et al., 2019)

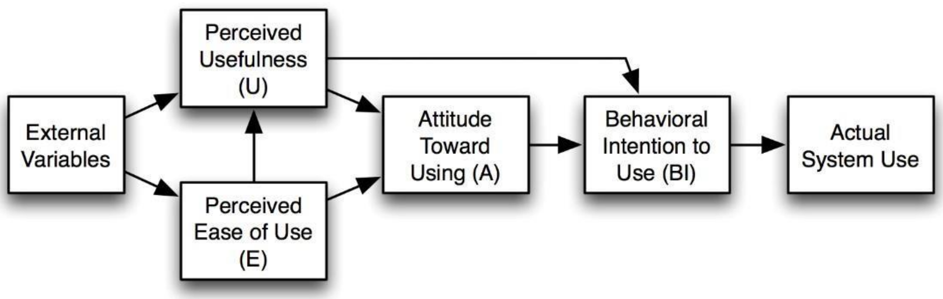


Figure 2. Technology Acceptance Model

2.6 Structural Equation Modeling (SEM)

Structural Equation Modeling (SEM) is a statistical modeling technique that is highly cross-sectional, general and linear in nature. In SEM is path analysis, factor analysis and regression (Sarwono, 2010). SEM is a common and useful multivariate analysis technique which includes specific versions in a number of other analytical methods as special cases.

SEM is developed and has several functions similar to multiple regression, it's just that SEM is superior due to the consideration of nonlinearity, interaction modeling, multiple correlated independents, measurement error, correlated error terms, and there are several latent independent variables or multiple latent independents, respectively. can be measured by several indicators. Therefore, SEM is one of the better modeling alternatives when compared to multiple regression methods, factor analysis, time series analysis and covariance analysis. SEM tends to be used to determine whether a model used can be said to be valid compared to determining whether the model used is suitable or not with the one being analyzed.

2.7 Surveys

Surveys are used to take samples or get a population to collect data. In research that uses the TAM method, it focuses more on explanatory research which can be used to measure the perception of user acceptance by using a quantitative approach. The results of a quantitative survey can be used to examine the symptoms of a group or the behavior of each individual and the relationship between variables in a population.

2.8 Data Samples

Sample is a smaller part of the population. There are several techniques in sampling and in this study the simple random sampling technique was used. Data collection was carried out by using a closed questionnaire method which will be filled in by the research object in this study, namely students of private universities in Surabaya. The sample can be said to be valid enough to be analyzed statistically at least thirty to one hundred respondents are needed. In this research it can be said that the number of research subjects is quite large, so that at least one hundred respondents will be needed.

2.9 Validity Test

Validity testing is carried out to determine whether the research question instrument that has been asked to measure the research variables can be said to be valid. The validity test is done by looking at the significant value of each instrument. The data can be said to be valid if the indicator score of each question correlates significantly to the total construct score. Measurement instruments that are said to be valid are instruments that are truly appropriate to measure what will be measured. The validity test can be said to be a test step carried out on the contents of an instrument to measure the accuracy of the instrument used in a study.

2.10 Reliability Test

Reliability testing is used to measure the consistency of respondents' answers. The test criteria were carried out using the Cronbach Alpha (CA) test. If the measuring instrument is valid, then the measuring instrument is tested. The reliability measurement technique used is the Cronbach technique. Looks for the reliability of an instrument whose score is not zero or one, but between how many scores. The scores used by researchers are one to four.

3. RESULTS AND DISCUSSION

3.1 Research Model

Several research hypothesis models that will be used as objects in the Zoom application as online learning media, which are taken from the relationship between dependent and independent variables are described as follows.

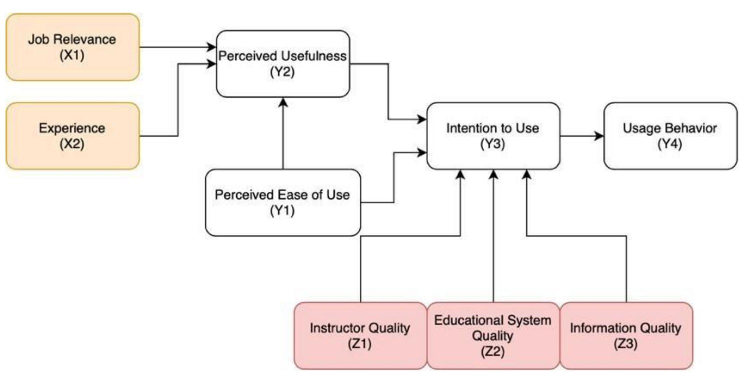


Figure 3. First Model

H1: Job Relevance has a significant impact on Perceived Usefulness
H2: Experience has a significant impact on Perceived Usefulness
H3: Perceived Ease of Use has a significant impact on Perceived Usefulness
H4: Perceived Usefulness has a significant impact on Intention to Use
H5: Perceived Ease of Use has a significant impact on Intention to Use
H6: Intention to Use has a significant impact on Usage Behavior H7:
Instructor Quality has a significant impact on Intention to Use
H8: Educational System Quality has a significant impact on Intention to Use H9: Information Quality has a significant impact on Intention to Use

3.2 Questionnaires Model

Respondents that participate in this study are students from private universities in Surabaya or can be called active students. At this stage the researcher compiles and distributes the TAM2 questionnaire. The questionnaire refers to the TAM2 variables and three external variables. The following are the attributes used shown at Table 1.

Table 1. TAM Indicator and Variable

No.	Code	Variable	Indicator	
1	X1	Job Relevance	A	User needs in using the application
			B	Obligations of users in using apps
2	X2	Experience	A	User experience in using the application
			B	Duration of use of the application by users
3	Y1	Perceived Ease of Use	A	The application is easy for users to learn
			B	The application is easy to use by users
			C	The application is easy for users to understand
			D	Users easily get application information
4	Y2	Perceived Usefulness	A	Application has ease of features
			B	Fast application performance for users
			C	The information provided by the application is precise
			D	Application effectively used by users
			E	Applications support user productivity
5	Y3	Intention to Use	A	The user is interested in using the application of his own accord
			B	Users are interested in using the application at the instigation or incitement of others
			C	Users are motivated when using the application
6	Y4	Usage Behavior	A	The number of times the user used the application
			B	User behavior when using the application
7	Z1	Instructor Quality	A	Instructor in an interactive lecture process with students
			B	Instructors in the lecture process master and understand the application
			C	The instructor understands the material provided during the lecture process
8	Z2	Educational System Quality	A	The education system is easily understood by application users
			B	The quality of education provided to application users is clear
9	Z3	Information Quality	A	The quality of information provided is good for application users
			B	Delivery of information through the application is conveyed clearly

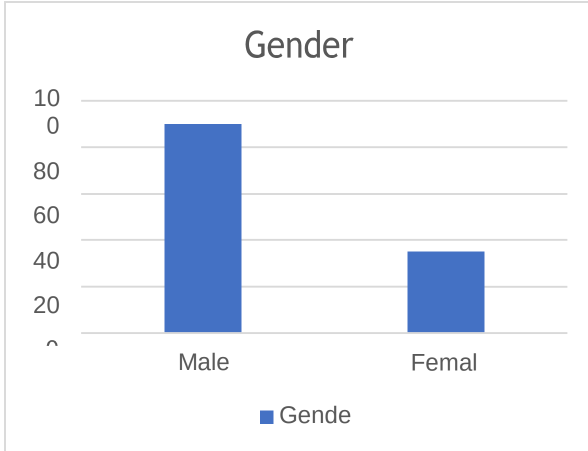


Figure 4. Gender Demography

Based on the figure 4, it is known that from 125 samples of respondents who were accepted, there were 72% of respondents who were male while 28% were women. The number of male respondents was 90 people and female respondents were 35 people.

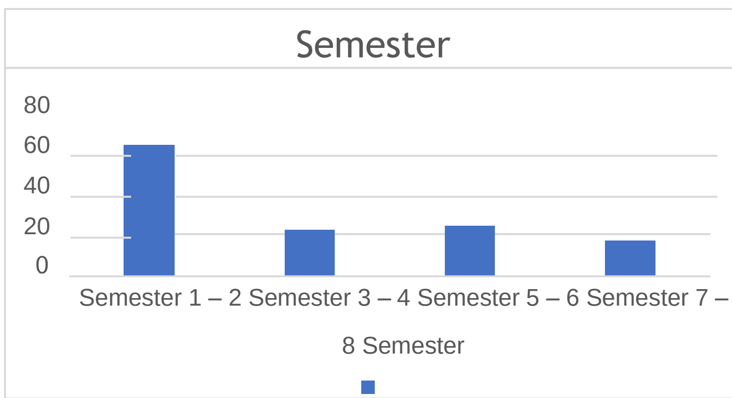


Figure 5. Semester Demography

Based on Figure 5 the distribution based on the semester of study, 49.6% of the samples were students in semesters 1 - 2, 17.6% were students in semesters 3 - 4, 19.2% were students in semesters 5 - 6 and 13.6% were students in semester 7 – 8.

3.3 Normality Test

The requirement in SEM analysis is data normality. Testing for the normality of a data is done by using the value of C.R Skewness and Kurtosis of the data distribution from the SEM output processed through AMOS software. This study uses the critical value of CR Skewness based on the 1% significance level, which is approximately 2.35 and the critical value of Kurtosis, namely:

a. Normal if the z statistic or the value of kurtosis under 7
b. Moderately non normal if the kurtosis value is between 7 to 21
c. Extremely non normal if the kurtosis value is over 21.

Table 2. Normality Test Result

Variable	Min	Max	Skew	C.R.	Kurtosis	C.R
X1,1	1.000	4.000	-2.501	-11.415	6.524	14.889
X1,2	2.000	4.000	-1.561	-7.126	1.453	3.315
X2,1	2.000	4.000	-3.227	-14.731	10.353	23.628
X2,2	3.000	4.000	-0.980	-4.473	-1.040	-2.373
Y1,1	1.000	4.000	-2.701	-12.330	7.543	17.215
Y1,2	1.000	4.000	-2.107	-9.617	4.727	10.788
Y1,3	1.000	4.000	-0,288	-1,313	-0,823	-1,879
Y1,4	2.000	4.000	-0,493	-2.252	-0,655	-1,495
Y2,1	1.000	4.000	-1.948	-8.890	5.318	12.137
Y2,2	2.000	4.000	-1.334	-6.091	0.783	1.788
Y2,3	2.000	4.000	-0,978	-4,464	-0,271	-0,618
Y2,4	1.000	4.000	-1,523	-6,950	1,958	4.469
Y2,5	1.000	4.000	-0,558	-2,548	-0,354	-0,807
Y3,1	1.000	4.000	-0.547	-2.496	-0.387	-0.883
Y3,3	1.000	4.000	-1,351	-6,168	1,841	4.202
Y4,1	1.000	4.000	-3.927	-17.925	16.349	37.312
Y4,2	1.000	4.000	-1.928	-8.798	3.573	8.154
Z1,1	2.000	4.000	-0.877	-4.002	-0.339	-0.774
Z1,2	2.000	4.000	-0.899	-4.105	-0.231	-0.528
Z1,3	2.000	4.000	-1.091	-4.979	0,173	0,396
Z2,1	1.000	4.000	-1.028	-4.691	1.276	2.913
Z2,2	1.000	4.000	-0.683	-3.116	1.270	2.898
Z3,1	1.000	4.000	-0.923	-4.215	0.203	0.463
Z3,2	1.000	4.000	-1.295	-5.910	2.068	4.720
Multivariate					91.677	14.507

3.4 Model Specification

Before interpreting the results of hypothesis testing, there are steps that must be taken, namely analyzing the goodness-of-fit model. This is done to ensure that the model created or constructed has a good fit with the settings used as the object being observed through the data obtained. The results of the structural analysis can be seen in the figure.

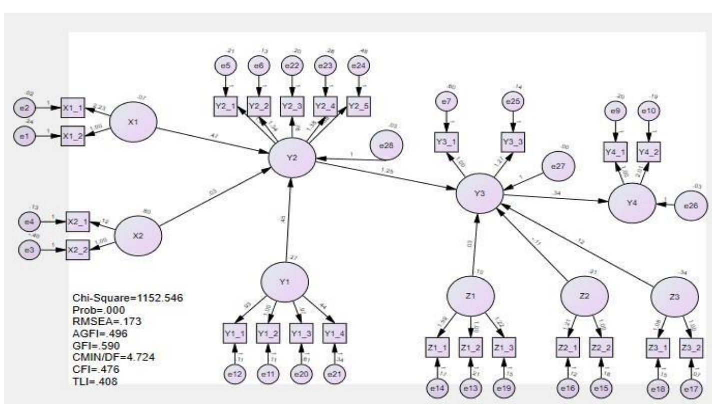


Figure 6. Initial Structural Equation Models

Because the model is bad, the researchers consider modifying the model to form an alternative model that has a better goodness of fit value.

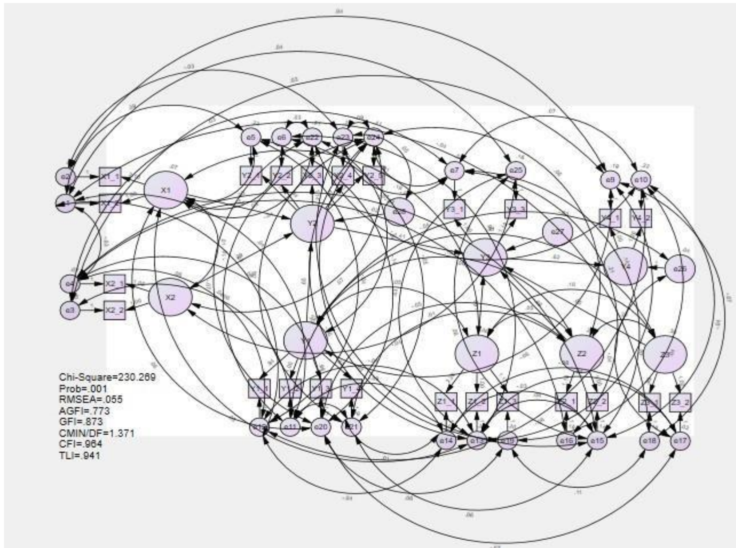


Figure 7. Modified Structural Equation Models

3.5 Hypothesis Test

The next stage in the research is an analysis of the structural relationships of the model or it can be called hypothesis testing after the goodness of fit of the structural model can be fulfilled. The relationship between constructs in the hypothesis is indicated by the value of regression weights. Hypothesis testing can be performed on the basis of the p-value of the current structural relationships by evaluating the significance level of the causal relationship between the constructs in the model. The analysis results are shown in table 4. 10 where the arrow (←) shows the direction of influence from one variable to another. A positive standardized regression weight means that therelationship between variables has a positive direction. The significance test of the relationship is done by looking at the p value of each relationship. If the p-value is smaller than 0.05, the relationship can be called significant. P value in Table is represented as *** because the value is less than 0.001 so it is considered close to 0.

Table 3. Weights Result

Variable Relationship			Estimate	S.E.	C.R.	P Value	Info
Y2	←	X1	0,489	0,119	4,117	***	H1 Accepted
Y2	←	X2	0,294	0,105	2,802	0,005	H2 Accepted
Y2	←	Y1	0,666	0,094	7,101	***	H3 Accepted
Y3	←	Y2	1,647	0,415	3,969	***	H4 Accepted
Y3	←	Y1	-0,298	0,261	-1,142	0,254	H5 Declined
Y3	←	Z1	-0,741	0,357	-2,075	0,038	H6 Accepted
Y3	←	Z2	-0,857	0,251	-3,410	***	H7 Accepted
Y3	←	Z3	0,713	0,258	2,768	0,006	H8 Accepted
Y4	←	Y3	0,642	0,167	3,845	***	H9 Accepted

4. CONCLUSION AND RECOMENDATION

4.1 Conclusion

- The results of the analysis show that Instructor Quality, Educational System Quality and Information Quality have a positive effect on the interest in using the Zoom application as an E-Learning Media for private university students in Surabaya.
- The results of the analysis show that Job Relevance and Experience have a positive effect on Perceived Usefulness in the use of the Zoom application as an E-Learning Media for private university students in Surabaya.
- The analysis shows that Job Relevance and Experience have a positive relationship with Perceived Usefulness so that the hypothesis can be accepted.
- The analysis results show that the Perceived Ease of Use has a positive relationship with Perceived Usefulness so that the hypothesis can be accepted.
- The analysis shows that Perceived Usefulness and Perceived Ease of Use have a positive relationship with Intention to Use so that the hypothesis can be accepted.
- The analysis shows that perceived ease of use has a negative relationship with intention to use so that the hypothesis can be rejected.
- The results in the goodness of fit index study indicate that the model used can be fit if the error points are correlated through the AMOS application. In the goodness of fit test, it was found that the p value still did not meet the cut of value so it was necessary to increase the number of respondents or replace the object of observation.
- With a literature review on education quality management and the level of success and satisfaction in e-learning it can be concluded that to improve the quality of education for online learning with the results of interest in use based on the analysis of factors that increase interest in use, instructor quality, educational system quality and information quality is an important factor in improving the quality of education. Therefore, increasing information quality, instructor quality and educational system quality can also improve the quality of education based on educational quality management points.
- The results of perceived ease of use which have a negative relationship with intention to use mean that the use of applications in ease has no effect on interest in use, so that the Zoom application specifications used in the teaching and learning process cannot be considered relevant.

4.2 Suggestion

- The object observed is an active student of the Private University of Surabaya, making this research limited. To apply this research in a different context, a review is required if the object being observed is different so that the research conceptual model needs a change with a literature review.
- This study uses the object of observation, namely active students of the Surabaya Private University. In further research, research can be carried out on a larger scale so as to get more diverse research results.
- In order to improve the quality of education, students or universities can use this research as a reference for managerial plans related to education with E-Learning media. The quality of the structure, the quality of the education system and the quality of information is one of the important points in the willingness of students to use the E-Learning application.

5. REFERENCES

Al-Fraihat, D., Joy, M., Masa'deh, R., & Sinclair, J. (2020). Evaluating E-learning systems success: An empirical study. *Computers in Human Behavior*. https://doi.org/10.1016/j.chb.2019.08.004

Brahma, I. A. (2020). Penggunaan Zoom Sebagai Pembelajaran Berbasis Online Dalam Mata Kuliah Sosiologi dan Antropologi Pada Mahasiswa PPKN di STKIP Kusumanegara Jakarta. *Aksara:*

Jurnal Ilmu Pendidikan Nonformal. https://doi.org/10.37905/aksara.6.2.97-102.2020

Chang, C. C., Yan, C. F., & Tseng, J. S. (2012). Perceived convenience in an extended technology acceptance model. *Mobile Technology and English Learning for College Students*.

Dalimunthe, N., & Wibisono, H. (2014). ANALISIS PENERIMAAN SISTEM e-learning SMK LABOR PEKANBARU DENGAN MENGGUNAKAN TECHOLOGY ACCEPTANCE
MODEL (TAM). *Jurnal Sains Dan Teknologi Industri*.

Devi, N. L. N. S., & Suartana, I. W. (2014). Analisis Technology Acceptance Model (Tam) Terhadap Penggunaan Sistem Informasi Di Nusa Dua Beach Hotel & Spa. *E-Jurnal Akuntansi Universitas Udayana*.

Ferdira, B. G., Partama, A., Gulo, N., Irvan, Y., Nugroho, D., Fernandes, J., & Gerald, B. (2018).
Menggunakan Technology Acceptance Model (Tam). *Jurnal Sistem Informasi Dan Tenologi*.

Hanggono, A. (2015). ANALISIS ATAS PRAKTEK TAM (TECHNOLOGY ACCEPTANCE MODEL) DALAM MENDUKUNG BISNIS ONLINE DENGAN MEMANFAATKAN
JEJARING SOSIAL INSTAGRAM. *Jurnal Administrasi Bisnis S1 Universitas Brawijaya*. Haqien, D., & Rahman, A. A. (2020). Pemanfaatan Zoom Meeting Untuk Proses Pembelajaran
Pada Masa Pandemi Covid-19. *SAP (Susunan Artikel Pendidikan)*.

Hootsuite, W. A. S. &. (2020). *Digital 2020 Global Digital Overview*. Data Reportal.

James A. O’Brien, & Marakas, G. M. (2017). MANAGEMENT INFORMATION SYSTEMS
Tenth Edition. In *McGraw-Hill Irwin*.

Jan, M. T., Jager, J. W. de, Ameziane, A. M., & Sultan, N. (2019). Applying Technology Acceptance Model to Investigate the Use of Smartphone Advertising in Malaysia. *Journal of Economics and Behavioral Studies*. https://doi.org/10.22610/jebs.v11i1(j).2760

Kemendikbud RI. (2020). *Surat Edaran Menteri Pendidikan dan Kebudayaan Nomor 4 Tahun 2020 Tentang Pelaksanaan Kebijakan Pendidikan dalam Masa Darurat Penyebaran Coronavirus Disease (COVID-19)*. Hukumonline.Com.

Khouroh, U., Sudiro, A., Rahayu, M., & Indrawati, N. K. (2020). The mediating effect of entrepreneurial marketing in the relationship between environmental turbulence and dynamic capability with sustainable competitive advantage: An empirical study in Indonesian MSMEs. *Management Science Letters*. https://doi.org/10.5267/j.msl.2019.9.007

Lee, J., Kim, J., & Choi, J. Y. (2019). The adoption of virtual reality devices: The technology acceptance model integrating enjoyment, social interaction, and strength of the social ties. *Telematics and Informatics*. https://doi.org/10.1016/j.tele.2018.12.006

Lemay, D. J., Doleck, T., & Bazelais, P. (2017). “Passion and concern for privacy” as factors affecting snapchat use: A situated perspective on technology acceptance. *Computers in Human Behavior*. https://doi.org/10.1016/j.chb.2017.05.022

Muntianah, Tutik S. Astuti, E. S. A. D. F. (2012). Pengaruh Minat Perilaku Terhadap Actual Use Teknologi Informasi dengan Pendekatan Technology Acceptance Model (TAM). *Profit Universitas Brawijaya Malang*.

Portz, J. D., Bayliss, E. A., Bull, S., Boxer, R. S., Bekelman, D. B., Gleason, K., & Czaja, S. (2019). Using the technology acceptance model to explore user experience, intent to use, and use behavior of a patient portal among older adults with multiple chronic conditions: Descriptive qualitative study. *Journal of Medical Internet Research*.

https://doi.org/10.2196/11604

Purwandani, I. (2017). Analisa Tingkat Kesiapan E-Learning (E-Learning Readiness) Studi Kasus: AMIK Bina Sarana Informatika Jakarta. *Bianglala Informatika*.

Rahayu, F. S., Budiyanto, D., & Palyama, D. (2017). ANALISIS PENERIMAAN E-LEARNING MENGGUNAKAN TECHNOLOGY ACCEPTANCE MODEL (TAM) (STUDI KASUS:
UNIVERSITAS ATMA JAYA YOGYAKARTA). *Jurnal Terapan Teknologi Informasi*.

https://doi.org/10.21460/jutei.2017.12.20

Sarwono, Y. (2010). Pengertian Dasar Structural Equation Modeling (SEM). *Jurnal Ilmiah Manajemen Bisnis Ukrida*.

Setiawan, P. (2020). *Pengertian E-learning – Karakteristik, Manfaat, Kelebihan, Kekurangan, Jenis, Komponen, Para Ahli*. Gurupendidikan.Com.

Yanti Sri Danarwati SS, S. M. (2013). MANAJEMEN PEMBELAJARAN DALAM UPAYA MENINGKATKAN MUTU PENDIDIKAN. *Jurnal Mimbar Bumi Bengawan*.

ANALYSIS OF BUSINESS DEVELOPMENT OF PROCESSING WOOD PELLETS AS RENEWABLE FUEL USING THE BUSINESS MODEL CANVAS METHOD
(CASE STUDY IN SETRA MEUBEL BUKIR PASURUAN)

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ABSTRACT

CV XY company made the concept for developing a new business model related to the use of wood waste to solve problems in Pasuruan furniture center, of the accumulation of sawdust. This company will expand its business by establishing a wood waste into wood pellets. One method that can be used to create business development is the Business Model Canvas method. The Business Model Canvas is a visual representation method or instrument that can explain business processes as a whole. The study is aimed at developing a wood pellet business model and provide recommendations for the business development model of CV XY. Research data were collected by interview, observation, documentation and Focus Group Discussion (FGD). The data is processed by making IFE and EFE matrices, as well as a SWOT analysis. The results of the research show that the development of the Pellet Business Model at CV XY using the Business Model Canvas (BMC) have: a) Value propositions, creating waste products which mostly underrated into high quality, feasible, efficient and sustainable fuel products; b) Customer segments, which previously consist of one segment became three segments, which are based on scale, business field and area; c) Channels, which do not only consist of offline and one online channel into several online channels; d) Customer relationships, i.e. customer satisfaction strategies, i.e. product and service quality; e) Revenue streams, changing from sales to direct customers, through agents and distributors; f) Key resources are sorted by wood type; g) Key activities are done by sorting out wood waste to create product variants h) Key partnerships include increasing supplier loyalty, buyers, collaborating with governments (Cities, District, Provincial and Central Government), establishing communication with communities and associations; and i) Cost structures is done by calculating production costs as a basis for setting a selling price.

Keywords: *Business Model Canvas, SWOT, wood pellets.*

1. INTRODUCTION

The potential for wood pellet trade to the world had enormous potential. The five largest importing countries in the world were Great Britain, Denmark, Italy, the Republic of Korea and Belgium. The rest came from the European Union and the United States (Sudabutar, 2018). In South Korea, the demand wass estimated to reach 5 million tons / year by 2020.

Meanwhile, the need for wood pellets in Indonesia will only be seen in 2020, along with most of the power plants being built, including a number of policies that can be effective because they are supported by these generating facilities. The Indonesian government is targeting the use of renewable energy in 2025 to reach 23% and by 2050 it is expected to reach 31%. This means that the need for wood pellets in the country is still wide open, let alone the needs of the world (https://hpn.or.id/p potential-usaha-bio-massa-wood-pellet-terbuka-lebar).

Given the huge market opportunity for wood pellet products, domestic companies needed to immediately take advantage of these opportunities. Large market opportunities should not be preceded by foreign investors who wanted to produce wood pellets in Indonesia by building factories in Indonesia and bringing wood pellet products to their home countries.

CV XY was one of the furniture companies located in Pasuruan region with an export scale. This company was founded in 2000, this company produced a lot of furniture products, in addition to producing ordered goods it also produced for stock items in the gallery. Number of orders in CV. XY from year to year increased contiously, orders from domestics, and abroad. CV. XY started exporting independently since 2004.

Foster care in a micro business was very much needed, this was intended to be able to even out the economy and encourage micro businesses to be more creative, this was done by CV.XY Furniture. CV. XY Furniture is the foster father of 20 micro businesses that exist in furniture centers in Pasuruan City, this micro business was under the guidance of CV. XY Furniture, so that to meet the market needs of CV. XY Furniture could collaborate with micro businesses that were foster children (fostered) of CV. XY Furniture.

With so many products that had been produced by CV. XY, there was the potential for shaved waste and powder waste that was very abundant, 30 sacks (450 kg) of shaved waste were produced in one day and an average of 28 sacks (840 kg) of powder waste per day. The waste produced could not be utilized properly, sometimes it was only made as fuel. Most of the waste is thrown away, not generating economic value for the company. To dispose of the accumulated waste, the company needed a fleet to transport it. This created additional costs for the company. Wood sawdust, which had been a waste for companies, could be used as a business opportunity and business opportunity. With the increasing price of gas and kerosene as fuel for cooking, sawdust could be substituted at a lower price. For this reason, a new business model development program was needed that could seek to use sawdust waste into products that had economic value.

Based on the description of the problem, CV. XY wanted to create a concept for developing a new business model related to the use of wood waste to solve the problem of wood waste accumulation produced by sawmills SMEs in Wood Industry Centers. This company would expand its business by establishing a wood waste processing business into wood pellets.

One method that could be used to create business development was the Business Model Canvas method. The Business Model Canvas was a visual representation method or instrument that could thoroughly explained a business process. Through this method, the researcher hoped that the development of new businesses in the wood waste processing sector could be realized. Therefore, the authors wanted to know a suitable business development model using the Business Model Canvas method.

Based on the background of this research, the formulations of the research problems are: (1) How was the description of the internal and external environmental conditions of SMIs in the furniture center of Pasuruan City related to the nine elements in the Business Model Canvas matrix; (2) How was the development of the wood pellet business model at CV. XY Furniture Pasuruan City, by utilizing the waste that has accumulated in the center area?; and (3) How were the recommendations for the business development model at the company CV. XY Furniture in the center of Pasuruan City furniture using the Business Model Canvas method?

2. LITERATURE REVIEW

2.1 Wood Waste

Wood waste is wood that is wasted in various shapes and sizes which must be sacrificed in the production process because it cannot produce products (output) that are of high economic value with a certain level of processing technology used (DEPTAN, 1970). Data from the Ministry of Forestry and Plantation for 1999/2000 showed that Indonesia's plywood production reached 4.61 million m^3, while sawnwood reached 2.6 million m^3 per year. With the assumption that the amount of wood waste produced reached 61%, it was estimated that the wood waste produced would reach more than 4 million m^3 (BPS, 2000). The potential for wood waste in Pasuruan City, based on data obtained from Pasuruan Timber Industry Unit, for the wood processing industry in Pasuruan City area consisted of 1198 wood industries, which had potential waste as shown in table 2.1 below.

Table 1. Wood Waste Type

No	Wood Waste Type	Average Amount of Wood Waste
1	Sawmill Powder	70 sack/day
2	Shaved	25 sack/day
3	Slash	25 sack/day
4	Beam	20 sack/day

2.2 Pellet

Pellets are a form of renewable energy made from wood biomass, such as wood waste from the timber industry and wood harvesting or compacted woody plants (Sylviani et al. 2013, Tampubolon 2008). Pellet is a superior fuel that has greater energy than firewood or sawdust because it is denser, easier to handle, does not need a large storage space, and has environmentally friendly properties so it is widely used by consumers as fuel for heating in home or small industrial fuel (Ciolkosz, 2009).

2.3 Business Model Canvas

The definition of Business Model Canvas according to Osterwalder & Pigneur (2010) is a logical description of how an organization creates and captures value. In making an organization or company, it is impossible to get and apply ideas that are applied carelessly. The Business Model Canvas is used to support market exploration in creating innovations which are then developed into company products (Joyce and Paquin, 2016).

The Business Model Canvas consists of nine main component blocks, each of which has the task of explaining part of the business model so that it can run well. The nine components are customer segments, customer relationships, channels, revenue streams, value propositions, key activities, key resources, cost structure, and key partners.

2.3 IFE and EFE Matrices

Internal Factor Evaluation Matrix or Internal Factor Evaluation Matrix is a formulation to evaluate the main strengths and weaknesses. Meanwhile, The External Factor Evaluation (EFE) matrix is used as a strategy formulation tool to evaluate the main opportunities and threats (Kinnear, 1991).

After forming the IFE and EFE matrices, the values obtained in the two matrices are then entered into a matrix called the IE (Internal External) matrix to see which strategy is implemented by each division (David, 2006). The X-axis in the IE matrix is the total score for the IFE matrix and the Y-axis is the total score for the EFE matrix.

2.4 SWOT Analysis

SWOT stands for Strength, Weakness, Opportunities, and Threats. This method was a method for formulating strategic planning using strengths, weaknesses, opportunities, and threats to be used as evaluation material. So that the SWOT analysis was used to assess the strengths and weaknesses of the company's resources as well as the external opportunities and challenges it faces (Jogiyanto, 2006).

3. RESEARCH METHODOLOGY

3.1 Preliminary Study

In the process of this preliminary study, problem identification was carried out in order to see what could be the basis for this research. In an effort to find out the problems that occur in the field, not only by direct observation, but also by conducting interviews with parties who are competent in the field of wood waste and pellets. After the condition of the problem is known, the problem is identified to get an overview of the attributes or factors that are considered in determining development alternatives.

3.2 Literature Study

In this phase or at this stage, a literature study was conducted to obtain information in the form of theories that supported problems related to develop business strategies with the Business Model Canvas Method on CV XY Furniture. This could be obtained from literature or journals that discuss this method.

3.3 Data Collection

The type of data in this study consisted of primary and secondary data. Secondary data collection was done by the researcher taking data from documents that had been recorded while the primary data collection the researcher conducts discussions and interviews directly in the Focus Group Discussion (FGD) session and also the documentation process. Data collection directly on business actors in the area of Pasuruan City Furniture Center. Data collection was carried out using the following methods: observation, interview, documentation, and forum group discussion.

3.4 Problem Identification

Based on the identification of the problems faced, it could be formulated a problem that would be discussed, namely "Pellet production development strategy by utilizing wood waste with the Business Model Canvas Method on CV XY Furniture".

3.5 Business Model Canvas Stages

The Business Model Canvas method was carried out in several stages, namely internal and external analysis using the IFE and EFE matrices and SWOT analysis. The next stage provided suggestions for improvements with the Business Model Canvas.

3.6 Data Processing

Data of this study processed by making IFE and EFE Matrices, analysis SWOT, and Strategy Business Development Stages.

3.7 Analysis and Discussion

In this phase, proposals for business and product development models were carried out in accordance with the wants and needs of the wood pellet market or consumer.

4. RESULTS OF THIS STUDY AND DISCUSSION

4.1 Evaluation of the Business Model Canvas (BMC) Design of Wood Pellet Business at Bukir Furniture Center Pasuruan Using Strength, Weakness, Opportunity, and Threat (SWOT) Analysis

a. Analisis SWOT

Based on the SWOT analysis obtained from interviews, observations, and documentation, it can be seen that the strengths, weaknesses, opportunities and threats are as follows: 1) Strengths : a) Having a product marketing network, b) Availability of raw materials, c) Competitive selling price, d) Strategic factory location, e) Cheap raw material prices, f) Good customer relations, g) Adequate working capital, h) Competent human resources. 2) Weakness : a) The raw materials are still mixed, b) Lack of HR training, c) Not yet experienced in the pellet business, d) Still using a simple machine. 3) Opportunity : a) The world's demand for pellets is getting higher, b) Government program regulation, c) The development of technological advances, d) Stable raw material prices, e) Loyalty of material suppliers, f) Change in fuel consumption. 4) Threats : a) High barrier to entry to industry, b) Lack of understanding of suppliers on product quality, c) The bargaining power of consumers is high, d) More experienced competitors

b. IFE, EFE, and IE Matrices Analysis

The calculation of IFE and EFE in this study is based on the SWOT results obtained from interviews, observation and documentation. The determination of the score and rating in the calculation of IFE and EFE is based on the results of the forum group discussion (FGD) which consists of CV XY owners, East Java Industrial Service officers, suppliers, and researchers. Each FGD participant was asked to provide an assessment related to the score and rating of each SWOT aspect that was still determined.

Table 2. Internal Factor Evaluation (IFE)

Internal Strategies Factors	Score	Weight	Rating	Score Weight
Strengths				
1. Having a product marketing network	4,00	0,08	5,00	0,41
2. Availability of raw materials	5,00	0,10	5,00	0,51
3. Competitive selling price	4,00	0,08	4,75	0,39
4. Strategic factory location	3,80	0,08	3.75	0,29
5. Cheap raw material prices	5,00	0,10	5,00	0,51
6. Good customer relations	4,00	0,08	4,25	0,35
7. Adequate working capital	3,40	0,07	4,25	0,28
8. Competent human resources	3,60	0,07	4,75	0,35
Sub Total	32,80	0,67		3,08
Weakness				
1. The raw materials are still mixed	4,80	0,10	3,25	0,39
2. Lack of HR training	3,80	0,08	4	0,39

3. Not yet experienced in the pellet business	3,60	0,07	3,5	0,33
4. Still using a simple machine	4,00	0,08	3,25	0,33
Sub Total	16,20	0,33		1,44
Total	49,00	1,00		4,52

Source: Data Processed (2021)

The most dominating component for internal factors between the strengths or weaknesses of the CV XY Company was abundant and cheap raw materials.

Table 3. External Factor Evaluation (EFE)

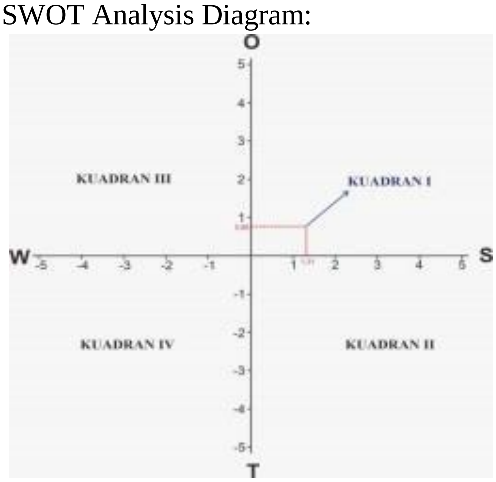
Internal Strategies Factors	Score	Weight	Rating	Score Weight
Opportunity				
1. The world’s demand for pellets is getting higher	4,40	0,10	4,00	0,40
2. Government program regulation	4,80	0,11	4,00	0,43
3. The development of technological advances	4,40	0,10	3,80	0,38
4. Stable raw material prices	4,80	0,11	3,60	0,39
5. Loyalty of material suppliers	4,60	0,10	3,00	0,31
6. Change in fuel consumption	4,60	0,10	3,40	0,35
Sub Total	27,60	0,62		2,27
Weakness				
1. High barrier to entry to industry	4,20	0,10	3,80	0,36
2. Lack of understanding of suppliers on product quality	4,00	0,09	4,00	0,38
3. The bargaining power of consumers is high	4,40	0,10	3,80	0,31
4. More experienced competitors	4,00	0,09	3,40	0,31
Sub Total	16,60	0,28	15,00	1,41
Total	44,20	1,00		3,68

Source: Data Processed (2021)

From the results of the composition of the internal and external factors above, the score series is as follows:

a) Strength = 2.46
b) Weaknesses = 1.15
c) Opportunities = 2.27
d) Threats = 1.41

The picture below is the SWOT Analysis Diagram:

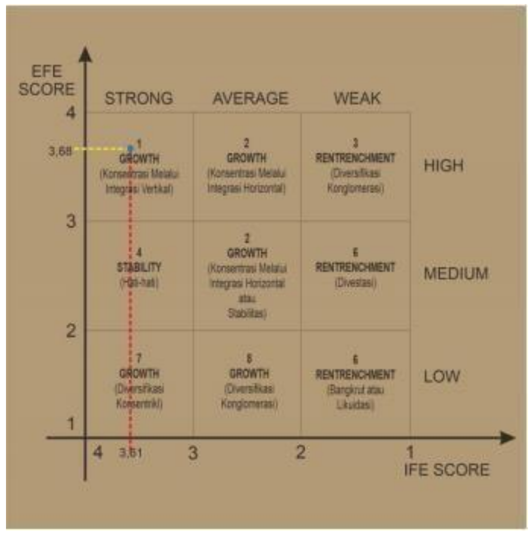


Source: Data Processed (2021)

Figure 1. SWOT Analysis Diagram

The right strategies to use in this quadrant were aggressive (market penetration, market development) or integrative (backward integration, forward integration and horizontal integration). Strategies that could be carried out were based on the company's internal and external environment, in the form of market penetration strategies and product development. The market penetration strategy was to seek a larger market share for existing products and services through more vigorous marketing efforts. Product development was a strategy that seeks to increase sales by improving or modifying existing or existing products.

Referring to the results of the total score of the strengths and weaknesses on the IFE matrix, which is 3.61 and the total score of the opportunity and threat factors in the EFE matrix is 3.68. The position of CV XY's wood pellet business strategy is in cell strategy 1 (one), called the growth strategy, which is a strategy that has a concentration position through vertical integration. This could be seen in the image below:



Source: Data Processed (2021)

Figure 2. IE Matrics

4.2 Development of a Business Model Canvas (BMC) for XYZ Company Wood Pellet Business by Utilizing Wood Waste

Based on the identification of the potential for wood waste and the internal and external conditions of the IKM furniture center in Pasuruan City, a Business Model Canvas (BMC) could be developed as follows:

a. Customer Segments

Based on research and SWOT analysis, the target customer segments or customer portfolios set by CV XY are: 1) based on industry scale 2) based on business field, 3) by region. Customer scale is divided into large companies, small and medium enterprises (SMEs), and micro companies. Customer business areas included PLTU, hotels, restaurants, cafes, and the manufacturing industry. Based on the customer area includes: Pasuruan, Pronolinggo, Lumajang, Malang, Jombang, and Madiun. Meanwhile, the target of foreign customers through export had not become the focus of CV XY's target. CV XY was still focused on the domestic market, especially the province of East Java.

b. Value propositions

Based on research and SWOT analysis, new value propositions or new product portfolios that could be applied in CV. XY, namely: 1) quality products 2) products that offer efficiency, 3) product continuity.

c. Channels

Based on research and SWOT analysis, the new channels or new distribution channels that were included in CV XY's new business model canvas were: 1) maintaining the old distribution channels that already existed in CV XY. 2) adding new channels or distribution channels to customer segments. Online distribution channels that could be added in order to support the development of marketing activities and wood pellet business operations in CV XY, including: owned media (website), and social platforms (Instagram).

d. Customer Relationships

Based on research and SWOT analysis, customer relationship that could be implemented in CV XY to make customer could be loyal was maintaining the method that had been implemented all this time because customer had gave the satisfaction statement about the service given.

e. Revenue Streams

Based on research and SWOT analysis, the new revenue streams that could be applied to CV XY was developing and increasing product capacity, so that by making these efforts the income from the company CV. XY obtained an increase pattern.

f. Key Resources

Based on research and SWOT analysis, new key resources that could be improved at CV XY include: 1) defending key resources on a business model canvas existence, namely the advantages of cheap and abundant raw materials CV XY, but it needed socialization to the suppliers to separate the wood waste. 2) adding infrastructure technologies. Infrastructure technologies were part of its tangible resources. So, infrastructure technologies were components of artificial resources, in this case a pellet processing machine that adapts to resource development, so it was hoped that these two things could make CV XY's wood pellet business easier in the ongoing wood pellet business operations.

g. Key Activities

Based on research and SWOT analysis, new key activities that could be improved by CV XY were: 1) defending key activities on CV XY's canvas existence business model, namely purchasing raw materials for wood waste 2) Socializing to raw material suppliers to separate wood waste by wood type, 3) Training for employees as an effort to increase the capacity of employees.

h. Key Partnership

Based on research and SWOT analysis, new key partnerships that CV XY could do included: 1) defending key partners on CV XY's business model canvas existence, namely suppliers of raw materials. 2) increasing cooperation with timber associations, it is hoped that with the cooperation with associations such as formers, there will be an even distribution of economic improvement for IKM in the wood center area of Pasuruan City. 3) build good relationships with pellet costumers community.

i. *Cost Structures*

Based on research and SWOT analysis, there are changes in the company's variable costs structure, namely costs for employee training, costs for socialization to suppliers and also costs for reinvesting wood pellet machines.

4.3 Recommendation for Business Model Canvas (BMC) Development of CV XY

Based on the presentation of data from the SWOT analysis above, several strategies were produced that could support the development of pellet business activities. The following were some of the strategic outputs obtained after the researcher conducted research activities in the field:

1) SO Strategy (Strength - Opportunity) : a) Increasing the amount of production by relying on abundant raw materials at relatively low prices; b) Offering pellets to new customers by taking advantage of changes in fuel consumption.
2) WO Strategy (Weakness - Opportunity) : a) Organizing young human resources training through collaboration with the government (channel) and (key relationship).; b) Socializing the use of wood waste together with the government (key activities) and (key relationship).
3) ST Strategy (Strength - Threat) : a) Improve quality and set competitive prices to survive in industrial competition by taking advantage of low raw material costs (revenue streams) and (cost structure); b) Utilizing product marketing networks to win bargains (key relationships) and (key activities).
4) WT (Weakness - Threat) Strategy: Outreach to suppliers to minimize mixed materials and increase supplier understanding of product quality (key activities) and (Chanels).

4.4 Discussion

Based on the results, the identification of the potential for wood waste produced and describing the internal and external environmental conditions of SMIs in furniture centers in Pasuruan City, developing a wood pellet business model at CV. XY Furniture Pasuruan City, by utilizing the waste that has accumulated in the center area, as well as recommendations for business development models at the company CV. XY Furniture, could be discussed as follows:

a. Value Proposition

According to Osterwalder and Pigneur (2010) value propositions are added value provided to customers consisting of products and services. This added value is a key solution for the variety of products and services offered in a business. The pellet industry is one of the many industries that take advantage of added value or value advantages to obtain a specific market segment, namely pellet fuel users. CV XY offers a value proposition, namely quality, efficiency, and continuity

b. Customer Segments

Osterwalder and Pigneur (2010) explain that a customer segment can be called a market segment if: it requires separate value propositions due to specific problems and needs, is achieved and served with different distribution channels, needs to be approached (customer relationships) which are different, provide different profitability, and have different ability to pay according to the perceived value they receive. Customer segments or pelleted customer portfolios can be divided into three, namely: 1) based on a scale 2) based on the business sector, 3) by region.

c. Channels

Osterwalder and Pigneur (2010) explain that channels are distribution channels in the form of communication channels, distribution channels and sales networks to connect with customers. Channels in the wood pellet industry can be distinguished by several criteria, depending on how the company or organization is designing their business model. CV XY distribution channels or channels consist of two approaches or methods. First, namely a method or approach based on segments which consists of two types of channels, in the form of online and offline channels.

d. Customer Relationships

Customer relationships were ways of keeping customers loyal to our business, or it could be described as post-service services and / or purchases of products from a company or organization. Meanwhile, according to Osterwalder and Pigneur (2010), customer relationships were a type of relationship that customers from a specific market segment wanted to have. If it was applied to customer relationships in the wood pellet industry was based on customer segmentation 1) defending the customer relationships model. 2) developing plan for new customer.

e. Revenue Streams

According to Osterwalder and Pigneur (2010), revenue streams are revenue received by companies from each of the existing market segments. In order to increase revenue, CV XY had two ways, first, by increasing sales of pellet products, and secondly by producing pellets with two product variants, namely one and two quality pellets.

f. Key Resources

The main resources currently owned by CV XY to run its business model, namely in the form of natural resources, artificial resources, and human resources. Key Resources were in accordance with the statement by Osterwalder and Pigneur (2010: 34) that key resources were the main resources needed by companies so that the business model could run. Key resources were formed based on the type of business model. Key resources could be in the form of physical, financial, intellectual, or human.

g. Key Activities

Osterwalder and Pigneur (2010: 36) explained that key activities were the main activities that an organization or company needed to do in order to provide added value properly. Every business model had main activities. CV XY wood pellet business activities were carried out through several activities. The activities referred to include: purchase of raw materials, transportation of raw materials, storage of raw materials, processing of raw materials, packaging of finished products, storage of finished products, distribution of products to customers / agents / distributors.

h. Key Partnerships

Key partnerships are the main partners in the business (eg suppliers) so that the business model can work. Companies or organizations make alliances to optimize their business models, reduce risk, or acquire resources (Osterwalder and Pigneur 2010: 38). CV XY’s main partners in developing the wood pellet business include: raw material suppliers, government, the private sector, associations and communities, agents and distributors.

i. Cost Structures

Cost structures are cost components used so that the organization or company can run according to its business model (Osterwalder and Pigneur, 2010). Cost structures themselves are formed from several cost components obtained through the creation and enhancement of value added (value propositions), dealing with customers (customer relationships), and obtainingrevenue streams. The cost structure issued by CV XY can be grouped into three, namely raw material costs, labor costs and costs overhead factory.

The BMC model after recommendations could be seen in Figure 3 below:

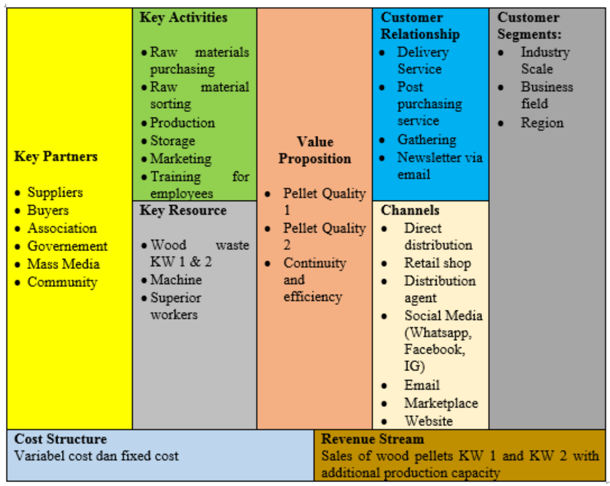


Figure 3. Wood Pellet Product Business Model Canvas Development

5. CONCLUSSION

Meubel center Pasuruan, based on IFE and EFE and SWOT analysis had strengths, weaknesses, opportunities and threats. Based on the IE matrix, it could be seen that strengths were greater than weaknesses and opportunities were greater than threats, so that in developing its business a company needs to use an aggressive strategy, namely focusing on increasing production capacity and increasing marketing with various media and distribution channels.

Development of the Pellet Business Model at CV XY Pasuruan using the Business Model Canvas (BMC) is as follows: (a) The value propositions or pellet product portfolio that CV XY currently offers are: quality fuel, easy to use, efficient and continuous.; (b) Customer segments or pelleted customer portfolios include customer segmentation based on scale, business sector and region. (c) Channels or distribution channels in the pellet business activities in CV XY include online channels and offline channels; (d) Customer relationships occur through: customer satisfaction strategies; (e) Revenue streams or revenue streams obtained by CV XY through the sale of wood pellet products; (f) Key resources or main resources in driving the pellet business activities in CV XY include: natural resources (wood waste), artificial resources (machines), and human resources. (g) Key activities or main pellet business activities in CV. XY, namely: purchasing raw materials, processing raw materials, packaging finished products, storing ready-to-sell products, and transporting products to customers, agents, distributors. (h) Key partnerships or main partners of CV XY in developing wood pellet business activities, namely: suppliers, government, Furniture, Crafts and Arts Forum, MSME / SME communities; (i) Cost structures or costs incurred by CV XY in order to develop the pellet business, namely, in the form of: raw material costs, labor costs, and factory overhead costs.

Recommendations for the CV XY Business Model Canvas (BMC) are as follows: (a) SO Strategy (Strength - Opportunity) (1) Increasing the amount of production by relying on abundant raw materials at relatively low prices; (2) Offering pellets to new customers by taking advantage of changes in fuel consumption. (b) ST Strategy (Strength - Threat) (1) Conducting young HR training in collaboration with the government; (2) Socializing the use of wood waste together with the government. (c) WO Strategy (Weakness - Opportunity) (1) Improving quality and set competitive prices to survive in industrial competition by taking advantage of low raw material costs; (2) Taking advantage of product marketing networks to win bargains. (d) WT (Weakness - Threat) Strategy (1) Outreach to suppliers to minimize mixing of ingredients and increase supplier understanding of product quality.

6. REFERENCES

Badan Pusat Statistik. (2000). *Indikator Sosial Ekonomi Indonesia*. Badan Pusat Statistik Indonesia, Jakarta.

Ciolkosz, D., (2009). Manufacturing Fuel Pellets from Biomass, Penn State Biomass Energy Center and Department of Agricultural and Biological Engineering. Penn State Renewable and Alternative Energy Program: energy.extension.psu.edu. The Pennsylvania State University 2009.

David, F. R., (2006). *Manajemen Strategi. Buku 1,* Edisi kesepuluh, Salemba Empat, Jakarta.

DEPTAN. (1970). *Limbah Kayu*, Balai Pustaka, Jakarta.

Jogiyanto., (2006). *Analisis & Desain Sistem Informasi : Pendekatan Terstruktur Teori dan Praktek Aplikasi Bisnis,* Andi Offset, Yogyakarta.

Joyce, A., & Paquin, R. L. (2016). The triple layered business model canvas: A tool to design more sustainable business models. *Journal of Cleaner Production*, *135*, 1474–1486. https://doi.org/10.1016/j.jclepro.2016.06.067

Kinnear, T., (1991). *Marketing Research. An Applied Approach,* 4 Ed, Mc Grow Hill, USA

Osterwalder, A., Pigneur, Y., (2010). *Business Model Generation A Handbook for Visionaries, Game Changers, and Challengers*, Wiley, New Jersey.

Roos, G. (2012). Manufacturing into the future. Adelaide Thinker in Residence 2010-11, Adelaide Thinkers in Residence, Government of South Australia, Adelaide, Australia. Retrieved from http://www.thinkers.sa.gov.au/roosreport/ files/inc/194455830.pdf.

Sylviani, D. H., Suryandari, E. Y. (2013). Analisis biaya penggunaan berbagai energi biomassa untuk IKM (studi kasus di kabupaten wonosobo). *Jurnal Penelitian Sosial dan Ekonomi Kehutanan*. 1(10): 48-60.

Tampubolon, A. P. (2008). Kajian kebijakan energi biomassa kayu bakar study of fuelwood biomass energy policies. *Jurnal Analisis Kebijakan Kehutanan*. 5(1): 29–37. Pusat Litbang Hasil Hutan, Bogor.

Tokarski, A., Tokarski, M., Wojcik, J., (2017). The Possibility of Using the Business Model Canvas in the Establishment of an Operator' S Business Plan, *Torun Business Review,* 16(4).

BUSINESS MODEL FOR STARTUP COMPANY PT JET KOE INDONESIA (CASE: JETQ APPLICATION DEVELOPMENT)

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ABSTRACT

Market potential of private jet air charter in Indonesia makes the startup company PT Jet Koe Indonesia was established. The company tries to develop a product as a solution for a lack in the current private jet air charter ordering process. To create value for customers and generate revenue, it is necessary to conduct a comprehensive study to create a business model concept suitable for the company. This research uses a quantitative descriptive approach in the form of survey research. The survey method was carried out using focus group discussions, interviews, and questionnaires as data collection tools. This study aims to develop a suitable business model for the new startup company PT Jet Koe Indonesia in developing JetQ products with the Lean Startup framework combined with the Value Proposition Canvas, Quality Function Deployment, and Business Model Canvas. The result of this study is a proposed business model that is considered suitable for the company described in the Business Model Canvas. From this analysis, it was found that the JetQ product concept focuses on providing a varied, safe, and easy private jet charter booking application platform. The concept of developing a business model carried out in this research can be applied and refined continuously so that it can keep the company continues to innovate quickly and generate value for customer satisfaction.

Keywords: Private jet air charter, Startup, Lean Startup, Value Proposition Canvas, Quality Function Deployment, Business Model Canvas.

1. INTRODUCTION

Aircraft is a mode of transportation that is very popular for many people in Indonesia. It can be seen from the increasing number of aircraft passengers, both domestic and international. Based on the data published by the Indonesian Central Bureau of Statistics (2019), domestic flights in Indonesia have an average increase of around 2.14% per year in the last five years. Meanwhile, international flights have an average increase of around 8.81% per year.

One type of air transportation favored by some people is private jet air charter. For some people, traveling by private jet is a routine for business travel and tourism. It is because the essential advantage of private jet charter operations is flexibility (Wells and Chadbourne, 1994). In commercial flights, a private jet is in the category of part 135, an aircraft with passengers 30 passengers below. Meanwhile, commercial aircraft with more than 30 passengers is a part 121. If viewed from the number of airlines in Indonesia, there are about 42 aircraft operators who have Air Operator Certificate (AOC) 135. This is 67.74% of all population of commercial airlines in Indonesia (Indonesian Ministry of Transportation, 2019).

Also, in the current era of the Covid-19 pandemic, it has a positive impact on private jet air charter. Public transportation like an airline will also be avoided due to higher pandemics risk. Private jet air charters will be chosen because people will prefer to travel while adhering to health protocols by avoiding public crowds that allow Covid-19 transmission to occur. It is predicted that the demand for air charters will continue to increase in the future. This is good market potential. Another consideration is because this potential number is not yet utilized by any online charter platform in Indonesia, a bright possibility for the startup platform that can accommodate the portion of the private jet charter (Setyantoro et al., 2018).

Seeing the market potential, startup company PT Jet Koe Indonesia was established to develop a platform application for ordering private jet air charter in Indonesia, JetQ. In the early stages of company establishment, a business model is needed as a guide for the company to creates, delivers, and captures value from its product (Osterwalder and Pigneur, 2010). Therefore, this research was conducted to develop a suitable business model for startup company PT Jet Koe Indonesia in terms of developing JetQ application.

2. BUSINESS MODEL AND LEAN STARTUP

Business model is a reflection of what customers want from a business, how customers want it, what they will get, and how a company can manage to meet customer needs. One of the newest definitions of a business model according to Osterwalder and Pigneur (2010) is a conceptual tool that contains a set of objects, concepts, and their relationships to express the business logic of a particular company. A framework that is often used to help companies visualize business models is the Business Model Canvas (BMC) developed by Osterwalder and Pigneeur (2010). In the matrix, there is a Value Proposition Canvas (VPC) matrix for developing value proposition products with a customer-centric approach (Osterwalder et al., 2014).

Startup companies that developing technological innovation products also need a business model as a reference in generating value for the company. Technological innovation does not guarantee business success (Teece, 2010). New product development efforts should be coupled with a business model defining their ’go to market’ and ’capturing value’ strategies. Many companies had been using their successful business models to enter new markets (Foss and Saebi, 2016). The fundamental activity of a startup is to transform an idea into a product, test the product for input and make necessary improvements based on the feedback (Belolipetskaya, 2019). Ries (2011) introduced the Lean Startup framework to develop startup companies. It is focusing on an iteration process called Build-Measure-Learn. One fundamental change is to accelerate the full circle of development.

There is a lot of literature that develops business models using the Lean Startup framework, VPC, and BMC. Some related research can be seen in Table 1. It is to get an overview of various aspects of the business model discussion. This paper focuses on the early-stage development of a business model for a startup company, PT Jet Koe Indonesia and creates a long-term business model innovation framework for the company.

Table 1. Comparison Literature Review

Authors (Years)	Country	Area	Methode / Approach				Finding
			Lean Startup	VPC	BMC	QFD	
Baptista (2015)	Portugal	Technology Company	✓	✓	✓		Lean startups are a suitable framework for companies to use in business model innovation. This framework is very flexible and encourages a culture of innovation.
Jarvenpaa (2014)	Finland	Startup Company	✓				Through the adoption of the Lean Startup method, Company Ltd was able to introduce a more complete and systematic working practice
Elonen (2019)	Finland	Startup Company	✓		✓		Early stage startups need to focus in acquiring multiple resources and networks to their team, rather than think about the strategic planning. From a product-oriented view the team should be considered as the front thought
Fitriani (2019)	Indonesia	Creative Industry			✓	✓	Business model innovation can create added value and competitive advantage as an opportunity to build a sustainable business. Combining the business model canvas method and the quality function deployment allows companies to carry out the latest innovations, develop superior products by prioritizing consumer needs.
Pitayachaval et al. (2017)	Thailand	Medical industry		✓	✓	✓	The company's ability to survival in business depends on providing to respond customer requirements. In order to respond customer requirements, the product development is the key success factor in the modern business
Proposed Model (2020)	Indonesia	Startup Company	✓	✓	✓	✓	Lean startup is suitable for a startup company. Combine with VPC and QFD you can respond to customer requirements, create value, and improve quickly. It can help to build product complete and systematic. Through BMC, the company can create revenue from the product value that has been created.

3. RESEARCH METHOD

This report is the results of a four-month research effort from October 2020 until January 2021. This type of research is to use a quantitative descriptive research approach paradigm. The form of this research is survey research. The survey method was conducted using focus group discussion, unstructured interviews, and questionnaires as data collection tools.

Sources of data used in this study come from primary data and secondary data. Primary data are direct data from focus group discussions, interviews, and questionnaires with respondents. The data taken comes from three sources, there are private jet air charter customers, providers, and PT Jet Koe Indonesia. Meanwhile, secondary data is from journals, books, and other documents that are considered relevant to the topic under study.

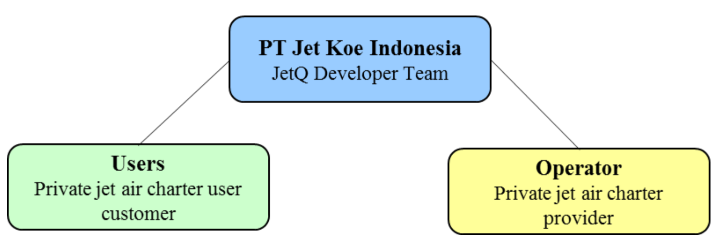


Figure 1. Data Collection Areas

The data processing model used is the Lean Startup framework. This method is used because the work process will be faster and more efficient. Also, using this method can minimize product failure when it is going to be marketed because this method focuses on the feedback that consumers give when the product is being worked on.

This method is carried out using three stages, there are Build, Measure and Learn (Ries, 2011). Each stage in the Lean Startup is combined with the Value Proposition Canvas, Quality Function Deployment and, Business Model Canvas.

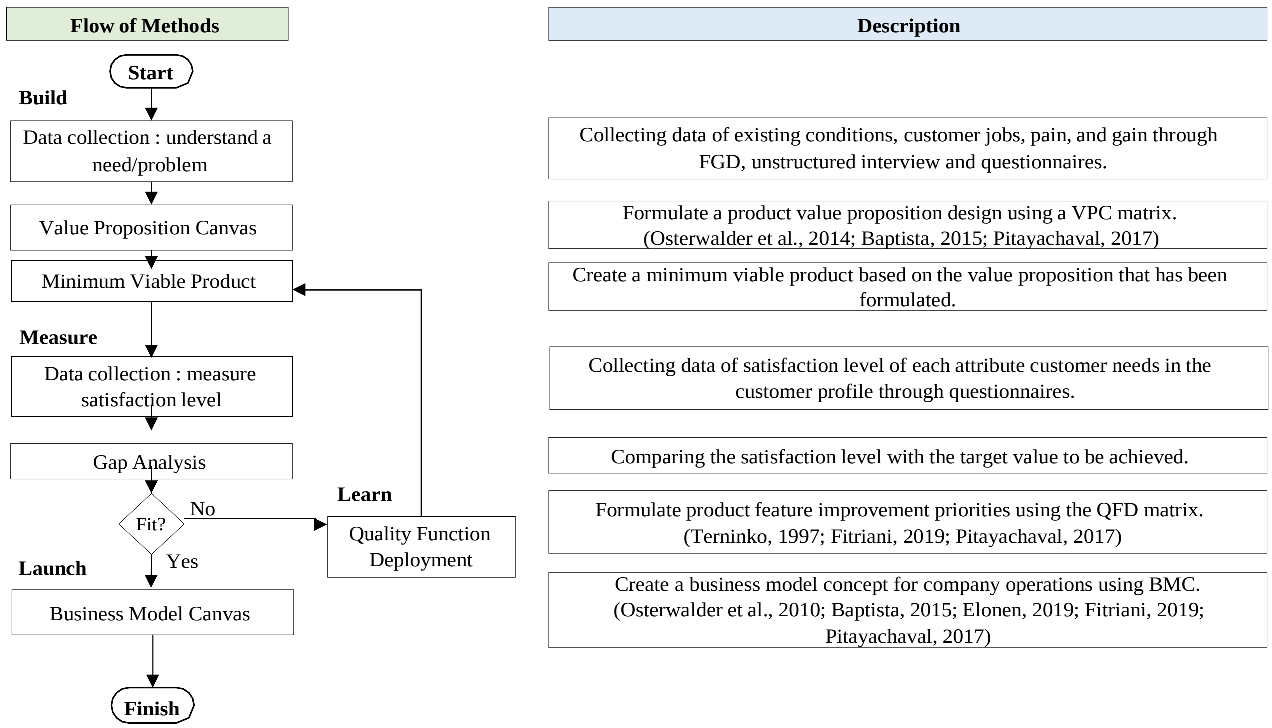


Figure 2. Flow Diagram of Methods

4. RESULTS AND DISCUSSION

4.1 Value Proposition Canvas

In the build stage, it uses a Value Proposition Canvas (VPC) where has two sides, the first side is the customer profile and the second side is the value map. The customer profile is useful for understanding the needs and wants of customers. Meanwhile, the value map describes how to create value for customers based on the customer profile.

4.1.1 Customer Profil

The customer profile is a useful framework for identifying customer needs. The required preliminary data are obtained through a focus group discussion with an air charter operator and practitioners to get the list of customer jobs, customer pains, and customer gains. After that, data validation was carried out by questionnaires to eight private jet air charter customers to get the importance level of each item. Determining the customer profile of eight sources is considered sufficient based on references from The Lean Startup (Ries, 2016) for the study requires around 6-12 people.

- Customer jobs are parts that describe what customers do. This research focuses on jobs when ordering a private jet air charter. The results of ranking customer activities in placing private jet air charter orders, ranging from insignificant to important can be seen in Table 2.

Table 2. Customer Jobs

Customer Jobs	Importance Level	Rank
Get information about aircraft availability & price quotation.	4.8	CJ 1
Comparing flight prices with other operators.	4.5	CJ 2
Define number of passengers and fill the data.	4.4	CJ 3
Define departure and arrival airport.	4.4	CJ 4
Define departure date and time.	4.1	CJ 5
Looking for private jet air charter providers.	4.1	CJ 6
Cancel or reschedule the flight.	4.1	CJ 7
Get the refund from operator.	3.9	CJ 8
Ask for additional services provided and order it.	3.6	CJ 9
Ask for available payment methods and carry out the payment process.	3.3	CJ 10
Waiting for payment confirmation and flight schedule.	3.0	CJ 11

- Customer pains is a part that describes what is annoying before, during, and or after doing an activity or job in the context of ordering a private jet air charter. The rating of customer pain is shown in Table 3.

Table 3. Customer Pains

Customer Pains	Importance Level	Rank
Unable to compare operator service levels.	4.3	CP 1
Relatively difficult to compare rental prices.	4.1	CP 2
Waiting for quite a long time to receive a flight price quote.	4.1	CP 3
Relatively difficult to find contact or information of the appropriate operator.	4.0	CP 4
A hassle to ask and find an available aircraft that fits the schedule and capacity.	4.0	CP 5
Ordering procedures are different for each operator.	3.6	CP 6

- Customer gains is a part that describes what results and benefits are desired by consumers. The rating of customer pain is shown in Table 4.

Table 4. Customer Gains

Customer Gains	Importance Level	Rank
Safe and comfortable transactions.	4.4	CG 1
Many aircraft options can be ordered.	4.0	CG 2
Many airport options are available for private jets.	4.0	CG 3
Can give a feedback regarding services provided.	3.9	CG 4
There are discounts or vouchers for travel.	3.9	CG 5
Clear and procedural refund.	3.8	CG 6
Can order additional services.	3.8	CG 7
There are payment options, making it easier.	3.6	CG 8
Can see aircraft specifications and interiors.	3.6	CG 9

4.1.2 Value Maps

Value map is an answer to the description of consumer needs that has been shown from the customer profile. By knowing every single thing that consumers do along with things that are annoying and that they want to exist, a value map is created to be able to overcome these things. The value map creation was carried out using a Focus Group Discussion approach by the development team from PT Jet Koe Indonesia. The following is the result of the value map in the form of products and services, pain relievers, and gain creators.

- Products and services are a section containing what products and or services are offered to consumers. The product to be developed is a JetQ application platform that accommodates all customer activities in ordering private jet air charters. In JetQ development will see flow process could be more convenient to use without leaving the important information.

Table 5. Products and Services

Customer Jobs	Products / Services	
CJ 1, CJ 2, CJ 3, CJ 4, CJ 5, CJ 6, CJ 7, CJ 8, CJ 9, CJ 10, CJ 11	PS 1	Air charter booking application, JetQ.

- Pain relievers are a part that contains anything that can relieve customer pain. Pain relievers created based on points in the customer profile are shown in Table 5.

Table 6. Pain Relievers

Customer Pains	Pain Relievers		Value
CP 1, CP 2	PR 1	Displays the price, rating and reviews of each aircraft.	Varied
CP 3	PR 2	Fast price calculation of the various aircraft available.	Varied
CP 4, CP 5	PR 3	Displays available aircraft from all operators the members of JetQ, automatically adjusted to the schedule and capacity.	Varied
CP 6	PR 4	Standard and convenient ordering procedure.	Easy

- Gain creators are a part that contains things that can make customers get customer gain. Products and services created based on the points in the customer profile are shown in Table 6.

Table 7. Gain Creators

Customer Gains	Gain Creators		Value
CG 1	GC 1	JetQ will be the third party between customers and operators, so transaction will be safe.	Safe
CG 2	GC 2	Increase the number of partners.	Varied
CG 3	GC 3	Provides many airports available for air charters.	Varied
CG 4	GC 4	Developed rating and reviews features.	Varied
CG 5	GC 5	Provide discounts or vouchers for promotion.	Value-added
CG 6	GC 6	Provide easy refund procedure according to the terms and conditions.	Easy
CG 7	GC 7	Displays additional services provided by each aircraft.	Easy
CG 8	GC 8	Provide a choice of payment methods.	Easy
CG 9	GC 9	Displays detailed specifications of the aircraft including the interior.	Varied

From the attributes listed in pain relievers and gain creators, the value that JetQ application wants to create is providing a private jet application that varied, safe and easy.

4.2 Minimum Viable Product

After we get the attributes and flow process from ordering a private jet air charter, the next step is to develop a minimum viable product. The MVP to be developed is based on the identified features of pain relievers and gain creators. The order flow also changes, because currently, JetQ is the third party between customers and operators in making transactions. However, the main work activity in ordering private jet air charters is not eliminated.

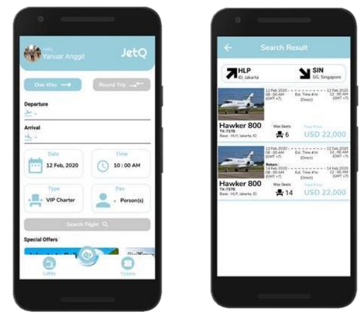


Figure 3. JetQ MVP

4.3 Gap Analysis

Gap analysis is used to measures which customer profiles have not been answered from the products that have been developed. Gap analyzed by comparing the level of customer satisfaction with the target value. The target value to be achieved for each customer profile attribute is equal to the importance level. The team believes that the higher the importance level of customer needs, the higher the satisfaction level must be. Because if important things are met, it is expected that customers will be satisfied with the product being developed. The following is the result of the gap obtained from the importance level and satisfaction level:

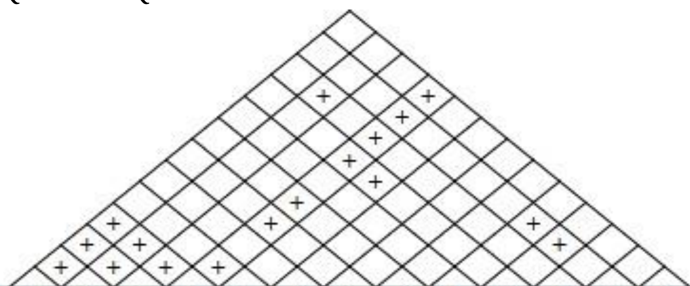
Table 8. Gap Analysis

Customer Profile	Target Value	Satisfaction Level	Gap	Info
CJ 1	4.75	4.38	0.38	Improve
CJ 2	4.50	3.75	0.75	Improve
CJ 3	4.38	2.75	1.63	Improve
CJ 4	4.38	4.38	0.00	Fit
CJ 5	4.13	4.00	0.13	Improve
CJ 6	4.13	4.50	-0.38	Fit
CJ 7	4.13	1.50	2.63	Improve
CJ 8	3.88	1.25	2.63	Improve
CJ 9	3.63	3.75	-0.13	Fit
CJ 10	3.25	3.63	-0.38	Fit
CJ 11	4.13	3.25	0.88	Improve
CP 1	4.13	4.38	-0.25	Fit
CP 2	4.00	4.50	-0.50	Fit
CP 3	4.00	4.50	-0.50	Fit
CP 4	3.63	4.38	-0.75	Fit
CP 5	4.38	4.50	-0.13	Fit
CP 6	4.00	1.88	2.13	Improve
CG 1	4.00	4.38	-0.38	Fit
CG 2	3.88	4.13	-0.25	Fit
CG 3	3.88	1.00	2.88	Improve
CG 4	3.75	1.50	2.25	Improve
CG 5	3.75	4.38	-0.63	Fit
CG 6	3.63	2.63	1.00	Improve
CG 7	3.63	4.25	-0.63	Fit
CG 8	3.00	3.00	0.00	Fit
CG 9	4.25	2.13	2.13	Improve

4.4 Quality Function Deployment

Customer profile items that have not reached the target will be increased their satisfaction level by improving related features. The relationship between a customer profile and features is analyzed using the QFD matrix in Table 9.

Table 9. QFD of JetQ Features



Row #	Relative Weight	Weight	Maximum Relationship	Features / Voice of Customer	Displays the price, rating and reviews of each aircraft	Fast price calculation of the various aircraft available	Displays available aircraft from all operators the members of JetQ, automatically adjusted to the	Standard and convenient ordering procedure	JetQ will be the third party between customers and operators, so transaction will be	Increase the number of partners	Provides many airports available for air charters	Developed rating and reviews features	Provide discounts or vouchers for promotion	Provide easy refund procedure according to the terms and conditions.	Displays additional services provided by each aircraft	Provide a choice of payment methods	Displays detailed specifications of the aircraft including the interior.
				Column #	1	2	3	4	5	6	7	8	9	10	11	12	13
				Direction of Improvement	▲	▲	▲	▲	▲	▲	◇	▲	▲	▲	▲	▲	▲
1	5.33%	5.16	9	Get information about aircraft availability & price quotation	●	●	●	▽		○							○
2	5.58%	5.40	9	Comparing flight prices with other operators	●	○	○			●		○			●		○
3	7.19%	6.96	9	Define number of passenger and fill the data			●	●									
4	4.39%	4.25	9	Define departure date and time			●	●									
5	11.72%	11.34	9	Cancel or reschedule the flight		●	○	●						●			
6	12.41%	12.01	9	Get the refund from operator				●	●					●		○	
7	8.78%	8.50	9	Unable to compare operator service levels	●				●	●		●			●		○
8	5.41%	5.24	9	Relatively difficult to compare rental prices	●	●			●	●							
9	8.82%	8.53	9	Many aircraft options can be ordered	○	▽	○		●	●							
10	15.51%	15.02	9	There are discounts or vouchers for travel									●				
11	9.69%	9.38	9	Clear and procedural refund				●	●					●		○	
12	5.17%	5.01	9	There are payment options, making it easier												●	
	100%			Max Relationship	9	9	9	9	9	9		9	9	9	9	9	3
				Technical Importance Rating	252.327	227.663	230.567	413.941	405.926	273.255	0	95.7714	139.618	304.341	129.245	112.835	59.0657
				Relative Weight	9.5%	8.6%	8.7%	15.7%	15.3%	10.3%	0.0%	3.6%	5.3%	11.5%	4.9%	4.3%	2.2%
				Rank	5	7	6	1	2	4	13	11	8	3	9	10	12

From the QFD matrix, priority JetQ features for improvement are obtained in Table 10.

Table 10. Priority Features to be Improved

Features	Weight	Priority
Standard and convenient ordering procedure	15.7%	1
JetQ will be the third party between customers and operators, so transaction will be safe	15.3%	2
Provide easy refund procedure according to the terms and conditions.	11.5%	3
Increase the number of partners	10.3%	4
Displays the price, rating and reviews of each aircraft	9.5%	5
Displays available aircraft from all operators the members of JetQ, automatically adjusted to the schedule and capacity	8.7%	6
Fast price calculation of the various aircraft available	8.6%	7
Provide discounts or vouchers for promotion	5.3%	8
Displays additional services provided by each aircraft	4.9%	9
Provide a choice of payment methods	4.3%	10
Developed rating and reviews features	3.6%	11
Displays detailed specifications of the aircraft including the interior.	2.2%	12
Provides many airports available for air charters	0.0%	13

4.5 Business Model Canvas

(7) Key Partners	(6) Key Activities	(2) Value Proposition	(4) Customer Relationships	(1) Customer Segments
• **Partner** (private jet operator) • **Server infrastructure provider**	• **Operational** (private jet booking) • **Sales and Marketing** • **User data management** • **IT Developing**	• **JetQ Apps** (providing a private jet application that varied, safe and easy)	• **Discounts and vouchers** • **Rating and review in application** • **Customer Service** (phone, mobile, email, chat)	• **Niche Market** (customer who frequently uses private jet charter)
	(8) Key Resources • **Core team PT Jet Koe Indonesia** • **Employees** • **Supporting technology**		**(3) Channels** • **Google Play Store** • **App Store** • **Website** • **Social Media**	
(9) Cost Structure • **Development costs** • **Marketing costs** • **Employee salary** • **Server rental cost**	• **Office rental cost** • **Tax** • **Others** (incidental cost)	**(5) Revenue Streams** • **Rental fee** (from private jet charter customer, who uses JetQ)		

Figure 4. Business Model Canvas of JetQ

Before releasing the product to the market, it needs to create a business model that is suitable for the product. The business model for JetQ is described using the Business Model Canvas created through an FGD with a developer team from PT Jet Koe Indonesia. Following the results of the Business Model Canvas from the discussion:

- **Customer Segment** is a niche market, those who have frequently used private jet air charters for trips.
- **Value Proposition** offered on the JetQ application is providing a private jet air charter booking service application that varied, safe, and easy.
- **Channels** that will be used to distribute JetQ are Google Playstore, Apps Store, Website, and Social media.
- **Customer Relationship** programs and media that will be used to maintain customer loyalty are Discounts and Vouchers, Ratings and Reviews in apps, and Customer Service (phone, fax, chat, email).
- **Revenue Streams** at the beginning of the JetQ product operation are from the rental costs, the customer of private jet air charters who use the JetQ application for booking.
- **Key Activities** in this business are connecting providers & customers, marketing activities, user data management, and IT development.
- **Key Partner** of PT Jet Koe Indonesia to run the JetQ application is a private jet air charter providers and server infrastructure providers.
- **Key Resources** of PT Jet Koe Indonesia are the core team of PT Jet Koe Indonesia (Founder and Co-founder), Employees, and supporting technology for JetQ application development.
- **Cost Structure** that will be issued by PT Jet Koe Indonesia is marketing costs, employee salary, server rental costs, officerental costs, tax, and other (incidental costs).

5. CONCLUSION

This study successfully applied the VPC dan QFD to formulate a value proposition for the development of the JetQ application concept. It can respond to customer requirements, create value, and improve quickly. It can help to build product complete and systematic. Then, through BMC the company can create revenue from the product value that has been created. From this analysis, it was found that the JetQ product concept focuses on providing a varied, safe, and easy private jet charter booking application platform.

The concept of developing a business model carried out in this research can be continuously applied and refined so that it can keep the company continues to innovate quickly and generate value for customer satisfaction. This framework is very suitable for future JetQ product development, such as JetQ Heli Charter, JetQ air medevac, JetQ air cargo, and others.

6. ACKNOWLEDMENTS

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7. REFERENCES

Baptista, M.N., (2015). Business Model Innovation using Lean Methodologies for Companies with Established Technologies. *Summary of dissertation for Master degree*. Instituto Superior Técnico. Lisboa.

Elonen, A., (2019). An Empirical Evaluation of Business Model Canvas in Software Startups: A Team Perspective. *Master Thesis*. University of Jyvaskyla. Finland.

Fitriani, R., (2019). Analisis Model Inovasi Bisnis Berbasis Business Model Canvas dan Quality Function Deployment. *Master Thesis.* Universitas Pendidikan Indonesia. Bandung.

Foss, N.J. and Saebi, T., (2017). Fifteen years of research on business model innovation: how far have we come, and where should we go?. *Journal of Management, Vol. 43 No. 1, pp. 200-227*.

Indonesian Central Bureau of Statistics, (2019). *Statistik Transportrasi Udara 2019.* Badan Pusat Statistik. Jakarta.

Indonesian Ministry of Transportation, (2019). *Civil Aircraft Register.* Direktorat Kelaikudaraan dan Pengoperasian Pesawat Udara. Tangerang.

Jarvenpaa, T., (2014). Lean Startup Method in Business Model Creation. *Master Thesis*. Turku University of Applied Sciences. Finland.

Osterwalder, A., & Pigneur, Y., (2010). *Business Model Generation*. New Jersey: John Wiley& Sons, Inc. New Jersey.

Osterwalder, A., Pigneur, Y., et al., (2014). *Value Proposition Design*. New Jersey: John Wiley& Sons, Inc. New Jersey. USA.

Pitayachaval, P., Chittrakool, K., & Arjharn, W., (2017). Integration of Business Model Canvas (BMC) and Quality Function Deployment (QFD) to Design Product. *4th International Conference on Industrial Engineering and Applications*, Nagoya.

Ries, E., (2011). *The Lean Startup*. New York: Crown Business. USA.

Setyantoro, G.H., Wijaya, A. & Akhyarsi, O., (2018). Developing an Online Platform for Air Charter Services in Indonesia: A Feasibility Study. *Conference & Exhibition on Business, Applied Science and Technology*, Jakarta.

Teece, D.J., (2010). Business Models, Business Strategy and Innovation. *Long Range Planning, vol 43 pp.172-194*.

Terninko, J., (1997). *Step-by-Step QFD Customer Driven Product Design 2nd Edition.* St. Lucie Press. USA.

Wells, A. T., & Chadbourne, B. D., (1994). *General aviation marketing and management*. Krieger Publishing Company. Malabar, Florida.

TOPIC

Management of IT/IS

AN ADAPTIF INFORMATION SIMPLE GAME TO CLARIFY THE FACT AND THE MYTH OF PREGNANCY

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ABSTRACT

The myth of pregnancy is a story, opinion or opinion in a culture that is considered to have true value, which contains recommendations and prohibitions regarding pregnancy that have been in effect at a time ago to the present whose truth is not necessarily true. During pregnancy, usually there will be advice from relatives, family, friends and also from those around them, about what to do and what not to do during pregnancy. Although the aims and objectives are good, not all of the advice or pregnancy abstinence is medically or scientifically correct. Therefore, an information medium was created that could clarify the myths of pregnancy that had been circulating in the community, so as to minimize the negative impact of these myths. In order to know what the truth is and not just follow something that is not known the reason and reality. For example, the myth about dietary abstinence in pregnant women is actually very detrimental to the health of pregnant women and the fetuses they contain, especially foods that are needed to fulfill the nutrition of pregnant women and fetuses, so that they can cause pregnant women to suffer from malnutrition such as anemia, bleeding during childbirth and babies born can experience LBW. Therefore this program is made for pregnant women who still believe in the myths of pregnancy. Through this program, it will add more insight to pregnant women, and will provide a form of medical evidence as a form of truth. In addition, this program is also to entertain like a quiz game to guess myths or facts.

Keywords: Pregnancy myths, maternal health, quiz games to guess the myths or facts.

1. INTRODUCTION

Myth is a story, or opinion in a culture that is considered to have the truth about a matter that has prevailed in a past, the truth of which is not necessarily true. Myth is included in the theological stage or the metaphysical stage. Mythology means knowledge of myths which is a collection of mythical stories. According to C. A. Van Peursen myth is a story that provides certain guidelines or directions to a group of people. The story can be transmitted, it can also be expressed through dances or wayang performances, and so on. Myth, maybe as old as language itself. Some myths survive because they provide advice that is relevant to everyday experiences. However, there are many myths, one of which is widespread one of which are the myths surrounding pregnancy and childbirth, which have been proven to be false or ineffective according to advances in medicine and technology. Pregnancy is a state of pregnancy, the extent of pregnancy is a relatively recent change in state, especially for women who experience it for the first time. During this period there were physical changes that affected the woman's daily movements and activities. The myth of pregnancy is a story, opinion or opinion in a culture that is considered to have the truth, which contains suggestions and prohibitions regarding pregnancy that have been in effect at a time ago to the present whose truth is not necessarily true. Every prohibition, taboo or recommendation, still has a reason. Especially now that pregnancy problems can be consulted with a doctor or midwife. Technology and the medical world have succeeded in helping pregnant women in various ways, for example, through tests for pregnant women that can predict the sex of the baby they are carrying. Behind all these technological developments, myths have emerged, one of which is the myth of pregnancy.

The phenomenon that has occurred to date regarding the myth of pregnancy, whether consciously or not, is often found in the community because of the strong culture and customs that apply in society in the form of recommendations, taboos or rules that are believed by the community when experiencing pregnancy. Some people even believe in these myths which vary from time to time. In fact, their existence can be different in each region. During pregnancy. Usually there will be a lot of advice from relatives, family, friends and also from people around them, about what is and isn't allowed during pregnancy. Even though the intent and purpose are good, not all of the advice or pregnancy abstinence that is announced is medically or scientifically correct. Most of the facts are based on myth or belief rather than reality. Therefore, an information medium was created that can clarify the myths of pregnancy that have been circulating in the community, so as to minimize the negative impact of these myths. In order to know what the truth is and not just follow something that is not known the reason and reality. There are many myths about pregnancy that develop in society, especially the common people, whose existence varies from time to time. Each region has its own characteristics which are adapted to the culture of its ancestors at that time. So that the myth that is believed by the community itself is still thick. These myths can be in the form of advice, suggestions or prohibitions. From the explanation previously disclosed, it can be broken down into several parts of the problem, namely:

a. There are still many mythical phenomena about pregnancy that occur in society.
b. There are still many people who believe in the myth of pregnancy.
c. There are suggestions and prohibitions circulating in the community regarding the myth of pregnancy.
d. There is still a lack of information obtained by the public about the myths of pregnancy.
e. There are worries experienced during pregnancy. Maternal Mortality Rate in Indonesia in 2017 until March was recorded 305 per 100,000 births.

Meanwhile, in 2016 the figure was 4834. The highest cause of maternal death, 32% was due to bleeding. Meanwhile, 26% is caused by hypertension which causes seizures, pregnancy poisoning which causes the mother to die and other causes of maternal death are hormonal, cardiovascular, and infection factors (Ministry of Health, 2017). For this reason, a technology has been developed that can help people access a variety of accurate information, but in fact, not a few people believe in myths, especially people who are currently pregnant, they still tend to believe in myths that require dietary abstinence during pregnancy.

2. METHOD

Many affect health in Indonesia, among others, it still exists hereditary socio-cultural influences still adhered to today, especially myths. Also, a number were found assessed cultural knowledge and behavior incompatible with health principles according to medical science or even provide less health impact beneficial for both mother and child.With these myths still being used today, there will be fear of these myths, fear that if they are not believed it will happen. For that we need research that can be proven true and is a theory called scientific. Clear studies on the condition of people who still believe in myths that can make them afraid. Even though the myth is not

necessarily justified scientifically. That way people know what to do now and in the future. Not only myths for pregnant and breastfeeding people, but other myths must also have scientific evidence and do not directly believe these myths. To conduct research on the myths and facts of this pregnancy, the researcher used descriptive research with qualitative methods. Researchers use qualitative research methods because the opinion of each individual / society is different about pregnancy, and also because of the nature of the qualitative approach which says that reality is multiple, complex, dynamic, and the truth of reality is dynamic. (Mulyana, 2013: 147). In addition, qualitative research is a process of research and understanding based on a methodology that investigates social phenomena and human problems. In this approach, the researcher creates a complex picture, examines words, collects data from accredited journals, and makes observations in the field. The data collection technique used in this study is the observation technique. Observation is a method of collecting data through the human senses. In observation, the researcher is involved in the daily activities of the person being observed or used as a source of research data. Researchers perform data analysis by enriching information, looking for relationships, comparing, finding basic patterns of the original data (not transformed into numbers). The results of data analysis in the form of an explanation of the situation under study are presented in narrative form in the hope of collecting data on the myths and facts of pregnancy which the researcher will convey to the community through the program that will be made.
Steps

1. Observation

Researchers conducted field observations and collected data related to and supported by research through various accredited journals.

2. Program Design

Then from these data the researchers designed a program to convey the truth about the myths and facts of pregnancy to the public with the hope that the community would be able to correctly distinguish between facts and myths of pregnancy.
First, the researcher conducted field observations and collected related data and supported the research title through various accredited journals. Then from this data the researcher designed a program to convey the truth about the myths and facts of pregnancy to the public in the hope that the community would be able to distinguish correctly between the facts and the myths of pregnancy.

3. DISCUSSION

Pregnancy myths are related to changes in the anatomy and physiology of pregnant women, pregnancy myths are related to foods that are prohibited and recommended for pregnant women, myths related to the behavior/psychology of pregnant women are an opinion or assumption in a culture. They still consider this myth to have been true in the past, even though the truth is not necessarily true. In fact, all existing myths can happen but are still possible due to coincidence. The myth of pregnancy relates to foods that are prohibited and recommended for pregnant women where mutton, sea fish are prohibited, will be very detrimental to pregnant women, where sea fish and meat have high protein nutritional value. Protein function is to help form new cells and increase immunity. Pregnant women can consume pineapple, strawberry because these two fruits contain high levels of vitamin C (ascorbic acid). Foods rich in vitamin C also help in the absorption of iron in the body. However, if the excess will cause stomach acid to increase, while the physiological changes of pregnant women, one of which is increased stomach acid. So if this is the case, consuming fruit with high vitamin C content needs to be limited. Likewise, consuming spicy foods. Pregnant women are advised to drink coconut oil (one tablespoon per day) before birth and drink a lot of coconut water which is completely unrelated to labor. All food elements will be broken down in the small intestine into amino acids, glucose, fatty acids, etc. so that they are easily absorbed by the intestine. However, the smoothness of the delivery process is influenced by the 5 P's including: power (pushing the mother), passanger (fetus), passage (birth canal), psychological (mental and readiness of the mother) and paramedics. Each of these factors has a long explanation, if the five factors are in good condition, prepared, the labor process will run smoothly. Myths related to the behavior / psychology of pregnant women in the form: prohibited from closing all holes, prohibited from passing behind a sitting pregnant woman, prohibited from eating with large plates, prohibited from lifting clothespins and doing heavy movements are irrational, because pregnancy is influenced by 5 P includes: power (pushing the mother), passanger (fetus), passage (birth canal), psychological (mental and readiness of the mother) and paramedics (Sukarni, 2013).

4. RESULT

Cultural Beliefs and Practices During Pregnancy

The kinds of myths surrounding pregnancy, among others: drinking ice makes a big fetus, mother pregnant should eat twice as much, should not eat pineapple, banana and durian Ambon, mother pregnant should not eat mutton, restrict certain foods, do not work or strenuous exercise, should not massage the stomach, no intercourse, drinking herbs, drinking water coconut hastens birth, it shouldn't be take long trips, drink mother's milk pregnant causes big babies, you get pregnant it is advisable to install small scissors or a knife small on underwear, belly shape determine the sex of the baby, if it is nipple dark, means the child conceived by a boy, eating green beans makes baby's hair bushy, drinking coconut water makes baby's skin turn white, drink coconut oil in order easy to give birth, pregnant women do not drink soda, the use of ultrasound is harmful to the fetus, the myth of mother's unfulfilled wishes resulting in the baby falling out, prohibited from sewing and cutting clothes, often doing intercourse during late pregnancy to run smoothly in the process of giving birth. Habits that mothers do during pregnancy. Based on the results of data collection through articles and websites, the habits that mothers adhere to during pregnancy can be seen in the following table.

Table 1. Habits of Mothers During Pregnancy

No	Habits	Believed Influence
1	Carry sharp objects such as scissors, pins tied to clothes or underwear for pregnant women	Protect mother and baby from evil spirits and spirits
2	Move a lot and walk around, especially in the morning when the air is still fresh	So that the delivery is smooth
3	Mothers who are pregnant are encouraged to do frequent dive movements, including mopping the floor by hand	So that the fetus in the womb quickly descends and opens the birth canal and makes labor smoothly without difficulty
4	Pregnant women with long hair are encouraged to tie their hair	So that it looks neat and clean
5	Pregnant women are prohibited from consuming green beans	Consumption Green Peas Make Baby Hair Thick
6	Pregnant women are prohibited from sewing clothes	Later the baby's lips will be cleft
7	Should not choose a cat when pregnant	Because it is dangerous for the fetus

No	Habits	Believed Influence
8	It is advisable to eat leaves of kaempferia galanga, a type of fern that contains a lot of mucus	So that the mother and the baby they are carrying are healthy

Source: Secondary Data

Don'ts That Mothers Should Follow When Pregnant

Based on the results of data collection through articles and websites, regarding the taboos that pregnant women must follow, they are as follows.

Table 2. Dont's That Mother Should Follow When Pregnant

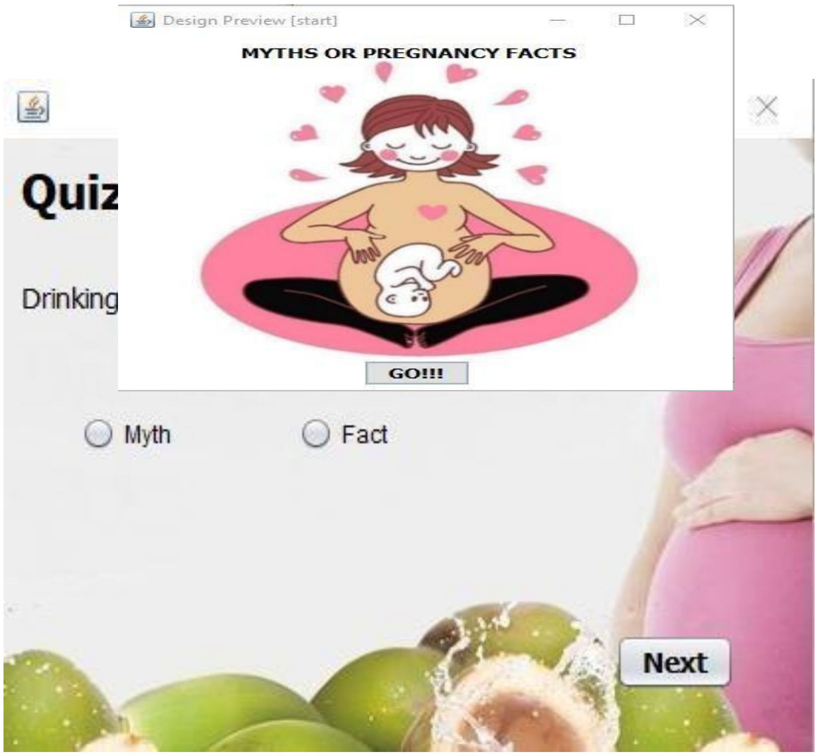
No	Prohibition	The believed result
1	Wear torn clothes	The baby will be disabled
2	Get out and take a walk at night	Will be followed and harassed by spirits
3	Sitting in Bangbarung (in front of the door)	Difficult during childbirth
4	Sitting on the porch of the house with feet ngarumbay (protruding to the ground)	Inhibits the birth of the baby
5	Sit on a rock	Inhibits the birth of the baby
6	Sit anywhere	Inhibits the birth of the baby
7	Wrap a towel around the neck	The umbilical cord is twisted
8	See the person who is making a hole in something	There are holes in the child's ears
9	Eat noodles	Resulted in the uterus out
10	Eat fruits that stick together / stick together	Resulting in babies to be born conjoined twins

Source: Secondary Data

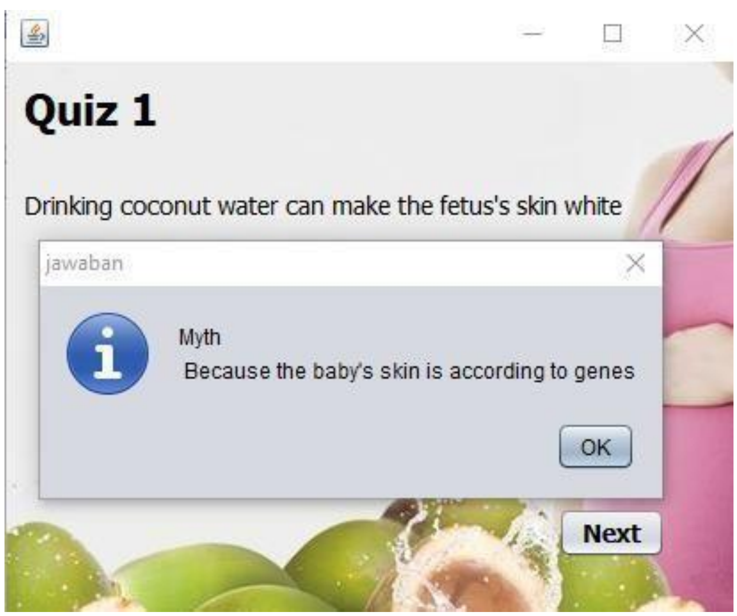
The results of the study revealed that some of these taboos included that prospective fathers were prohibited from slaughtering animals such as chickens, sheep, snakes and so on because it was believed that babies born later would have red necks. Prospective fathers are also prohibited from speaking harshly / casually, the aim is for the safety of the mother and baby. In addition, prospective fathers are also prohibited from wrapping a towel around the neck because it is believed that the baby's neck will be wrapped around the umbilical cord so that it will be difficult for the baby to be born during labor. As long as his wife is pregnant, the husband is also prohibited from fishing because it is believed that the baby that his wife is carrying can have cleft lip defects. Even though there are these taboos, the community still believes that it is permissible to do so as long as the prospective father invites the baby in his wife's womb even though he is far away, for example the prospective father is in Bandung while his pregnant wife is in Karangsari, when he will do an activity which is prohibited like fishing, by saying "Dede utun let's fish" (baby sister let's go fishing). By inviting this, it is believed that the dreaded effect, namely the umbilical cord wrapped around the neck, will not happen to the baby. A series of rituals that must be performed by the husband during the period of pregnancy, childbirth and postpartum of his wife, known as the couvade ritual, is a form of husband involvement (Helman: 2002, Cooper: 2005). With this, a simple game program for pregnant women about quizzes on the myths and facts of pregnancy is made with the aim of helping pregnant women better understand and gain insight that these emerging myths are not true compared to medical research evidence.

Here is the result of the program we created

1. Presented the user start menu selects "go" to start the game.



2. A statement is presented, then the user must choose the answer to myth or fact, for the next question the user presses the "next" button.
3. When the user chooses an answer to a myth or fact, the program will issue an answer dialogue board along with the reason.



5. CONCLUSION

People today still follow the habits that should be done by mothers during pregnancy and also restrictions/prohibitions that must be avoided by pregnant women. They believe that violating these restrictions will result in bad things for the mother and the baby they are carrying. Myths related to the behavior/psychology of pregnant women in the form: prohibited from closing all holes, prohibited from passing behind a sitting pregnant woman, prohibited from eating with large plates, prohibited from lifting clothespins and doing heavy movements are irrational, because pregnancy is influenced by 5 P includes: power (pushing the mother), passanger (fetus), passage (birth canal), psychological (mental and readiness of the mother) and paramedics.

6. REFERENCE

Cooper, S. (2005). *A Rite of Involvement?: Men's transition to fatherhood. Durham Anthropology Journal Volume 13(2) ISSN 1742-2930.*

Helman, G.C. (2002). *Culture, Health and Illness. London: Arnold Publisher.*

Agus, Y., Horiuchi, S. and Porter. S. (2012). Rural Indonesia women's traditional beliefs about antenatal care. BMC Research, 5:589. http://www.biomedcentral.com/1756-0500/5/589.

Hindaryatiningsih, N. (2016). *Model Proses Pewarisan Nilai-Nilai Budaya Lokal Dalam Tradisi Masyarakat Buton. Sosiohumaniora, Volume 18 (2): 100 – 107*

M'soka, N.C., Mabuza L.H. and Pretorius, D. (2010). *Cultural And Health Beliefs Of Pregnant Women In Zambia Regarding Pregnancy And Child Birth.Curationis38(1), Art.#1232,7pages.http://dx.doi.org/10.4102/curationis.v38i1.1232Maharlouei, N. (2016). The Importance of Social Support During Pregnancy. Women's Health Bull, 3(1):e34991. doi: 10.17795/whb-34991*

Naidu, M. and Koleki, N.K. (2013). *Indigenous Mothers: An Ethnographic Study of Using the Environment during Pregnancy. Ethno Med,7(2), 127-135*

Otoo, P., Habib, H. and Ankomah, A. (2015). *Food Prohibitions and Other Traditional Practices in Pregnancy: A Qualitative Study in Western Region of Ghana. Advances in Reproductive Sciences, 3(1) 4149. http://dx.doi.org/10.4236/arsci.2015.33005*

Rowan, C. (2006). *Maternal infant Attachment. In:Squire, C (eds) The Social Context of Birth (pp:153-171). Radcliffe Medical Press Ltd: Abingdon*

Thomas, C.J., Letourneau, N.N., Campbell, T. and Giesbrecht, F.G. (2015). *Maternal social support during pregnancy supports postnatal maternal caregiving via reductions in prenatal depression. Paper presented at Alberta Children's Hospital Research Symposium, Calgary, April.*

Ministry of Health (2017). *https://www.neliti.com/id/kemenkes*

THE EVALUATION OF LOCAL GOVERNMENT WEBSITE OF EAST NUSA TENGGARA PROVINCE: AN INTEGRATION OF UTAUT2AND IS SUCCESS MODEL

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ABSTRACT

The aims of writing this paper is to identify the success and acceptance of the local government website of East Nusa Tenggara Province www.nttprov.go.id through the integration of the UTAUT2 model and Information System Success Model. Using the online survey method, with a research sample of 175 respondents consisting of the State Civil Apparatus (ASN) of the East Nusa Tenggara Province and part of the people in Kupang City as users of the NTT Provincial Government website www.nttprov.go.id. Primary data collected were analyzed using SEM-AMOS software. The results showed that information satisfaction substantially affects performance expectancy, system quality substantially affects information quality, system satisfaction substantially affects information satisfaction, system quality substantially affects system satisfaction, system satisfaction substantially affects effort expectancy, support quality substantially affects support satisfaction, hedonic motivation substantially influences behaviour intention to use website, habits substantially influences behaviour intention to use website, and habits that have an influence on behaviour intention to use website are moderated by experience. The results of this study will help the administrators of the NTT Provincial government website to be able to increase user behaviour intentions in using regional government website that are integrated and comprehensive.

Keywords*:* E-Government, Website, UTAUT2, IS Success, SEM

1. INTRODUCTION

The East Nusa Tenggara Provincial Government as an inseparable part of the government has the duties, functions, and position in administering and implementing various aspects of development, governance, and community services to accelerate the progress of society in realizing the Vision of an Awakened, Prosperous Society. In carrying out its duties and functions, the Provincial Government of East Nusa Tenggara is required to be able to provide good and effective services and also qualified and reliable public services that can support the implementation of an Electronic-Based Government System.

One of the products-government which has become a medium to increase interest and opportunities for citizens in obtaining public services and feedback from citizens to government is the website (Satriya, 2006). This is what was then developed by world countries and also Indonesia. Through the website, some information can be provided by the government to its citizens, businesses, and / or to the same government. The website is a window of the entire wealth of information owned by the government, both the central government and regional governments that are used as support for the development and implementation of the government as well as the improvement of public services electronically to the community.

Evaluation of public service work through government websites is an important variable to reveal the extent to which the quality of digital website services and the popularity of website services in the perceptions ofcitizens of the quality of services they consume as well as the level of citizen satisfaction and acceptance of services provided by the government online (Magoutas and Mentzas, 2007). McLean (1992) said that after an information system includes implementation phases in the information system development life cycle, it is necessary to conduct a post-implementation study. The aims of this study is to determine the effectiveness of thesystem and examines the extent to which the system can achieve its objectives and evaluate the system development process. The quality of the website can be said to be good if the website is tested and always revises or improves the system and its implementation (Yulius, 2016).

Addressing this, and for an integrated and comprehensive public service development process in an electronic governmental system oriented towards users of public services in the community, then researcher is interested in studying it as a topic of research by evaluating the regional government website of the East Nusa Tenggara Province, namely www.nttprov.go.id by integrating the UTAUT2 Acceptance Model and Information System Success Model.

2. METHODS

In this study the UTAUT2 model is used to measure the acceptance of the use of the local government website services seen from the way in which the behaviour is used when using the local government website, while the Delon and McLean IS Success Model is used to measure the success of the local government website services.

Several components in the UTAUT2 model and IS Success can be combined to avoid repeated measurements. Facilitating conditions and service quality can be combined to become support quality, where the support quality is related to the technical and managerial support that is received by individuals when interacting with the system. **Figure 1** shows the UTAUT2 and IS Success integration models that used in the research.

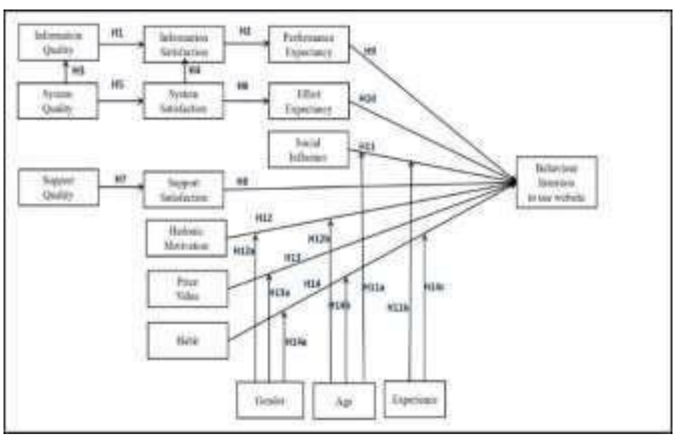

Figure 1. The Research Model

The research framework that results in this integration consists of thirteen variables, six independent variables namely (1) system quality, (2) support quality, (3) social influence, (4) hedonic motivation, (5) price value, dan (6) habit; seven dependent variables namely (1) information quality, (2) information satisfaction, (3) system satisfaction, (4) support satisfaction, (5) performance expectancy, (6) effort expectancy, and (7) behaviour intention to use website; and three moderation variables namely age, gender and experience. The construction in this proposed research has often been used in previous information systems research (Livari, 2005; DeLone and McLean, 2003; Venkatesh et al., 2012; Seddon, 1997; Seddon and Kiew, 1994).

The results of the integration obtained fourteen hypotheses that still had to be tested. The explanation of each hypothesis in this research model is set as follows:

H1: Information Quality substantially affects Information Satisfaction.
H2: Information Satisfaction substantially affects Performance Expectancy.
H3: System Quality substantially affects Information Quality.
H4: System Satisfaction substantially affects Information Satisfaction.
H5: Support Quality substantially affects System Satisfaction.
H6: System Satisfaction substantially affects Effort Expectancy.
H7: Support Quality substantially affects Support Satisfaction.
H8: Support Satisfaction substantially affect Behavior Intention to use the website.
H9: Social Influence substantially affects Behavior Intention to use the website.
H10: Effort Expectancy substantially affects Behavior Intention to use the website.
H11**:** Social Influence substantially affects Behavior Intention to use the website.
H11a: Social Influence substantially affects Behavior Intention to use the website is moderated by age.
H11b: Social Influence substantially affects Behavior Intention to use the website is moderated by experience.
H12: Hedonic Motivation substantially affects Behavior Intention to use the website.
H12a: Hedonic Motivation substantially affects Behavior Intention to use the website is moderated by gender.
H12b: Hedonic Motivation substantially affects Behavior Intention to use the website is moderated by age.
H13: Price Value substantially affects Behavior Intention to use the website.
H13a: Price Value substantially affects Behavior Intention to use the website is moderated by gender.
H14: Habits substantially affects Behavior Intention to use the website.
H14a: Habits substantially affects Behavior Intention to use the website is moderated by gender.
H14b: Habits substantially affects Behavior Intention to use the website is moderated by age.
H14c: Habits substantially affects Behavior Intention to use the website is moderated by experience.

The respondents in the research are government employees of The East Nusa Tenggara Provincial and part of citizen where live in Kupang City as a user of local government website www.nttprov.go.id. Questionnaires distribution is the method implemented to collect the data by using the online survey to respondents.

The number of respondents was determined based on the number of indicators. In this case referring to the minimum analysis sample size requirement for SEM between 100-200 or a minimum of five times the indicator (Santoso, 2011; Hair, 2014; Bahri and Zamzam, 2014). There are 35 indicators in the research variables, therefore the number of respondents needed in this data collection is 175 respondents. In distributing the questionnaire, respondents were asked to answer several statements in the questionnaire with a likert scale between 1 which stated that they strongly disagreed up to a scale of 5 who stated strongly agree. Respondents were also asked to fill in open-ended questions as material for data calculation analysis. The results of data collection from the online questionnaire were then tested and analysed using SEM (Structural Equation Modelling) with AMOS 24.0. After fulfilling the SEM assumption test, the next step is to test the acceptance or rejection of a model based on the suitability index and cut of values as a tool for the goodness of fit. In this study, five measurement parameters for the goodness of fit were used, namely CMIN/DF, GFI, RMSEA, CFI and PCFI.

3. RESULTS AND DISCUSSION

The distribution of questionnaires conducted online resulted in 175 respondents who filled in the online questionnaire. The results of the questionnaire data used are the data that has been filled in by respondents who answered the questionnaire consistently. Inconsistent questionnaire data will be deleted. From the results of these filters, 167 respondents who are required in the study all answered the questionnaire consistently.

The initial stage carried out from the results of the questionnaire collection was to carry out research statistical tests in the form of validity tests and reliability tests. The validity test is to measure the validity of the data obtained from the research data collection, whether the data is valid according to the research instrument used (Hair et al., 2014). The method used is to compare the r-count value of the research variable with the r-table value, with a significance level of = 0.05. If the calculated r-count value > the r-table value, the questionnaire as a research instrument is declared valid (Hair et al., 2014). The test results show that all the questions used in the questionnaire are Valid (**Table 1**).

A reliability test is used to find out whether data can be trusted according to the criteria that have been set in the survey. A data is said to be reliable if it has a Cronbach Coefficient (α) value greater or equal to 0.6 (Hair et al. 2014). Based on the reliability test results for each variable, it shows the reliable results in which the Cronbach Coefficient (α) of each variable is greater or equal to 0.6 (**Table 2**).

Table 1. The Validity Analysis

Indicator	**R-count value**	**R-table value**	**Information**
Information Quality			
IQ1	0.912	0.151	Valid
IQ2	0.906	0.151	Valid

Indicator	R-count value	R-table value	Information
IQ3	0.924	0.151	Valid
IQ4	0.904	0.151	Valid
Information Satisfaction			
IQS1	0.892	0.151	Valid
IQS2	0.866	0.151	Valid
System Quality			
SYSQ1	0.906	0.151	Valid
SYSQ2	0.888	0.151	Valid
SYSQ3	0.905	0.151	Valid
System Satisfaction			
SYSQS1	0.911	0.151	Valid
SYSQS2	0.736	0.151	Valid
Support Quality			
SQ1	0.860	0.151	Valid
SQ2	0.907	0.151	Valid
SQ3	0.898	0.151	Valid
Support Satisfaction			
SQS1	0.926	0.151	Valid
SQS2	0.874	0.151	Valid
Performance Expectancy			
PE1	0.929	0.151	Valid
PE2	0.936	0.151	Valid
PE3	0.930	0.151	Valid
Effort Expectancy			
EE1	0.898	0.151	Valid
EE2	0.948	0.151	Valid
EE3	0.946	0.151	Valid
Social Influence			
SI1	0.859	0.151	Valid
SI2	0.826	0.151	Valid
SI3	0.846	0.151	Valid
Hedonic Motivation			
HM1	0.975	0.151	Valid
HM2	0.975	0.151	Valid
Price Value			
PV1	0.926	0.151	Valid
PV2	0.933	0.151	Valid
Habit			
HT1	0.936	0.151	Valid
HT2	0.945	0.151	Valid
HT3	0.953	0.151	Valid
Behaviour Intention			
BI1	0.949	0.151	Valid
BI2	0.962	0.151	Valid
BI3	0.915	0.151	Valid

Table 2. The Reliability Analysis

Research variable	Cronbach's Alpha coefficient	Information
Information Quality	0.931	Reliable
System Quality	0.880	Reliable
Support Quality	0.856	Reliable

Research variable	Cronbach's Alpha coefficient	Information
User Satisfaction	0.935	Reliable
Performance Expectancy	0.924	Reliable
Effort Expectancy	0.922	Reliable
Social Influence	0.797	Reliable
Hedonic Motivation	0.948	Reliable
Price Value	0.842	Reliable
Habit	0.939	Reliable
Behaviour Intention	0.936	Reliable

Furthermore, a descriptive analysis was carried out of descriptive statistics. The descriptive statistics in this study were derived from open questions when respondents filling in the questionnaire. The results of the descriptive statistics analysis can be seen in **Table 3**.

Table 3. Descriptive statistics of respondents' characteristics

Variable	Category	Frequency	Percent %
Gender			
	Male	111	66
	Female	56	34
Age group (Years)			
	< 25	12	7
	25 - 35	40	24
	35 - 45	69	41
	45 - 55	35	21
	> 55	11	7
Respondent's occupation			
	Student	11	7
	entrepreneur	9	5
	Government employees	128	77
	Employees of state-owned enterprises/ region-owned enterprises	4	2
	Others	15	9
How long has the respondent been using the internet (Years)			
	< 3 years	3	2
	3 - 4 years	9	5
	4 - 5 years	11	7
	> 5 years	144	86
How many times a week do respondents use the internet?			
	Every day	155	93
	4 or 5 times a week	6	4
	3 or 4 times a week	6	3
	< 3 times a week	-	-
How long does the respondent use the internet in one day?			
	< 1 hour	7	4
	1-2 hours	28	17
	3-4 hours	34	20
	> 4 hours	98	59
The purpose of the respondent using the internet?			
	Email	4	2
	Searching for information	103	62
	Online shopping	5	3
	Entertainment	7	4
	Social networking	25	15
	Others	23	14

In the SEM assumption test, there are two tests carried out, namely the multicollinearity test and the normality test. The multicollinearity test is carried out by looking at tolerance value and variance inflation factor (VIF). Multicollinearity occurs when the VIF value > 10 or the tolerance value < 0.10 (Hair et al., 2014). Based on the multicollinearity test results show in **Table 4**. The normality test is a test to determine whether the data is normally distributed or not, so that it can be continued to the SEM analysis stage. The data is said to be normally distributed if the curtosis value > c.r (critical) value (Hair et al., 2014). Based on the results of the normality test, the curtosis value is 342.987 and the critical value is 43.547, which means that the data in this study are multivariate normally distributed and can be processed further to the SEM modelling stage.

The next step is to test the structural model by testing the goodness of fit model. The goodness of fit model test is used to test the model used in the study. If the goodness of fit has shown a good value, then the model is acceptable. However, if the opposite is true, the model must be modified or specified to achieve a fit value (Hair et al., 2014; Santoso, 2011). The results of the measurement of the goodness of fit test after respesification show that all measurement values have met the standard criteria for acceptable values, namely the chi-square value (X^2) = 1280.989, DF = 899, CMIN / DF = 1.425, GFI = 0.904, RMSEA = 0.051, CFI = 0.955 and PCFI = 0.735. The results of testing the initial Goodness of Fit value and after respecification can be seen in **Table 5**.

Table 4. Multicollinearity Test

No	Independent Variable	Tolerance	VIF	Information
1.	System Quality	0.242	4.127	Multicollinearity Free
2.	Support Quality	0.307	3.257	Multicollinearity Free
3.	Social Influence	0.577	1.734	Multicollinearity Free
4.	Hedonic Motivation	0.206	4.863	Multicollinearity Free
5.	Price Value	0.568	1.761	Multicollinearity Free
6.	Habit	0.234	4.269	Multicollinearity Free

Table 5. Goodness of Fit Value Initial and After Respecification

Goodness of Fit Index	Cut-off Value	Goodness of Fit Value Initial	Information	Respecification Results	Information
Chi-square (X^2)	Expected small	1715.453		1280.989	
DF	≥ 0	923	Fit	899	Fit
CMIN/DF	< 3,00	1.859	Fit	1.425	Fit
GFI	≥ 0.90	0.737	Not Fit	0,904	Fit
RMSEA	≤ 0,08	0.072	Fit	0,051	Fit
CFI	≥ 0.90	0.907	Fit	0,955	Fit
PCFI	≥ 0,60	0,712	Fit	0,735	Fit

Then, the next process is testing the R-square value. The higher the R-square value means the better the predictive model of the proposed research (Hair et al., 2014). In this research, the R-square value on the behaviour intention variable (BI) is 0.817, which means that 81.7% of the behaviour intention variable to use the local government website www.nttprov.go.id is influenced by the support satisfaction variable, support system, information quality, effort expectancy, information satisfaction, performance expectancy, social influence, hedonic motivation, price value and habit variable, while the remaining 18.3% is through other variables outside the model.

The next step is test the hypotheses to determine whether the hypothesis are rejected or accepted based on the research model. Testing the hypothesis in this research is to see the positive estimate value generated in the structural model and the critical ratio (CR / t-value) higher than 1.96 at the 0.05 level (Hair et al., 2014). **Table 6** depicts the results of the hypothesis testing of each variable relationship in the research model. The final structural model is shown in **Figure 2**.

Table 6. Hypothesis Testing

Hypothesis	Relationship	Estimate	C.R/ t-value	Keterangan	Research Result
H1	IQ → IQS	0,092	1,483	Take effect & not significant	Rejected
H2	IQS → PE	0,959	13,907	Influential & significant	Accepted
H3	SYSQ → IQ	1,202	11,564	Influential & significant	Accepted
H4	SYSQS → IQS	0,931	11,864	Influential & significant	Accepted
H5	SYSQ → SYSQS	1,201	12,466	Influential & significant	Accepted
H6	SYSQS → EE	0,866	13,668	Influential & significant	Accepted
H7	SQ → SQS	1,331	14,031	Influential & significant	Accepted
H8	SQS → BI	0,054	0,287	Take effect & not significant	Rejected
H9	PE → BI	0,241	1,644	Take effect & not significant	Rejected
H10	EE → BI	-0,098	-0,303	No effect & not significant	Rejected
H11	SI → BI	0,042	0,645	Take effect & not significant	Rejected
H11a	SI*Age → BI	0,030	0,620	Take effect & not significant	Rejected
H11b	SI*Experience → BI	0,044	0,943	Take effect & not significant	Rejected
H12	HM → BI	0,291	2,218	Influential & significant	Accepted
H12a	HM*Gender → BI	0,000	0,006	Take effect & not significant	Rejected
H12b	HM*Age → BI	0,057	0,831	Take effect & not significant	Rejected
H13	PV → BI	0,004	0,082	Take effect & not significant	Rejected
H13a	PV*Gender → BI	0,046	1,184	Take effect & not significant	Rejected
H14	HT → BI	0,333	2,412	Influential & significant	Accepted
H14a	HT*Gender → BI	0,046	1,293	Take effect & not significant	Rejected
H14b	HT*Age → BI	-0,234	-3,342	No effect & not significant	Rejected
H14c	HT*Experience → BI	0,264	4,823	Influential & significant	Accepted

According to the hypothesis analysis, there is a big influence between information satisfaction and performance expectancy on the use of the local government website. The website www.nttprov.go.id is a window of the entire wealth of information owned by the government of East Nusa Tenggara Province and information disclosure of users become more valued. When users become satisfied with the information generated by the local government website service, they will find useful information and data to complete tasks quickly, save time, and increase productivity. Therefore, complete, accurate, clear, timely, and up to date information on the website need to be further improved by the government of East Nusa Tenggara Province.

System quality has considerable influence to information quality, system quality has considerable influenceto system satisfaction, system satisfaction has significant influence to information satisfaction and system satisfaction has significant influence to effort expectancy on the use of the local government website. System quality concerns the quality of functions and performance characteristics of online services that users want from information systems (Wixom and Todd, 2005). According to user perceptions, the main functions and characteristics of the system quality on government websites are reliability, speed, and availability of information. By improving the system quality, the local government of East Nusa Tenggara Province will provide a system that is easy to use, effective and helps user in completing their work as well as fast application. The greater the user's perception of the quality of the system that users can get on the local government website, the more likely the user is to be satisfied.

Support quality has significant influence to support satisfaction on the use of the regional government website. Users are likely to seek assistance when using the system, therefore the development of local government websites must be supported by improving the quality of the services provided. The higher the user's perception of the quality of support received online, the greater the user's satisfaction with the support offered, thus the user tends to use the local government www.nttprov.go.id.

There is a significant influence between hedonic motivation and behaviour intention to use the local government website. The better the enjoyment and convenience of users with the system received through the local government website services, the more user intentions to use the local government website services will increase. People will be more willing to use website www.nttprov.go.id if they receive enjoyment and convenience. The local government website administrator has to provide an interactive and innovative modern style website accessibility.

Habit has significant influence to behaviour intention to use the local government website. Habit is a level of behavior that occurs automatically after the learning process in using technology (Venkatesh et al., 2012), so that when users use technology as often as possible it creates a habit. This shows that someone tends to behave automatically because of previous learning. The more users use information technology, the more they will use it automatically. In addition, habits have significantly effect to behavior intention to use the website is moderated by experience. Someone that has good experience in using website will be motivate him to use website www.nttprov.go.id regularly.

For variables that do not affect other variables, it does not mean that these variables are not good for the application of the NTT Provincial Government website services. This can be seen in the descriptive process of research variables where the average respondent's perception has the value of agreeing to several indicators on each variable and only a little on the average of the respondents' perceptions who have sufficient value to agree. This may occur due to the lack of understanding or perception of respondents who only focus on their habits when accessing the website www.nttprov.go.id, so that the variables of performance expectancy, effort expectancy, social influence, price value, and support satisfaction cannot be felt the benefit by the respondent.

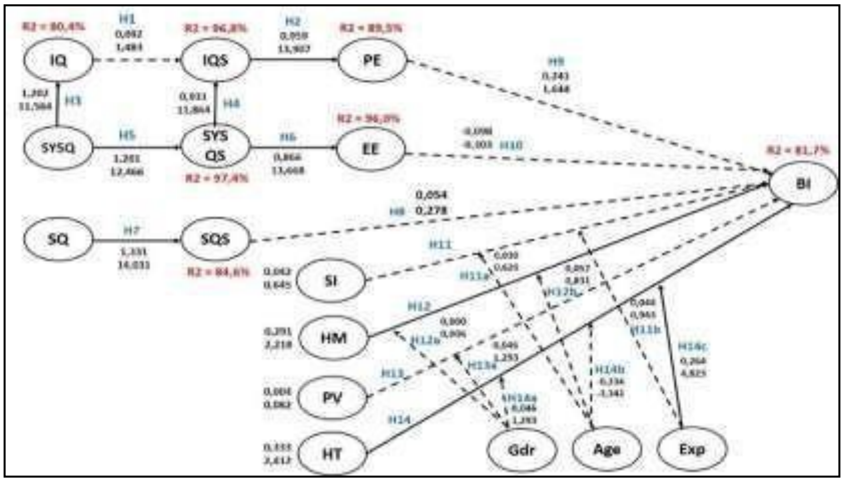

Figure 2. Structural Model of Research Hypotheses

4. CONCLUSIONS

Based on the results of research that has been carried out on the implementation of the UTAUT2 and IS Success models regarding the level of success and acceptance of the use of the NTT Provincial government website www.nttprov.go.id it can be concluded:

1. In the results of testing and analysis model against 14 hypotheses, the results of eight accepted hypotheses are hypotheses H2, H3, H4, H5, H6, H7, H12, and H14 (H14c), and six hypotheses that are rejected, namely hypotheses H1, H8, H9, H10, H11 (H11a, H11b), (H12a, H12b), H13 (H13a), dan (H14a, H14b) which have no significant impact on behaviour intentions to use the NTT Provincial Government website.
2. The variables rejected in the measurement of the NTT Provincial government website in different studies are likely to capture significant results that influence behaviour intention to use local government website services.
3. 81.7% of the behaviour intention variable to use the local government website www.nttprov.go.id is influenced by the support satisfaction variable, support system, information quality, effort expectancy, information satisfaction, performance expectancy, social influence, hedonic motivation, price value and habit variable, while the remaining 18.3% is through other variables outside the model
4. Recommendations in the form of increasing the provision of the latest, complete and relevant online information, integrated service systems between regional devices, easily accessible navigation systems, fast response times, availability of reliable links, and support for adequate facilities and infrastructure can become the driving factor to increase user behaviour intentions in using local government website service.

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6. REFERENCES

Al-Khatib, Hala (2013). *E-Government Systems Success and User Acceptance in Developing Countries: The Role of Perceived Support Quality*. Thesis Degree of Doctor of Philosophy., *Brunel Business School, Brunel University, London, United Kingdom*.

Bahri, Syamsul, Fahry Zamzam. (2014). *Model Penelitian Kuantitatif Berbasis SEM-AMOS*. Yogyakarta: Penerbit Deepubllish (Group Penerbitan CV. Budi Utama)

Carter, L., and Belanger, F. (2005). The Utilization of E-Government Services: Citizen Trust, Innovation and Acceptance Factors. *Information Systems Journal* (15:1), pp 5-25. doi: https://doi.org/10.1111/j.1365-2575.2005.00183.x

DeLone, William H. dan McLean, Ephraim R. (1992). Information System Success: The Quest for the Dependent Variable. *Information System Research*,vol 3:60-95. doi: https://doi.org/10.1287/isre.3.1.60

DeLone, William H. and McLean, Ephraim R. (2003). The DeLone and McLean of Information System Success: A Ten-Year Update. *Journal of Management Information System*, Vol. 19, No. 4. doi: https://doi.org/10.1080/07421222.2003.11045748

Fishbein, M., dan Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research, Reading*, MA: Addison-Wesley. doi: https://doi.org/10.2307/2065853

Gattiker, E. U. (1984). *Managing Computer-based Office Information Technology: A Process Model for Management*, In H. Hendrick and O. Brown (Eds.), Human factors in organizational design. Amsterdam, The Netherlands: North-Holland.

G. D. Garson (2012). *Structural Equation Modeling: Blue Book.*: Statistical Associates Publishing, 2012.

Gonçalo Baptista, Tiago Oliveira. (2016). A weight and a meta-analysis on mobile banking acceptance research. *Computers in Human Behavior*. doi: https://doi.org/10.1016/j.chb.2016.05.074

Hair JF, RE Anderson, and RL Tatham (1998). *Multivariate Analysis* (5th ed). Prentice Hall International, Inc.

Hair JF, Josep. Black,Wiliam., Babin, Barry J.,dan Anderson (2014), *Multivariate Data Analysis,* (7th ed), Pearson., Edinburg

Halaris, Christos., Magoutas, Babis., Papadomichelaki, Xenia., and Mentzas, Gregoris. (2007). Classification and synthesis of quality approaches in e-government services, *Internet Research*, 17(4):378-401. doi: https://doi.org/10.1108/10662240710828058

Ho, Ringo Moon-Ho & McDonald, P. Roderick (2002). Principles and Practice in Reporting Structural Equation Analyses. *The American Psychological Association*, Inc, Vol. 7, No. 1, 64–82. doi: https://doi.org/10.1037/1082-989X.7.1.64

Indrajit, R. (2006). *Elektronik Government: Strategi Pembangunan dan Pengembangan Sistem Pelayanan Berbasis Teknologi Digital.* Edisi III, Cetakan I. Yogyakarta: Penerbit ANDI.

Latan, Henky (2013), *Model persamaan struktural,teori dan implementasi Amos 21,* Penerbit Alfabeta, Bandung.

Livari, J. and Ervasti, I. (1994). User Information Satisfaction: IS Implementability and Effectiveness, *Information & Management*, Vol. 27, No. 4, pp. 205-220. doi: https://doi.org/10.1016/0378-7206(94)90049-3

Marriott, H., Williams, M., & Dwivedi, Y. (2017). What do we know about consumer m-shopping behaviour? *International Journal of Retailing & Consumer Services*, 45(6), 568-586. doi: https://doi.org/10.1108/IJRDM-09-2016-0164

Martins, G., Oliveira, T., & Popovic, A. (2014), Understanding the Internet banking adoption: A unified theory of acceptance and use of technology and perceive drisk application, *International Journal of Information*

Management, 34(1), Hal 1–13. doi: http://dx.doi.org/10.1016/j.ijinfomgt.2013.06.002

Mosquera, A. *et al*. (2018) Key factors for in-store smartphone use in an omnichannel experience: Millennials vs. nonmillennials, *Complexity*. doi: https://doi.org/10.1155/2018/1057356

Santoso, Singgih. (2011). *Structural Equation Modeling (SEM) Konsep dan Aplikasi dengan Amos 18*. Jakarta: Elex Media Komputindo

Santoso, Singgih. (2018). *Konsep Dasar dan Aplikasi SEM dengan AMOS 24,* cetakan pertama, Penerbit PT.Elex Media Komputindo, Jakarta

Satriya, E. (2006). Pentingnya Revitalisasi e-Government. *Konferensi Nasional Teknologi Informasi & Komunikasi untuk Indonesia*, 38–43.

Seddon, P.B. (1997). A Respecification and Extension of the DeLone and McLean Model of IS Success. *Journal of Information Systems Research*, 8, 240-253. doi: http://dx.doi.org/10.1287/isre.8.3.240

Seddon, Peter and Kiew, Mien-Yen (1994). A Partial Test and Development of Delone and Mclean's Model of IS Success. *Australasian Journal of Information Systems* 4(1). doi: https://doi.org/10.3127/ajis.v4i1.379

Sutanto, S., Ghozali, I. and Handayani, R. S. (2018) Faktor-Faktor Yang Memengaruhi Penerimaan Dan Penggunaan Sistem Informasi Pengelolaan Keuangan Daerah (SIPKD) Dalam Perspektif The *Unified Theory Of Acceptance And Use Of Technology 2* (UTAUT 2) Di Kabupaten Semarang, *Jurnal Akuntansi Dan Auditing*. doi: https://doi.org/10.14710/jaa.15.1.37-68

Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View," *MIS Quarterly* (27:3), pp 425-478. doi: https://doi.org/10.2307/30036540

Venkatesh, V., Thong, J.Y.L, Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. MIS Quarterly, (36)1, 157-178. doi: https://doi.org/10.2307/41410412

Wixom, B.H. and Todd, P.A. (2005). A Theoretical Integration of User Satisfaction and Technology Acceptance. *Information Systems Research*, vol. 16, no. 1, pp. 85-102. doi: https://doi.org/10.1287/isre.1050.0042

Yulius, Rina., Santosa, I. Paulus., and Hartanto, Rudy (2016). Efek Moderasi Kesukarelaan Terhadap Pembelajaran Online Pada Universitas Sahid Surakarta. *Jurnal IPTEKS Terapan* (10)4, *Research of Applied Science and Education* V10.i4 (218-224). doi: https://doi.org/10.22216/jit.2016.v10i4.534

FACTOR INFLUENCING ADOPTION OF MOBILE POCKET OFFICE BY SHIPPINGAND LOGISTICS COMPANY: EXTENDING UTAUT 2 WITH RISK, TRUST AND USER INNOVATIVENESS

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ABSTRACT

Nowadays, communication technology and innovation play an important role in economic growth. It resulted in competition between businesses increasingly tight. To improve service quality, one of the shipping and logistics companies in Surabaya launched a mobile pocket office-based application to support work efficiently, especially in the operational division. The objective of this study is to explain the factors that affect user acceptance on the usage of the pocket office mobile application. UTAUT 2 model which is extended with the variable perceived risk (PR), personal innovativeness (SINN), and trust (TR) is used in this study. This study used a sample of 243 respondents. Based on 11 tested hypotheses using PLS-SEM, 2 of them were rejected. The rejected variables are perceived risk (PR) and effort expectancy (EE), these results indicate a large amount of effort felt by the user, and a high enough risk of usage reduces the user's intention in using the application. Hedonic Motivation has a greater positive influence than the other constructs to increase the user desire to use the application. The proposed model also succeeds in explaining 85.7% of its effect on Behavioural Intention (BI) and 72.1% on Use Behavior (UB) in application usage. The results of this analysis can be used as recommendations and suggestions for shipping and logistics companies in developing their applications further.

Keywords: Mobile Pocket Office, UTAUT 2, PLS-SEM, User Acceptance, Technology Adoption, Information Technology.

1. INTRODUCTION

Technology communication and innovation play an important role in driving economic growth (Maneejuk and Yamaka, 2020). This has an impact on business competition between companies to become tighter. Companies must continue to innovate in technology to improve the quality of their services so that they are not left behind by other business competitors (Maneejuk and Yamaka, 2020). According to Laudon, (2018) sustainable information technology innovation transforms traditional business concepts into digital businesses that allow business entrepreneurs to create new technology-based services, develop new business models, and even change the culture in daily business behavior. Innovation technology smartphone-based to support digital businesses are recognized as very effective and efficient in improving service quality and customer satisfaction. Holzinger *et al.*, (2011) in their research applies and develop mobile applications to meet business needs in hospitals and evaluate their effectiveness. The results of this research indicate that the mobile application provides benefits to both patients, medics, and hospital managers. The medical were able to reduce 90% of work time more efficiently and save costs for the medical institution (Holzinger *et al.*, 2011). Not inferior to other industries, the shipping industry has also changed its business processes by digitizing both operations and strategies to improve service quality and efficiency (Lambrou, et al., 2019).

Bankole *et al.*, (2017) also emphasized that IT infrastructure is very important for the sustainability of the maritime sector. In carrying out their daily business processes, many shipping companies in Indonesia, both small and large, have used web-based information technology (Atmojo, et al., 2019). Atmojo, et al., (2019) also explained that this was done because in the shipping business the speed of transportation and delivery service was the key to success. However, in the operational division, especially ship operational, it is difficult for those who work in the field to do their job because web-based applications are less flexible. This is the reason for one of the shipping and logistics companies in Surabaya to innovate by developing and launching a mobile pocket office application. This application is intended for port delivery services, namely loading and discharge activities. The key to success in improving operational services for the company is how all users can switch to using mobile pocket office applications and leave web- based applications. Motivating employees to use the app is not an easy process (Alalwan *et al.*, 2018). So the empirical research is needed to know the factors that influence users in using applications, especially in shipping companies in Surabaya. However, there is still very little or no research that discusses behavior intention to use mobile pocket offices.

Therefore, this study will discuss several objective questions, namely as follows:

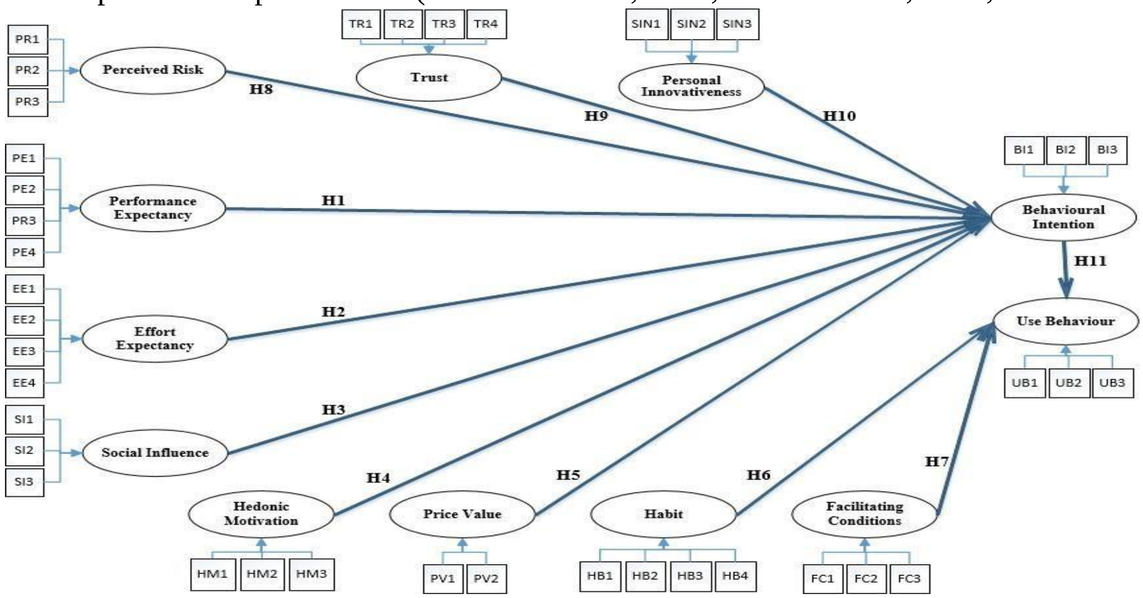
1. What factors may hinder the user acceptance of the mobile application at a shipping company in Surabaya?
2. What factors can improve the user acceptance of the mobile application at a shipping company in Surabaya?

2. LITERATURE REVIEW

Examining and explaining user intention on the adoption of technology like mobile pocket apps have been recently the focus of many researchers (Alalwan, et al., 2017). Venkatesh, et al., (2012) has proposed the user acceptance theory namely the UTAUT 2 model which increased the explanatory level of prior technology application adoption. The UTAUT 2 consists of constructs, namely Hedonic Motivation, Price Value, Habit, Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions (Venkatesh, et al., 2012). This model is applied by various researchers with various development including adding new variables according to certain needs and conditions. Therefore, this study adopts UTAUT2 as a basic reference for implementing the user acceptance model for technology.

Mobile pocket office technology is a new technology that has been applied by one of the shipping and logistics companies in Surabaya so that in its application, user's trust in this technology is needed. With these considerations, the researchers adopted the research from (Alalwan, et al., 2017; Merhi, et al., 2019). Both studies discuss factors that influence customer acceptance of the application of mobile banking. Both studies add variable trust (TR) to their research. The results of their research prove that trust (TR) is one of the variables that influence user acceptance in the application, especially mobile banking. This study also adopts the personal innovativeness variable (SINN) conducted by (Farooq *et al.*, 2017; Dajani and Abu Hegleh, 2019) who also stated in their research that innovation from users when using technology has an effect on the acceptance of technology itself. The mobile pocket office application implemented by one of the shipping and logistics companies in Surabaya is currently in the development stage so personal innovativeness may affect technology acceptance. As for the usage of the latest technology launched by the company, there may be risks that are felt by users, this risk can cause user performance to decrease and also cause delays in processing. This could be due to ignorance of technology, bugs from application features, or other reasons. Research related to the perceived risks in adopting a technology was conducted by (Alalwan *et al.*, 2016, 2018). Their research concluded that the perceived risk by users has a negative influence on technology acceptance. According to these reasons, the researcher felt the adoption of variable perceived risk (PR) was needed in this study. Based on previous research, this research has the aim of developing the UTAUT 2 model by adding the Trust (TR) variable, perceived risk (PR), and User Innovativeness (UIN) as shown in Figure 1.

Figure 1. Proposed conceptual model (Venkatesh et al., 2012; Alalwan et al., 2018; Merhi et al., 2019)



In addition, this study also explained the effect of the proposed model on user acceptance of technology, especially user intention on the usage of mobile pocket office.

3. CONCEPTUAL MODEL

Following the UTAUT 2 theory as the basis of the model by adding a few other constructs. The constructs of the proposed model as shown in Figure 1 are perceived risk (PR), performance expectancy (PE), Trust (TR), effort expectancy (EE), social influence (SI), User Innovativeness (UIN), Hedonic Motivation (HM), Price Value (PV). Those proposed constructs have a direct positive effect on user desire to use the application (IB). Whereas Habit (HB), Facilitating Conditions (FC) and User Intention (BI) have a direct positive effect on the adoption of application (UB). Performance expectancy (PE) is expressed as “someone’s optimism that the usage of technology can enhance their performance” (Venkatesh *et al.*, 2003). According to the various literature on user acceptance, it shows that performance expectancy has been shown to affect the context of technology adoption (Alalwan, Dwivedi and Rana, 2017; Farooq *et al.*, 2017; Dajani and Abu Hegleh, 2019; Mehta *et al.*, 2019). The mobile pocket office technology at one of the shipping and logistics companies in Surabaya was still at the development stage. This makes the performance of the application may hold an important role to drive the desire of the user on using the technology application. Effort expectancy (EE) is expressed as “a perceived of the ease when using technology” (Venkatesh *et al.*, 2003). Perceived as easy and convenient when using technology will increase user intention, and vice versa. According to the various literature on the acceptance of this variable, it is proven to have a positive effect on the context of technology adoption (Baabdullah *et al.*, 2019; Maneejuk and Yamaka, 2020). The application which easy to operate will certainly increase interest in the usage of those applications.

Social influence (SI) is expressed as "the degree where somebody thinks or believes that colleagues, family and even other people must use a particular technology" (Venkatesh *et al.*, 2003). SI has a direct influence on user Intention, and this influence will be greater if the usage of technology is mandatory. Based on various literature on acceptance of this variable technology, it is proven to have a positive effect on the context of application adoption (Mehta *et al.*, 2019). As workers who are required to use new technology by the company, their teammates will feel that they must use the technology too. Hedonic Motivation (HM) is expressed as "the perceived of happiness, satisfaction or pleasure obtained when a person uses technology" (Venkatesh, *et al.*, 2012, 2016). Venkatesh, et al., (2012) also explained that HM holds a big determinant to drive the user acceptance in the context of new technology. In the usage of an application, the pleasure that was arisen and obtained from new experiences has positive effects on the user intention towards technology acceptance. Price Value (PV) is expressed as "the value/benefits obtained from the use of technology may have a significant effect on the usage of the technology itself" (Venkatesh, et al., 2012). Venkatesh, et al., (2012) also explained that PV holds a positive effect when the benefits on application usage are more considerable than the capital costs. In the application of mobile pocket office technology, the company bears monetary costs for its application, while employees/users do not. However, certain incidents may occur, such as the company's smartphone internet quota running out or experiencing damage so that employees have to use their smartphones or use their quota. This construct may affect the user's use of technology. Habit (HB) is expressed as the degree where a person can behave automatically to use technology. Venkatesh, et al., (2012) explained that HB is important determinant of technology usage, especially in diverse and changing situations. HB is measured by 3 (three) indicators that refer to the research of (Venkatesh, et al., 2012), namely Prior Use, Addiction, and Behavior to be automatic.

Facilitating Conditions (FC) is expressed as a conceptualization where people believe that the provision of tools, facilities, and techniques needed can support the user acceptance of the technology application. Venkatesh et al., (2003) stated that FC is less significant towards user intention but affects use behavior when PE and EE are used. Lack of availability of support, both goods, and incomplete information and limited resources can hinder individuals from accepting technology. In its application to mobile pocket office technology, smartphone tablet facilities, GSM internet connection is provided to related users by the company. This is done so that users do their job in the field properly, but if these facilities are provided in a limited number, it will certainly hinder the process of receiving technology. Based on these conclusions, the researcher thinks that FC is an important determinant of use behavior. Perceived Risk (PR) is expressed as "a sense of unpredictability regarding the possible adverse conditions arising from the use of an application" (Featherman and Pavlou, 2003; Alalwan *et al.*, 2018). Mobile pocket office technology at a shipping company in Surabaya is still under development. So it may be allowing potential bugs in application features that arise in these technologies' usage. In this research, the researcher focuses on common risk which might affect user intention to use the mobile pocket office. In line with the definition of trust according to (Straub and Gefen, 2004).

Trust (TR) is defined as the accumulated confidence of technology users based on integrity, convenience, and ability that can increase the willingness and intention of users to use technology. Trust is measured by 4 (four) indicators, namely Specific Beliefs, General Belief, and willingness, Feeling confidence and security, and the Combination of those elements (Straub and Gefen, 2004). Based on the various literature on acceptance of this variable technology, it is proven to have an effect on the context of technology adoption (Straub and Gefen, 2004; Alalwan, et al., 2017; Merhi et al., 2019). User Innovativeness (UIN) is expressed as a sense of desire that makes people feel to learn more and try regarding the technology application, and also have the belief that technological capabilities can provide tangible benefits. User innovativeness is assessed based on 3 (three) indicators that refer to the research of Farooq *et al.*, (2017), namely Interest to do experiments, Innovative ideas, and Willingness to do experiments. Based on research that has been done, this variable affects user intention related to the adoption of new technology. Based on these conclusions, researchers assume that User Innovativeness also has an influence on behavioural intention on mobile pocket office technology. Behavioural Intention (BI) is expressed as a "state the level of a someone desire to use the technology" (Venkatesh *et al.*, 2003). This construct is an important determinant regarding the frequency of usage on the technology application. According to the various literature on user acceptance, it shows that BI has an effect on the context of technology adoption.

4. METHOD

The method of the data aggregation in this study is carried out by distributing questionnaires to employees who use the Mobile Pocket Office application, especially at one of the shipping and logistics companies in Surabaya. The questionnaire uses a 5-point Likert scale with strongly disagree (1) to strongly agree (5) of value. Before distributing the questionnaire, a pre-test was carried out using Google Forms for supervisors and admins who know the usage of mobile pocket office application, this is done to get suggestions so that the questionnaire questions can be said good and unambiguous when distributed to employees. Furthermore, a pilot test is carried out to see whether the data collection is valid and reliable on 30 mobile pocket office users, validity the pilot test is carried out using SmartPLS by looking at the loading factor and composite reliability, if it exceeds 0.70 then it is said to be valid. After the pilot test was said to be valid and reliable, the distribution of the final questionnaire was carried out using the web service survey form provided by the company, thus the survey was distributed formally to make the employees complete the filling seriously. The total data of respondents who filled out the questionnaire amounted to 243 respondents from a total population of 250 employees who used the mobile pocket office application, especially the company's operational division. After the data collection is complete, the analysis is carried out using PLS-SEM.

5. ANALYSIS

The demographics of respondents in this study consisting of age, work experience, and education as shown in Table 1. The table showed that the majority of employees using mobile apps are over (36) years of age. Education of the majority of employees are the senior high school and followed by diploma. While the majority of the work experience of application users is under

(5) years. Furthermore, the model feasibility test is carried out using PLS-SEM. The software used to assist the data analysis process is SmartPLS 3.0. The PLS-SEM method consists of 2 stages, namely a measurement model and a structural model.

Table 1. Demographic Responden

Age (Years)	*Total*	*Frequency*
< 25	24	10%
26 - 30	62	25%
31 - 35	43	39%
> 36	114	47%
Total	243	100%

Education	Total	Frequency
Junior Highschool	8	3%
Senior Highschool	91	37%
Bachelor's degree	94	29%
Master's degree	50	21%
Total	243	100%
Experience	**Total**	**Frequency**
0 - 5	86	35%
6 – 10	66	27%
11 – 15	53	22%
> 15	38	16%
Total	243	100%

5.1 Measurement Model

Examination of this model was conducted via testing convergent validity and reliability. To evaluate convergent validity, the steps that must be taken is to make sure that outer loading value > 0.70 and AVE > 0.50 (Hair *et al.*, 2012). Meanwhile, to evaluate reliability, the steps are to make sure that the Composite Reliability value of each variable > 70. The test results are shown in Table 2 which shows that all indicators have AVE values> 0.50 and outer loading> 0.70 so that all indicators have passed the convergent validity test. Composite Reliability for each variable has a value > 70. Therefore, it can be said that all indicator data has met a good reliability test.

Table 2. Convergent Validity

Variable Laten	*Loadings*	*AVE*	*CR*	*References*
Behavioural Intention				
BI1: I plan to continue using a mobile pocket office in daily task	0.925	0.866	0.951	(Venkatesh, et al., 2012)
BI2: I will always try to use mobile pocket office	0.939			
BI3: I plan to use mobile pocket office more frequently	0.928			
Effort Expectancy				
EE1: Learning how to use the mobile pocket office is easy for me	0.838	0.744	0.921	(Venkatesh, et al., 2012)
EE2: The User interface of the apps is clear and understandable	0.875			
EE3: I find the mobile pocket office is easy to use	0.863			
EE4: I can easily become proficient in using mobile pocket office	0.874			
Facilitating Conditions				
FC1: Using mobile apps is well-matched with other systems I use on the company	0.893	0.769	0.909	(Venkatesh, et al., 2012)
FC2: I have enough information to use mobile apps	0.844			
FC3: My teammates are there to help me if I face any problem in using mobile apps	0.894			
Habit				
HB1: Using mobile apps has become a habit for me	0.908	0.841	0.955	(Venkatesh, et al., 2012)
HB2: I am addicted to using mobile apps	0.903			
HB3: I have to use mobile apps	0.929			
HB4: Using mobile apps has become natural to me	0.926			
Hedonic Motivation				

HM1: Using mobile apps is excitement	0.904	0.815	0.93	(Venkatesh, et al., 2012)
HM2: Using mobile apps is a necessity for me	0.916			
HM3: Using mobile apps is entertaining and enjoyable	0.888			
Performance Expectancy				
5.2 PE1: I find mobile apps helpful in my daily work	0.909	0.838	0.912	(Venkatesh, et al., 2012) 5.2
PE2: Using mobile apps increase my chances of achieving the tasks that are important to me	0.927			
PE3: Mobile apps help me accomplish things more quickly than the other apps	0.928			
PE4: Mobile apps increase my capacity in daily task	0.897			
Perceived Risk				
PR1: Mobile apps sometimes perform poorly	0.815	0.775	0.954	(Featherman & Pavlou, 2003; Alalwan, et al., 2018)
PR2: Mobile apps put me in a lot of risks	0.925			
PR3: I often experience problems when using mobile apps	0.898			
Price Value				
PV1: The Tablet to use the apps is fairly cheap	0.898	0.823	0.903	(Venkatesh, et al., 2012)
PV2: mobile apps provide me more benefits than tablet prices	0.917			
Social Influence				
SI1: My teammates think that I should use mobile apps	0.873	0.785	0.916	(Venkatesh, et al., 2012)
SI2: My company supports the use of mobile apps	0.911			
SI3: My teammates influence me to use mobile apps	0.874			
Trust				
TR1: I believe mobile apps will perform well	0.898	0.807	0.944	(Gefen, et al., 2004; Alalwan, et al., 2017)
TR2: I don't doubt that mobile apps are dependable	0.854			
TR3: I don't doubt the quality of the mobile apps	0.914			
TR4: I believe mobile apps prioritize convenience and flexibility	0.927			
Use Behaviour				
UB1: In the future, I determine to always use mobile apps	0.88	0.768	0.908	(Venkatesh, et al., 2012)
UB2: I often try to use mobile apps in my daily work	0.898			
UB3: I plan to continue using mobile apps	0.849			
User Innovativeness				
UIN1: I like to experiment new feature when using mobile apps	0.888	0.715	0.882	(Farooq, et al., 2017; Dajani & Hegleh, 2019)
UIN2: I like to find new innovations for mobile apps to become more efficient	0.884			
UIN3: I am interested in trying when there are new features	0.759			

5.2Structural Model

The evaluation of this model was managed to test the hypothesis via testing coefficient path and significant value (Ghozali, 2011). The R-square value is used to explain the predictive power of the predictor variable on the predicted variable of the model. The result of the R-Square test value of the predicted variable user Intention (BI) is 0.857. This explains that the constructs, namely PE, SI, UIN, HM, PV, TR, strongly explain 85.7% of variance affects the dependent variable BI. While the R-square test value of the dependent variable Use Behavior (UB) is 0.721. This shows that FC, HB, and BI moderately explain 72.1% of the variants affecting the dependent variable of UB. Furthermore, the bootstrapping method is used as a significance test. The results of the hypothesis test are shown in table 3. Acceptance or rejection of the hypothesis is based on the standard error value of 1.96 and an alpha value of 5%. 11 hypotheses are tested to find out the effect of the independent constructs on the dependent constructs. Hypotheses H2 and H8 are rejected, this is because the p-value > 0.05 ($\alpha = 5\%$) and the t-statistic < 1.96. While H1, H3, H4, H5, H6, H7, H9, H10 and H11 are accepted, because the p-value < 0.05 ($\alpha = 5\%$) and t-statistic > 1.96.

Table 3. Result of the tested hypotheses

Hipotheses		Path Coefficient	T-Statistics	P-Values	Result
H1	PE-> BI	0.149	2.095	0.036	Accepted
H2	EE -> BI	0.019	0.430	0.667	Rejected
H3	SI -> BI	0.165	2.290	0.022	Accepted
H4	HM -> BI	0.275	3.038	0.002	Accepted
H5	PV -> BI	0.163	3.015	0.003	Accepted
H6	HB -> UB	0.355	4.377	0.000	Accepted
H7	FC -> UB	0.304	4.218	0.000	Accepted
H8	PR -> BI	0.010	0.437	0.662	Rejected
H9	TR -> BI	0.155	2.779	0.006	Accepted
H10	UIN -> BI	0.115	2.893	0.004	Accepted
H11	BI -> UB	0.254	2.563	0.010	Accepted

6. RESULT AND DISCUSSION

The research was conducted to explain factors that influence the user acceptance of mobile pocket office applications in one of the shipping companies in Surabaya by adopting the UTAUT
2 which extended constructs PR, TR, and UIN. The hypothesis proposed is tested using SmartPLS. Empirically, the research has found out that H4 has the highest path coefficient value on user intention. It means that HM has a greater positive influence than other constructs to increase the user desire to use the application. These findings are the same as research conducted by Dajani and Hegleh, (2019). This shows that using mobile apps is more fun than the web-based application or other apps they used before. Furthermore, the second hypothesis that has greater influence on user desire is H3. This indicates that social interactions with colleagues have a considerable influence and positive determinant on user desire in application usage. That point might be a suggestion to the company that good social interaction, motivation, and appreciation can increase employee desire to use the application.

H5 and H9 also accepted, which means that the PV construct has a positive influence that might increase user desire for mobile apps usage. This indicates that the greater the benefits that the user gets when using the mobile pocket office application, the greater the user's desire to use the application. The TR construct also prove as important determinant on user desire in using mobile pocket office application. This shows that the greater trust in the application, hence the greater desire of the user to use the application that companies provided. The last hypothesis that was accepted and has an influence on user intention is H1 and H10. It means that the PE construct has a positive influence to increase user desire for mobile apps usage. The greater the performance a user gets from using the pocket office mobile application, the greater the user's desire to use the application. The UIN construct also prove as an important determinant to affect the user desire. These findings are the same as the study managed by (Farooq *et al.*, 2017; Dajani and Hegleh, 2019). It shows that the greater the user's innovation and curiosity towards technology, the greater the user's desire to use the application.

Furthermore, the hypotheses that are accepted and have an influence on use behaviour are H6, H7, and H11. The HB construct has the greatest positive influence on the use behavior, FC in the second place, and then the last is BI. H6 is accepted, It means that the more accustomed user in using the pocket office mobile application, the greater the frequency of the user in using the application. H7 was accepted, which means that the more complete the supporting facilities, the more often users will use the mobile pocket office application. As for H11, this shows that the bigger user desire in the mobile pocket office application usage, the greater the intensity of the user to use this technology. H2 and H8 are rejected, it was indicating that the user feels a big effort in using the pocket office mobile application, so on the other hand effort expectancy has a negative impact on the user desire to use technology. Perceived risk constructs in H8 also do not have a positive impact to increase user desire for application usage. This means that PR also has a negative impact on the desire to use technology. This result is the same as previous research on perceived risk by Alalwan, et al., (2017) which shows that empirically perceived risk has a negative effect on the user desire in using technology.

7. CONCLUSION

The study examined and explained the factors that influence user acceptance of mobile pocket office applications using the UTAUT 2 model introduced by Venkatesh et al. (2012). The proposed design is extended by adding the constructs of trust, perceived risk, and user innovativeness. The design was tested using PLS-SEM with a total of 243 respondents from the questionnaire. The research was conducted at one of the shipping and logistics companies in Surabaya. The PLS-SEM analysis shows that factors, namely performance expectancy, social influence, hedonic motivation, price value, facilitating conditions, trust, and user innovativeness are important determinants to increase the user desire in using pocket office mobile applications. These factors also succeeded in explaining 85.7% of the research model about the effect on the user intention for the application usage, while the remaining 14.3% was explained by other variables outside those studied. Whereas habit, facilitating conditions, and behavioural intention are important determinant to affect the Use Behavior (UB) of the pocket office mobile application. These factors succeeded in explaining 72.1% of the research model while the remaining 27.9% were explained by other variables outside the one under study. There is also effort expectancy and perceived risk which do not have an impact on user desire for application usage. This shows that there is a high enough effort that the user must make in using the application and the higher the risk can reduce the user intention to use it. In addition, the results of this study could be a new contribution in a different context from previous research on technology acceptance and technology use.

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9. REFERENCES

Alalwan, A. A. *et al.* (2016) 'Consumer adoption of mobile banking in Jordan: Examining the role of usefulness, ease of use, perceived risk and self-efficacy', *Journal of Enterprise Information Management*, 29(1), pp. 118–139. doi: 10.1108/JEIM-04-2015-0035.

Alalwan, A. A. *et al.* (2018) 'Examining factors influencing Jordanian customers' intentions and adoption of internet banking: Extending UTAUT2 with risk', *Journal of Retailing and Consumer Services*. Elsevier Ltd, 40(July 2017), pp. 125–138. doi: 10.1016/j.jretconser.2017.08.026.

Alalwan, A. A., Dwivedi, Y. K. and Rana, N. P. (2017) 'Factors influencing adoption of mobile banking by Jordanian bank customers: Extending UTAUT2 with trust', *International Journal of Information Management*. Elsevier Ltd, 37(3), pp. 99–110. doi: 10.1016/j.ijinfomgt.2017.01.002.

Atmojo, R. N. P., Karuh, J. C. and Martono, Y. (2019) 'Web-Based Shipping Application for Small- Medium Sized Logistics Companies', *Proceedings of 2019 International Conference on Information Management and Technology, ICIMTech 2019*. IEEE, 1(August), pp. 559–563. doi: 10.1109/ICIMTech.2019.8843764.

Baabdullah, A. M. *et al.* (2019) 'An integrated model for m-banking adoption in Saudi Arabia', *International Journal of Bank Marketing*, 37(2), pp. 452–478. doi: 10.1108/IJBM-07-2018-0183. Bankole, O. A. *et al.* (2017) 'Information technology in the maritime industry past, present and future: Focus on LNG carriers', *Proceedings - 7th IEEE International Advanced Computing Conference, IACC 2017*, (February), pp. 759–763. doi: 10.1109/IACC.2017.0157.

Dajani, D. and Abu Hegleh, A. S. (2019) 'Behavior intention of animation usage among university students', *Heliyon*. Elsevier Ltd, 5(10), p. e02536. doi: 10.1016/j.heliyon.2019.e02536.

Farooq, M. S. *et al.* (2017) 'Acceptance and use of lecture capture system (LCS) in executive business studies', *Interactive Technology and Smart Education*, 14(4), pp. 329–348. doi: 10.1108/ITSE-06-2016- 0015.

Featherman, M. S. and Pavlou, P. A. (2003) 'Predicting e-services adoption: A perceived risk facets perspective', *International Journal of Human Computer Studies*, 59(4), pp. 451–474. doi: 10.1016/S1071- 5819(03)00111-3.

Ghozali, I. (2011) *Aplikasi Analisis Multivariate dengan Program SPSS*. Semarang: Badan Penerbit Universitas Diponegoro.

Hair, J. F. *et al.* (2012) 'An assessment of the use of partial least squares structural equation modeling in marketing research', *Journal of the Academy of Marketing Science*, 40(3), pp. 414–433. doi: 10.1007/s11747-011-0261-6.

Holzinger, A. *et al.* (2011) 'Design and development of a mobile computer application to reengineer workflows in the hospital and the methodology to evaluate its effectiveness', *Journal of Biomedical Informatics*. Elsevier Inc., 44(6), pp. 968–977. doi: 10.1016/j.jbi.2011.07.003.

Kenneth C. Laudon, J. P. L. (2018) *Manajement Information Systems: Managing the Digital Firm*. 15th edn.

Lambrou, M., Watanabe, D. and Iida, J. (2019) 'Shipping digitalization management: conceptualization, typology and antecedents', *Journal of Shipping and Trade*. Journal of Shipping and Trade, 4(1). doi: 10.1186/s41072-019-0052-7.

Maneejuk, P. and Yamaka, W. (2020) 'An analysis of the impacts of telecommunications technology and innovation on economic growth', *Telecommunications Policy*. Elsevier Ltd, 44(10), p. 102038. doi: 10.1016/j.telpol.2020.102038.

Mehta, A. *et al.* (2019) 'The Influence of Values on E-learning Adoption', *Computers and Education*, 141(June). doi: 10.1016/j.compedu.2019.103617.

Merhi, M., Hone, K. and Tarhini, A. (2019) 'A cross-cultural study of the intention to use mobile banking between Lebanese and British consumers: Extending UTAUT2 with security, privacy and trust', *Technology in Society*. Elsevier Ltd, 59(January), p. 101151. doi: 10.1016/j.techsoc.2019.101151.

Straub, D. and Gefen, D. (2004) 'Validation Guidelines for IS Positivist Research', *Communications of the Association for Information Systems*, 13. doi: 10.17705/1CAIS.01324.

Venkatesh, V. *et al.* (2003) 'User acceptance of information technology: Toward a unified view', *MIS Quarterly: Management Information Systems*, 27(3), pp. 425–478. doi: 10.2307/30036540.

Venkatesh, V., Thong, J. Y. L. and Xu, X. (2012) 'Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology', *MIS Quarterly: Management Information Systems*, 36(1), pp. 157–178. doi: 10.2307/41410412.

Venkatesh, V., Thong, J. Y. L. and Xu, X. (2016) 'Unified theory of acceptance and use of technology: A synthesis and the road ahead', *Journal of the Association for Information Systems*, 17(5), pp. 328–376. doi: 10.17705/1jais.00428.

DATA MANAGEMENT BASED ON COBIT 19: CASE STUDY AT THEPUBLIC RELATION & PROTOCOL BUREAU OF THE REGIONAL SECRETARIAT OF EAST JAVA PROVINCE

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ABSTRACT

The Public Relation & Protocol Bureau of the Regional Secretariat of East Java Province (Biro Humas Sekretariat Daerah Provinsi Jawa Timur) is an organizational unit of the East Java Provincial Government that is responsible for preparing and drafting public policy, evaluating organization program related to public policy, and organizing technical meeting, administration, and allocating resources related with public relation. The organization uses some applications to study public sentiment, common news, and issues in media such as SiMomed (Media Monitoring Information system) and the official website of the organization. Hence, data and information management are needed by the organization to produce good information and will help the management in decision making. In this research, COBIT 2019 enabling process is used as a framework to identify I&T processes, whereas COBIT 2019 for data and information is used to conduct the data and information management activities. Data and information in this process were obtained from interviews and observation and then mapped to corresponding ideal conditions based on COBIT 2019 objectives and APO14-managed data. The output of this research is a document containing a list of Best Practice data and information management of the organization. Good corporate governance, specifically in data & information management, will help the decision-maker of the organization to make a strategic decision.

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Keywords: Data and Information Management, COBIT 2019, Good Corporate Governance, Decision Making

1. INTRODUCTION

Good government administration was developed to optimize the investment value of Information & Technology (I&T) in the organization. Every business process needs a governance body that ensures that the organization is running well based on the organization’s rules. For that purpose, there are efforts performed in the data and information management of The Public Relationand Protocol Bureau Secretariat of East Java Province (Biro Humas Sekretariat Daerah Provinsi Jawa Timur – Biro Humas Setda) with the aim of making a good corporate governance, specificallyin data and information management.

Corporate governance is usually defined as “Procedures and Processing according to which an organization is directed and controlled,” (Cadburry, 1992). Good corporate governance does not only include activities of the Board and its relationship with the shareholders, managers, but also with external parties such as auditors, regulators, and any related organizations or companies (Krechovska & Prochazkova, 2013). The board of directors in a corporate/organization specifies and delegates their responsibility to the structure, which involves the head of department, managers, staff, and any shareholders. Corporate systems and procedures should also ensure accountability and ethical behavior. Today, so many various definitions of corporate governance that used to be byorganizations and companies depend on their goals itself.

Data management is the planning, execution, and oversight of policies, practices, and projects that acquire, control, protect, deliver and enhance the value of data and information assets (Model, 2015). A well-developed data management program within an organization has the ability to positively affect to force management change the condition in the internal organization and I&Tgives a newly perspective of management how to using and understanding of the data across units in the organizations. There are many benefits of data management include improvements in operation management, giving the excellent services to the clients or publics, establish a compliance control’s mechanism the internal, build the awareness in security and privacy, reduction of risk across the unit in the organization, making faster system development, improvements in decision making and reporting, sustained business growth and numerous others advantages in the organization.

This research will focus on measuring the capability level using an assessment process related to COBIT 2019 at Biro Humas Protokol Setda Provinsi Jawa Timur. The assessment will focus on the objectives of APO14-Managed Data through EDM03 about Ensured Risk Optimization. After the assessment has been done, the organization decides the level that will be achieved in the future through milestones that have been set at every level.

2. Research Methodology

2.1 COBIT 2019

Control Objectives for Information and Technology 2019 (COBIT 2019) is a framework thatwas developed and published by the Information System Audit and Control Association (ISACA) in 2018 (ISACA, 2018). Digital transformation, information, and technology (I&T) have become the crucial issues that faces to build sustainability and growth of the organization. COBIT 19 help the organization to optimize the organization’s I&T resources. The application of I&T in this sectoris started by the understanding of enterprise goals-related business alignment and how value is created by the organization. The step of this will be represented at figure 1.

Figure 1. The Context of Enterprise Governance of Information and Technology

Enterprise governance of information and technology (EGIT) is an integral part of corporate governance (ISACA, 2018). I&T will present the board of director in the organization with a guideline on what must be done in the process of establishing organizational structure then define the standard operational mechanism in order to make I&T resources fully support the management'swork and create the value of business that they wanted. I&T gives the positive impact to making theawareness of business investment related to I&T alignment resources.

Basically, EGIT is helpful to the organization understanding the business risk from digital transformation process (Astuti, Muqtadiroh, Putri, & Darmaningrat, 2017). It's hardly revolutionaryfor organization which is not fully support to understand and aware about I&T risk profile. The outcomes are seen to benefit realization which involves creating value for the enterprise through I&T, increasing the value derived from existing I&T investments, and eliminating I&T initiatives. The process must be running well in the transforming process. The second is risk optimization which addresses the business risk associated with the use, units, operation of I&T within an enterprise (Wulandari, et al., 2019). The last is resource optimization which ensures that the appropriate capabilities are in place to execute the strategic plan and that sufficient, appropriate and effective resources are provided. There are 3 at the digital transformation in the organization using EGIT.

COBIT 2019 framework has five key principles in making I&T governance that meets the stakeholders' needs, covering the enterprise end to end, applying a single integrated framework, andenabling a holistic approach. These five principles enable the enterprise to make an effective corporate governance's process. The process will give positive impact to the organization in producethe business values.

2.2 DATA MANAGEMENT

Data management is the development and execution of architectures, policies, practices, andprocedures that properly manage the full data lifecycle needs of an enterprise (DAMA International, 2017). This process aims to ensure the availability, validity, and security of data collection. Data management is pivotal since I&T may reduce security risk, data loss, and help the organization to make an accurate decision. Proper data management also helps ensure that information stays secureand never ends up in the wrong hands. Data management makes certain that the organization will be making the most accurate decisions based on the most accurate pieces of information.

2.3 THE PUBLIC RELATION & PROTOCOL BUREAU OF THE REGIONALSECRETARIAT OF EAST JAVA PROVINCE

The public relation and protocol bureau of the regional secretariat of East Java province (Biro Humas dan Protokol Setda Provinsi Jawa Timur) is an organization that focuses on preparingand drafting the formulation of public policy, evaluating program organization related to public policy, organizing technical meeting, administration, and allocating resources related with public relation (BIRO HUMAS & PROTOKOL SETDA JAWA TIMUR, 2019). Today, the organizationadopts I&T to support their business process and to make a quick response to the public issue. Thereare some applications that are used in its internal organization. The first is the official website of theorganization, the second is SIMOMED (Sistem monitoring media online).

The organizational structure is shown in figure 2. There are 4 departments that have differenttasks. The first is the department of data and information collection which focuses on coordination, filtering data, and general administration function. This department has 2 sub-departments; generaladministration and information filtering and processing. The second department is Media and Documentation that focuses on preparing media and image or video records. This department has 2sub-departments which are media and documentation and publishing.

The third department is the department of protocol which focuses on managing, planning, and giving protocol services for the Governor, Vice Governor, Regional Secretary, and anyceremonials. This department has 3 sub-departments; sub-department of ceremonial protocol, sub- department of service protocol, and sub-department of invitation protocol. The last department is the department of administration and cooperation that focuses on relation coordination in the government sector across departments, regional or abroad. This department has 3 sub-departmentswhich are sub-department of abroad cooperation, sub-department of domestic cooperation, and sub-department of monitoring and evaluation.

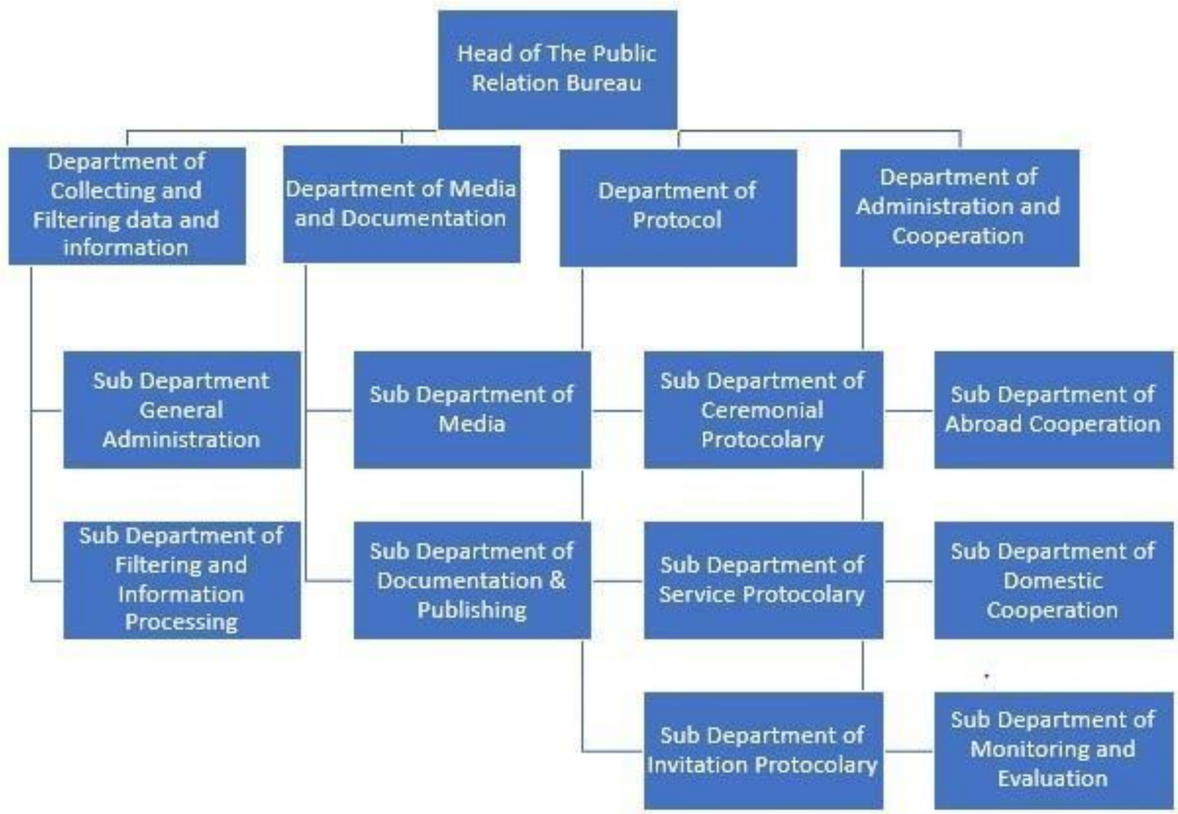

Figure 2. Organizational Structure of Biro Humas dan Protkokol Setda Provinsi Jawa Timur

2.4 Gap Analysis

Gap analysis deals with the analysis of the difference between the current state to the desired state in the future (Nazaridoust, Bidgoli, & Rezaeenoor, 2013). I&T is possible to find the real level of knowledge in the organization by analyzing the current gaps in the organization and comparing them with the provided standards in this area. The organization has to make a strategic gap to solve this program. Some researchers used strength, weakness, opportunity, and threat analysis in makingstrategic maps to help them determine steps or formulation to reach the next stage/level.

2.5 Data Collection Process

This research was conducted in Biro Humas dan Protokol Setda Provinsi Jawa Timur. The method involved interviews and observation because these instruments allow the authors to gather and collect data simultaneously within the current situation (Queiros, Faria, & Almeida, 2017). Theparticipants in this interview were the top-level management in Biro Humas dan Protokol Setda Provinsi Jawa Timur; the Head of the public relations bureau and 4 heads of departments.

There were 2 interviews that had to be done in the process. The first interview involved a questionnaire on the rating of the current situation in regards to the I&T objectives and the steps thatshould be taken to reach the desired condition in the future. In the second interview, the participantwas asked to rate the activities that have been done to reach the chosen I&T objectives. There were4 categories that can be determined by the respondents for every activity. There were N, P, L, and F for every single condition as represented by Tabel 1.

Table 1. Level of Achieved Activities

No	Symbol	Description
1.	N	Not partially Achieved; only implemented in 0-15%
2.	P	Partially Achieved; only implemented in 16%-50%
3.	L	Largely Achieved; only implemented in 50%-85%
4.	F	Fully Achieved; Implemented (85%-100%)

Define Gap Analysis

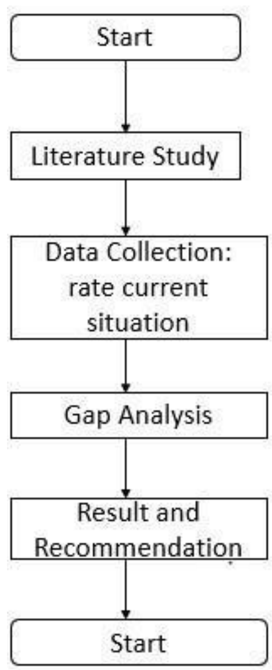

Figure 3. Research Flowchart

Gap analysis is an important step in this research. After the data were collected to analyze the current condition in the chosen objectives, a target that should be achieved in the future was then determined. The gap analysis will be presented in a table that contains objectives, current state,future state, and gap level between the current state and future state.

2.6 Establishing Recommendation

A recommendation was arranged based on the 2 steps that had been taken before in this research. After the position on the chosen objectives was known, an improvement method could then be made. The first thing to do was to ensure that all the condition at the current level has been fully achieved. If I&T is not, this process cannot be considered as successful and the steps taken must be improved.

3. RESULT AND ANALYSIS

In this section, the authors analyze the overall process within the COBIT 2019 framework. The analysis will focus on 1 government objective which is Evaluate, Direct, and Monitoring 03 (EDM03: Ensured Risk Optimization), and 1 management objective which is Align, Plan, and Organize 14 (APO14: manage data).

3.1 Result of Data Collection

From the research of process that involvement of interviews, document review, and observation, detailed information from the respondents that filled the questionnaire was obtained. There were 2 objectives used in this research; EDM03 and APO14. Two chosen objectives were setas the focus because they prioritize aligned terms of the quality of management data. EDM03 in thecurrent state was on level 2 and was grouped in the not achieved (implemented in 0%-15%) category. APO14 in its current state was also on level 2, grouped in the not achieved (implementedin 0%-15%) category.

3.2 Define Gap Analysis

In this research, gap analysis is shown in Table 2. The objectives of EDM03 in its current state were noticed to be on level 2 and were expected to reach level 4 in the future. The objectives of APO14 in the current state were on level 2 and were expected to reach level 3 in the future. Therewere many tasks that must be filled in blank and I&T will be explained in subchapter 3.3.

Table 2. Gap Analyze In The Organization

No	Objectives	Current State	Future State	Gap distance(s)
1.	EDM03	2	4	2
2.	APO14	2	3	1

3.3 Recommendation

The steps that should be taken to reach future objectives can be established after knowing the current and future state in the organization. EDM03 has a gap distance of 2 levels in its objectivecriteria. To fully reach level 3 from level 2, the organization is expected to:

1. Understanding the position of organization to manage I&T risk profile that must be faced intheir own business process.
2. Determine the risk profile that accordance with organization profile
3. Define the risk tolerance level that can be handled by the management at the organization.
4. Ensure the handling risk has been defined and declared in the organization profile risk canbe solved by the organization.

5. Establish the risk strategy in the organization's business strategy (Rencana dan Strategi Organisasi) so that the organization can take the appetite action when they face the problem.
6. Direct the standard mechanism to respond the something changing in the organization. The mechanism was composed by the management in order to define the principle of escalationwith 5 w + 1 h principal (what, where, when, who, why and how).
7. Direct the evaluation process that consist about to the research process in define the risk profile, opportunities, common issued that happening within organization.

To reach level 4 from level 3 in terms of EDM03 objectives, the organization must:

1. Establish the monitoring process, methods, techniques for identify the risk profile in thegovernance and management process.
2. Define the tolerance level in order to face the risk in the organization.
3. Establish the system for management to monitor the risk's identification progress.
4. Ensure that there is budget's allocation in order to upgrade the skill of staff to solve the issuewithin organization.
5. Evaluate risk management activities to ensure alignment with the enterprise's capacity forIT-related loss and the leadership's tolerance towards it.
6. Evaluate I&T risk factors periodically to decide the desired process and establish the solutionof risk profile. I&T presents that risk considerations are part of the strategic organization.

Meanwhile for APO14 objectives, in order to reach APO14 at level 3, the organizationmust:

1. Establish the risk profile that related in data management within organization.
2. Maintain the procedure of cleansing data process. Define the requirements in the cleansingdata like the age of data, volume of data, necessary level and any related factors.
3. Build the disaster recovery center mechanism to fully backup the data.
4. Define a rules, Standard Operational Procedure and Scenario which is needed in data riskprofile.
5. Build the framework of information system that consists of management data include acquiredata, processing data to produce the information and verification and validation scenario.

4. Conclusion

The result of this study shows that the awareness of the organization in data management has been poorly executed. This is reflected from the first assessment of 2 chosen I&T objectives, asI&T has been known to be on level 2 in the not achieved category. The steps that must be built is moreover in awareness of data backup and management strategy in order to produce the good information to spread I&T to the public.

Data management is needed by any organization. This is a priority plan that must be built by the organization. The first thing to do to ensure that all fundamental rules and strategic plans are established is to further the EDM03 and APO14 from level 2 to level 3. The organization needs to input risk management and data management as an enterprise strategy that is supported in enterprisegoals.

5. REFERENCES

BIRO HUMAS & PROTOKOLER SETDA JAWA TIMUR. (2019). *Perubahan Rencana Strategis Tahun2019-2024.* Surabaya: BIRO HUMAS & PROTOKOLER SETDA JAWA TIMUR.

Cadburry, A. (1992). *Report of the Committee on the financial aspects on corporate governance.* UnitedKingdom: Gee Professional Publishing Ltd.

DAMA International. (2017). *DAMA DMBOK: Data Management Body of Knowledge.* Kingsley Road:Technics Publication.

ISACA. (2018). *COBIT 2019 Design Guide: Designing an Information and Technology GovernanceSolution.* Schaumberg, Illinoise: ISACA.

ISACA. (2018). *COBIT 2019 Framework: Introduction and Methodology.* Schamburg, Illinois: ISACA. Krechovska, M., & Prochazkova, P. T. (2013). Sustainability and Its Integration into Corporate Governance Focusing on Corporate Performance Management and Reporting. *24th DAAAM International Symposium on Intelligent Manufacturing and Automation* (pp. 1144-1151). Vienna: Elsevier Ltd.

Model, O. D. (2015). *Data Governance and Data Management White Paper.* New Zealand: Open DataModel LLC.

Nazaridoust, M., Bidgoli, B. M., & Rezaeenoor, J. (2013). Providing a Triangular Model for Gap AnalysisCase Study: Iran Khodro Company. *International Journal of Computer Science Issues*, 627-638.

Queiros, A., Faria, D., & Almeida, F. (2017). Strengths and Limitations of Qualitative and QuantitativeResearch Methods. *European Journal of Education Studies Vol.3*, 369-387.

Astuti, M. H., Muqtadiroh, F. A., Putri, C. U., & Darmaningrat, E. W. (2017). Risk Assesment ofInformation Technology Processes Based on COBIT 5 Framework: A Case study of ITS Service Desk. *4th Information System International Conference, ISICO*, 569-576.

Wulandari, S. A., Dewi, A. P., Pohan, M. R., Sensuse, D. I., Mishbah, M., & Syamsudin. (2019).Risk Assesment and Recommendation Strategy Based on COBIT 5 for Risk: Case Study SIKN JIKN Helpdesk Service. *The Fifth Information System International Conference*, 168-177.

STUDY OF ICT READINESS OF BUSINESS CONTINUITY IN THE DISASTER RECOVERY SYSTEM

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ABSTRACT

The company's dependence on ICT makes ICT-related resources must be safe and secure from various threats. Disasters, either natural or human-made, are threats to companies. A disaster recovery plan (DRP) is a documented process and procedure designed to help restore or protect a company from disasters. Although DRP is more commonly used, DRP is part of the Business Continuity Plan (BCP) framework. BCP is a technique utilized to construct and verify an organization to find a way to recover partially or fully interrupted critical business functions and resume operation during a predetermined timeframe after a disaster. In most cases, critical business functions requiring business continuity are usually dependent on ICT. This research focuses on non-bank financial institution PT JPAS, where the protection of customer information is the most crucial thing in business transactions. This study assesses the readiness and conducts a gap analysis of the BCP procedures implemented based on the information security management system (ISMS) ISO /IEC 27001 against the information and information technology readiness guidelines for business continuity ISO / IEC 27031. Therefore, assistance in implementing and running a management system business continuity (BCMS) in line with the information security management system (ISMS) is highly appreciated. The methodology used in this study is a qualitative case study. Data collection was carried out by observation, the study of documents related to the process and procedure, literature study, and interviews. Through the study author found that the factor of the more organization have the knowledge and readiness of business continuity and realize their training needs because they had more disaster experience. This study's results are suggested infrastructure and technologies that the company should consider to successfully implement and operate BCMS according to business needs and regulatory requirements.

Keywords: disaster recovery, business continuity, IRBC, BCMS, ISMS.

1. INTRODUCTION

Information is crucial in a company or organization. More precisely, information is the main factor that builds a company. Based on this, information is very valuable, including the process of obtaining it, using it, and maintaining its security. Information protection in organizations is the duty of information security, and is a fundamental topic of information system that convey a variety of essential function in organization, including: ensuring the organization's ability to operate, ensuring the protection of the organization's information technology infrastructure, organizational information, and other assets (Hanus, 2014).

Organizations spend significant resources to build and ensure the implementation of information security governance. Often these regulations are required by governments or regulators (Paarlberg, 2016). As a non-bank financial institution, PT JPAS must also cater to the Otoritas Jasa Keuangan (OJK) as a regulator. OJK Regulation No. 2 / POJK.05 / 2017 concerning "Penyelenggaraan Usaha Lembaga Penjaminan" is regulated on data center management and disaster recovery center (Otoritas Jasa Keuangan Republik Indonesia, 2015). The OJK regulation is made to protect confidential customer information. Disaster recovery is a procedure implemented by companies to ensure the continuity of business processes after a disaster has disrupted business processes (Al-Shammari & Alwan, 2018). Disasters such as floods, fires, and earthquakes are threats to the organization that make information systems their primary means of support. According to Snedaker and Rima (2014), disasters are divided into three that is, natural, technology, and human-induced disaster. Natural disasters are caused by natural causes such as earthquakes, storms, floods, volcanoes, and others. Technology disasters or accidents are caused by machine failure, equipment destruction, and others. Human-induced disasters are caused by human factors, such as negligence, crime and group strife (Dhanujati & Girsang, 2018).

Although the term Disaster Recovery Plan (DRP) is more commonly used, DRP is part of the larger Business Continuity Plan (BCP) framework. DRP caters to information technology service continuity and is mostly technical. Business continuity needs by organization to keep its business operated with reasonable downtime and dealing with all potential interuptions. The goal is to protect employee's sustainability, minimize financial losses, maintain the organization's reputation, continue to serve customers, and comply with the laws and regulations that have been implemented by regulators (Dey, 2011).

The organization’s reliance on ICT makes it necessary for the organization to ensure that ICT-related resources and services are safe and secured from damage as business continuity is related to the Information Security Management System (ISMS). In compliance with the ISO / IEC 27031 standard, Information and Communication Technology (ICT) infrastructure must ensure the confidentiality, integrity, and availability of ICT services in every circumstances and become a significant part in maintaining Business Continuity (International Standard Organization, 2011).

Learning about the effects of implementing business continuity on information security can be applied in all business types. Still, in financial institutions, protecting customer information confidentiality is the most crucial thing in business transactions (Liggett, 2020). PT JPAS as a non-bank financial institution is also inseparable from its dependence on ICT, wherein 2015 PT JPAS was declared eligible to obtain ISO / IEC 27001: 2013 Information Security Management System (ISMS) certification at the IT Unit / Department. Periodic evaluation of the ISMS process is carried out as part of a continuous improvement plan (Jaminan Pembiayaan Askrindo Syariah, 2013).

Information Security Management System (ISMS) implementation and operation based on ISO / IEC 27001 define that it is essential to develop and implement an ICT service readiness plan to ensure business continuity. PT JPAS has implemented ISO / IEC 27001 ISMS since 2015, needs to evaluate the extent to which the Business Continuity Management System (BCMS) has been implemented and should consider existing processes related to ISO / IEC 27031: 2011 as a guide for information and communication technology readiness for business continuity.

Although PT JPAS already has the existing data center and data recovery center, the infrastructure is still lacking in disaster recovery. However, the machine can support the disaster recovery process according to the existing procedure and the latest technology already implemented. However, the network or data communication, maintenance, and license become a challenge because the cost of operating expenditure (OPEX) for the communication data, maintenance, and license are expensive. Although business continuity is considered a management responsibility, it lacks of knowledge and attention from stakeholders and is still considered ICT scope and responsibility (Kato & Charoenrat, 2018).

Even though business continuity still lacks the attention of stakeholders such as managerial position and board of the director, the organization still demand the ensuring continuity of business operation in a specific predetermined period, so this study assesses and revise the ICT readiness of business continuity in the disaster recovery infrastructure and suggested the upgrade from technology-wise such as infrastructure or communication data, to meet the stakeholder demand.

2. LITERATURE REVIEW

2.1 Disaster Recovery Planning

According to Toigo (2013), disaster recovery planning is an ICT procedure that decides an organization's capability to bounce back from a natural or human-induced disaster (White, 2017). One of the ways to distinguish the types of disasters that could arise is by grouping them by the origin of the disasters. The three general approaches to identify the causes of disasters are whether the threat factor is natural, human, or environmental (Conrad et al., 2016). The natural factor is the kind of threat that is naturally occurring and leads to a disaster, such as floods, earthquakes, storms, and a few kinds of fires. The human factor is the most typical cause of disasters, and these threats can be classified as either deliberate or accidental. A deliberate attack is a motivated attack by an individual, and whether motivated by money or other cause, accidental attacks are those when an individual has unintentionally behaved as a source of the threat, such as negligence. Environmental threats do not correlate with nature or weather and are based on the environment as it applies to the data center or information system (Conrad et al., 2016).

Identification and determining the likelihood of these threats is a significant part of BCP and DRP process, this analysis allow us to focus on the essential step in recovering from disaster and guide the preparation and prioritization of recovery (Conrad et al., 2014). Threats understanding can help direct a variety of possible risk mitigation or preventive plans for organization.

2.2 Business Continuity Management (BCM)

International Organization for Standardization (2015) 22301:2012 define BCM is a management process that systematic used to determine the possibility of threats, and it's consequences to business process, whereas those threats, if recognized, may contribute to presented developing a resilience organization framework and with the capacity for a successful response that protects the interest of its reputation, brand, main stakeholders, and value-added operations (Kato & Charoenrat, 2018).

Several suggestions and requirements for business continuity planning have been proposed by many authors. Overall categories of business continuity planning of crisis response, information technology disaster recovery, business continuity, and appropriate preparation have been identified by Samson (2013). Further explanation of these planning steps included performing and overviewing a business impact analysis, identifying risk analysis, and determining the objective's priorities (Christian, 2019).

Despite the common understanding and regulation that business owners will need to implement business continuity planning, a few business owners continue to report definitive business continuity strategies. The reasons for this lack of preparation of business continuity include the shortage of tools, lack of human resources, disbelief of catastrophic incident that might impact the organization business process, and the lack of awareness and knowledge of concept and components of business continuity (Christian, 2019).

2.3 Relation of DRP and BCP

Disaster Recovery Plan (DRP) is a part of the bigger framework of Business Continuity Plan (BCP). BCP is an umbrella program that incorporates a variety of specific strategies especially the DRP. While the BCP and DRP caters to different matters, with the BCP attending to the organization as a whole and DRP caters to information systems, both of these processes overlap (Conrad et al., 2016).

The Business Continuity Plan is structured to ensure that an organization is sustainable before, during, and after significant disastrous event. Without quickly recovering critical systems, this sustained viability would not be possible, which is basically what a Disaster Recovery Plan provides. An alternative way of distinguishing between a DRP and BCP is that the BCP is more integrated while DRP is information-system-centric. BCP is not as overtly systems-focused as the DRP but instead considers items such as people, vital records, and processes in addition to critical systems and an organization as a whole.

2.4 ICT Readiness

According to Hamidovic (2011), the demands of top-level management that required ICT solution to be resilient and recover into the predetermined timeframes is made possible because the movement toward ICT continuity, which supports the organization's overall business continuity management. The success of this strategy has contributed to its acceptance by the International Standards Organization (ISO). The BS 25777 that formerly used as business continuity standard was officially replaced and nullified by officially published in 2011 ISO/IEC 27031 standard. The ICT continuity terminology effectively shifting away because the idea of ICT Readiness for Business Continuity has introduced by the ISO/IEC 27031 standard. Many of the structure ICT Readiness for Business Continuity is adopted and stays the same in ICT continuity management (Koen et al., 2016).

As the name suggests, the ICT strategy involves readying or preparing actions and its related objectives in the organization for the business continuity management is called ICT Readiness for Business Continuity (IRBC). According to International Standard Organization (ISO) IRBC identified as "the capability of an organization to support its business operations by prevention, detection, and response to disruption and recovery of ICT services" (International Standard Organization, 2011). This can be identified into the objective of implementing strategies that will lower the danger of disturbance to ICT services and react to and recover from a disruption (Koen et al., 2016).

3. METHODOLOGY

3.1 Approach of Disaster Recovery

The method used in this study is a qualitative approach. According to Aberdeen (2013), qualitative method is a hierarchical yet practical method between a variety of research procedures. Case study research might be difficult for researcher according to researcher’s skill and expertise, but this method offers realistic and technical discussions on six element of case study research that are the plan, design, preparation, data collection, analysis, and reporting and gives the researcher adaptability in data collection (Adro & Franco, 2020).

This study will be limited to business continuity plans in disaster recovery system in Unit/Department IT PT JPAS. Data collection will be conducted by learning the documented procedure and filing about the relative subject, such as guideline and standard operational procedure the document based on ISO 27001, observing and practicing the technical procedure.

The selection of cases in PT JPAS's disaster recovery system was because researchers actively participated in organizational systems changes. This is because researchers are the Information Technology Unit / Department staff and are fully involved in changing the organization's ICT system, both technical and practical. In this research, the following three phases are revised and evaluate, designing and implementing a strategy for service recovery in an environment in predetermined timeframe with proper tools that can put the suggested solution into effect. Definition the ICT elements of DR that are impacting the business operation of the critical service and determine an acceptable threshold of downtimes such as RTO (Recovery Time Objective) and RPO (Recovery Point Objective). Testing and evaluating the existing solution and evaluate steps needed to recover the service.

The maximum RPO and RTO are defined by analyzing the impact of each application on the business and considering the demand of the main-stakeholders. This research will enable evaluating current infrastructure, critical applications, managing existing backup storage and systems, and finding the ideal compromise between recovery time (RTO) and recovery point objective (RPO). Taking into consideration the business and information areas correlate in the organization, the faster service is available, and the risk of data loss is lower and the risk of brand damage is lower. Virtualization plays an important role today because of its simplicity and robustness, allowing the organization to keep costs at an acceptable level. The aim of this research is to assess existing infrastructure and disaster recovery system to get the best value for RTO / RPO and suggested the appropriate infrastructure and system that support the needed RTO / RPO. Figure 1 show the disaster recovery steps in organization.

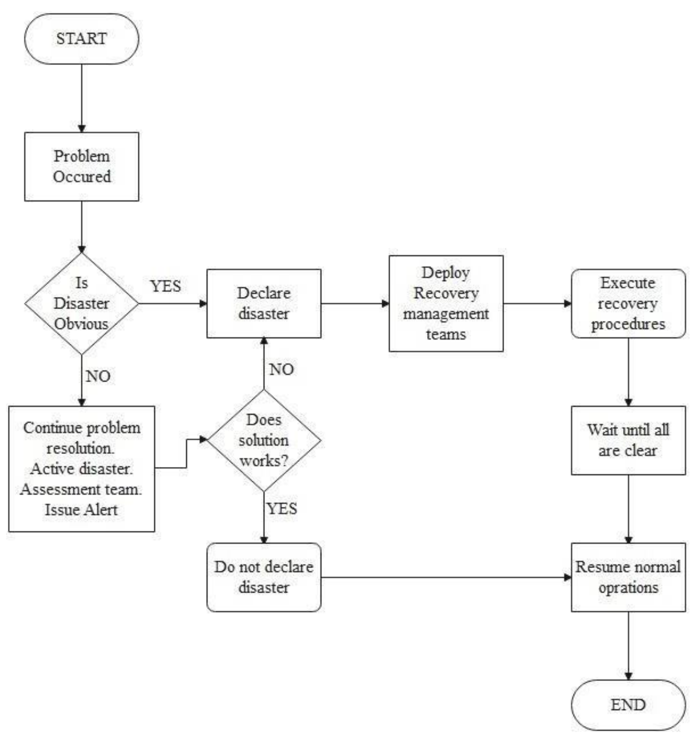

Figure 1. Step-by-step recovery strategy

3.2 Approach of Business Continuity

The phases to maintain the business continuity of ICT services in this stage, are identified according to professional assessment and management demand. These phases are identifying the effect of data center and disaster recovery center on the cost either capital expenditure (CAPEX) or operational expenditure (OPEX). Evaluating the procedure to determine the disaster recovery and business continuity performance according to the RTO, RPO and cost (storage, network, license) performance metrics.

3.3 Organization Infrastructure

The company's data center and data recovery center infrastructure uses on-premises private cloud technology that is supported by a hyper-converged infrastructure. This infrastructure integrates data storage sources and compute servers so that need less space than conventional converged infrastructure. In terms of scalability and modularity, this infrastructure adopted scale- out technology in adding and upgrade either from a technical or physical, and this infrastructure supports virtualization technology. Figure 2 below show the DC-DRC infrastructure topology.

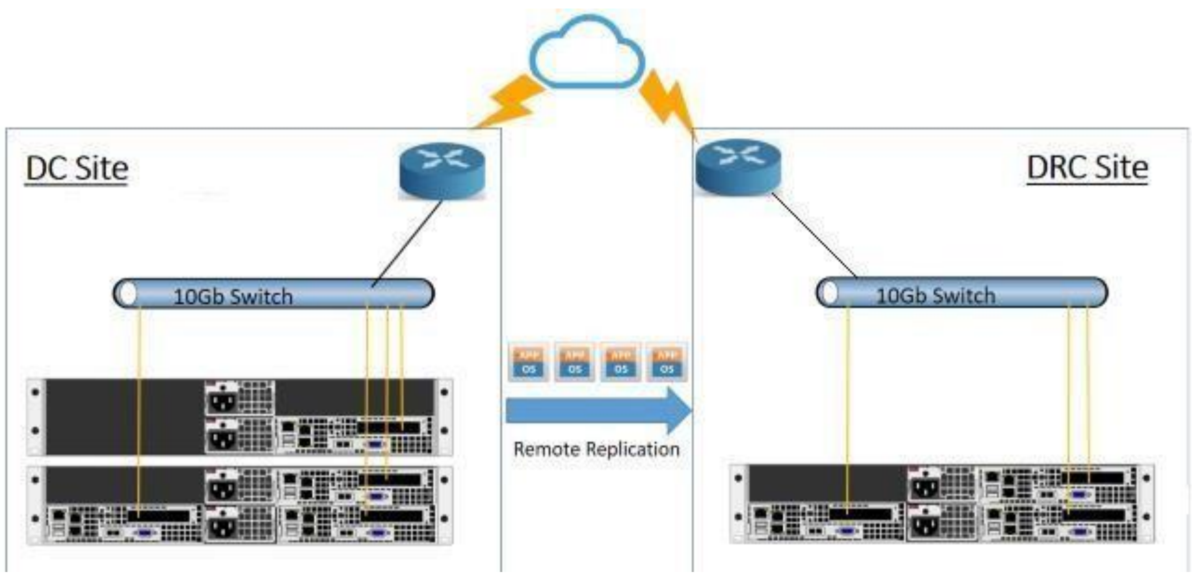

Figure 2. DC-DRC Infrastructure

The organization's infrastructure consists of a variety of Windows servers (2012, 2018, and 2020) and Linux (CentOs, Ubuntu, Redhat) systems, fully x86, existing in on-premises private cloud based on Nutanix technology.

These servers build in Acropolis hypervisor as virtualization technology, although this system support all hypervisor such as Hyper-V and VMware, we choose to user Acropolis as build-in hypervisor without added hypervisor license.

The replication technology between the data center and disaster recovery site used the build-in features in Nutanix, called Data Protection, whereas the administrator can update the critical application virtual machine that needs protection.

The entire network between the data center and disaster recovery center based on Fiber optic Channel links and routers CISCO / Mikrotik is the external link provided by Telkom Indonesia (PT). DC and DR sites communicate through a virtual private network (VPN) with 10 Mbps bandwidth.

The existing databases consist of Oracle 11g and Microsoft SQL, and current applications to create highly heterogeneous by joint development between internal programmer and third party. The primary activities of the business and social action are mainly business-to-business (B2B).

There is one datacenter in the organization's infrastructure in colocation site provide by Telkom Indonesia (PT), and one a Disaster Recovery on the another colocation provided by Telkom Indonesia (PT). Because the technology used is hyper-converged, the storage already includes in the server. For this, there is the need to add external storage systems to prevent single point failure so that there is one storage environment in the data center and one more in a disaster recovery.

3.4 Application criticality

Application criticality is defined based on the impact on the business should a problem occur. We undertook an assessment of the criticality to PT JPAS of the different applications. We worked with the relevant experts to determine the criticality of Level-1 applications. The discussion included identification of the application functions, criticality to the business, remedial action available in case of failure, and acceptable downtime. These inputs were then used as a reference to identify the criticality level of the applications. Note there was no commercial data available for reference. Thus this criticality assessment was purely based on a business judgment.

As a result, the applications can be segregated into three different critical levels, as defined in the following section.

Table-1 below shows the list of applications available in PT JPAS, including its criticality. Note those applications assessed as a '1' are the most critical to organization operation.

Table 1. Productivity Application List

No	Application	User	Type	Server Location	Criticality
1	E-filing	PT JPAS	Web	Data Center	2
2	Email	PT JPAS	Web	Data Center	2
3	OSA	PT JPAS	Web	Data Center	1
4	SOCP	PT JPAS	Web	Data Center	1
5	Owncloud	PT JPAS	Web	Data Center	3
6	Servicedesk	PT JPAS	Web	Data Center	2
7	SisMark	PT JPAS	Web	Data Center	3
8	Tableau	PT JPAS	Web	Data Center	3
9	Corporate website	PT JPAS	Web	Data Center	3
10	ITSM	PT JPAS	Web	Data Center	3
11	Talenta (HR App)	PT JPAS	Web/Mobile App	Hosting	3
12	Care Application	PT JPAS	Web	Data Center	1

The criticality level, as referred to in the above table, can be categorized into three (3) levels:

a. Criticality Level-1: Operation-critical, high business impact – means when the application is not functioning, it will cause direct impact to the company's ability to generate revenue or the possibility to increase the potential loss of revenue
b. Criticality Level-2: Operation-support, medium business impact – means when an application is not functioning, the operation can still run with remedy solution in- placed. No/small revenue loss is expected in this case.
c. Criticality Level-3: Non-critical operations, low business impact – means when an application is not functioning, the operation can still run even without any remedy action in-placed. No direct impact on the revenue is expected.

4. RESULT

The main parameters used to assess the approaches are the RTO and RPO. To maintain the BC of the services and to address the quality of the matching results determined these performance metrics are the most frequent measure used by preceding works of DR, which explained (Al-Shammari & Alwan, 2018). Recovery Time Objective (RTO) is described as the maximum amount of downtime that an IT-based business procedure can be tolerated by the organization before it begins to experience unacceptable consequences (brand damage, financial losses, influence to customer satisfaction standing, etc). Recovery Point Objective (RPO) indicates the maximum amount of information an IT-based business procedure allows to lose before causing harmful damage to the organization. Cost is identified as the amount of capital expenditure (CAPEX), or operational expenditure (OPEX) that will be needed to build the infrastructure and system that support the demands of disaster recovery such as storage for backup, length of bandwidth that will be needed to transfer the information from the data center to the disaster recovery center. The more information protected from being lost, the more cost needed, the lower cost budgeted to the system, the bigger chance of information being lost (Sengupta & Annervaz, 2014).

The main-stakeholders demand Recovery Point Objective (RPO) and Recovery Time Objective (RTO) of 15 minutes and 2 hours for critical application and service, respectively, as set in the standard of procedure BCP DRP PT JPAS become the aim and focus of this research. An RTO of 2 hours means that the maximum time acceptable for a critical system to be unavailable is 2 hours. This number is driven by assessing the total time required to determine the problem, deciding whether to go to the DRC Site, restoring the system, and coordinating with the users, as shown in Figure 1. The commercial aspect is considered using an assumption due to limited information available.

The RPO of 15 minutes means that the maximum total amount of data loss acceptable to the business is 15 minutes worth of data. The number is derived from the DRC design in which data synchronization and replication will be implemented between the Data Center and the DRC Site.

Table 2 below shows the result of the DR exercise, which is scheduled minimal once a year according to the procedure. The exercise consists of four significant steps:

a. Start replication of critical application
b. Failover virtual machine from DC to DR;
c. Run the application from DR
d. Failover from DR to DC

Table 2. DR Exercise Result

Description	Desired Outcome	Remark
Add Site	Remote Site added	
Create Protection Domain	PD Created	
Add VMs and Schedule to PD	Show ease of per-VM Backup/DR	
Start Replication to DR	Verify Replication Process	Time needed 17h 27m (vm size: 56GB)
Failover VM to DR	VM failover to DR	VM successfully moved to DR site in 2 minutes.
Run VM at DR	VM power on and run at DR	RTO 2 hour accomplished
IP Changes to DR Segment	Change VM IP manually to DR Segment	
Make changes at DR	Input “Registrasi Debitur” on application	
Start Reverse Replication to DC	Verify Replication Process	The time needed 2 minutes with metadata 100 MB
Failback VM to DC	VM failback to DC	VM successfully moved to DC site in 2 minute
Run VM at DC	VM Power on and run at DC	RTO 2 hour accomplished
IP Changes to DC Segment	Change VM IP manually to DC Segment	
Check the application	Verify the changes when VM run at DR	All data valid

5. CONCLUSION

This research presents the readiness of ICT Readiness of Business Continuity in the Disaster recovery system. This paper aims to revise and evaluate the readiness of ICT technology and system in disaster recovery. Furthermore, it designs and implements an approach to maintain the BC concerning RPO, RTO, and low backup storage cost. From the research with RPO and RTO's requirement of 15 minutes and 2 hours, we conclude that the organization has to upgrade the communication data from DC to DRC bandwidth minimal 40%. Also, the storage upgrade needs to execute shortly. Besides, awareness training might be conducted in the organization to help the main stakeholders understand the essential of disaster recovery and business continuity, and technical skill training needed to established for junior employee about the data information backup and disaster recovery process and how to execute and maintain according to the procedure. Thus the future study of BCM practices needs to involve all stakeholders such as senior-level managers, board members, clients, and the third party. Likewise, BCM has gradually considered become the responsibility of management and stakeholder, and we suggested reaching up to top-level management and third party for future study.

6.REFERENCES

Adro, F. do, & Franco, M. (2020). Rural and agri-entrepreneurial networks: A qualitative case study. *Land Use Policy*, *99*, 105117. https://doi.org/10.1016/j.landusepol.2020.105117

Al-Shammari, M. M., & Alwan, A. A. (2018). Disaster Recovery and Business Continuity for Database Services in Multi-Cloud. *1st International Conference on Computer Applications and Information Security, ICCAIS 2018*. https://doi.org/10.1109/CAIS.2018.8442005

Christian, K. A. (2019). A Qualitative Multiple Case Study of Small Business Leaders' Implementation of Successful Business Continuity Planning. In *ProQuest Dissertations and Theses* (Issue December). https://search.proquest.com/docview/2198695970?accountid=190474

Conrad, E., Misenar, S., & Feldman, J. (2014). Domain 8: Business Continuity and Disaster Recovery Planning. *Eleventh Hour CISSP*, 135–153. https://doi.org/10.1016/b978-0-12-417142-8.00008-x

Conrad, E., Misenar, S., & Feldman, J. (2016). Domain 7: Security Operations (e.g., Foundational Concepts, Investigations, Incident Management, Disaster Recovery). *CISSP Study Guide*, 347–428. https://doi.org/10.1016/b978-0-12-802437-9.00008-4

Dey, M. (2011). Business Continuity Planning (BCP) Methodology - Essential for Every Business. *2011 IEEE GCC Conference and Exhibition (GCC)*, 229–232.

Dhanujati, N., & Girsang, A. S. (2018). Data Center-Disaster Recovery Center (DC-DRC) for High Availability IT Service. *Proceedings of 2018 International Conference on Information Management and Technology, ICIMTech 2018, September*, 55–60. https://doi.org/10.1109/ICIMTech.2018.8528170

Hanus, B. T. (2014). *The Impact of Information Security Awareness on Compliance with Information Securities Policies: A Phishing Perspective*. University of North Texas.

International Standard Organization. (2011). *INTERNATIONAL STANDARD ISO / IEC 27031 Information technology — Security techniques — Guidelines for information and communication technology readiness for business continuity*. *2011*. https://www.iso.org/obp/ui/#!iso:std:44378:en

Jaminan Pembiayaan Askrindo Syariah, P. (2013). *Panduan ISO 27001: 2013*.

Kato, M., & Charoenrat, T. (2018). Business continuity management of small and medium sized enterprises: Evidence from Thailand. *International Journal of Disaster Risk Reduction*, *27*(June 2017), 577–587. https://doi.org/10.1016/j.ijdrr.2017.10.002

Koen, R., Von Solms, R., & Gerber, M. (2016). ICT Readiness for Business Continuity in local government. *2016 IST-Africa Conference, IST-Africa 2016*, 1–11. https://doi.org/10.1109/ISTAFRICA.2016.7530583

Liggett, R. L. (2020). The Effects of Infromation Security on Business Continuity: Case Study. In *ProQuest LLC* (Vol. 53, Issue 9). University of Phoenix.

Otoritas Jasa Keuangan Republik Indonesia. (2015). *Peraturan Otoritas Jasa Keuangan Nomor 2 /POJK.05/2017 Tentang Penyelenggaraan Usaha Lembaga Penjaminan*.

Paarlberg, J. W. (2016). *An Empirical Analysis On the Effectiveness of Information Security Policies, Information Technology Governance, And International Organization for Standardization Security Certification* (Issue June) [Capella University]. https://doi.org/10129949

Sengupta, S., & Annervaz, K. M. (2014). Multi-site data distribution for disaster recovery - A planning framework. *Future Generation Computer Systems*, *41*, 53–64. https://doi.org/10.1016/j.future.2014.07.007

White, G. R. (2017). *Enhancing Existing Disaster Recovery Plans Using Backup Performance Indicators*. Walden University.

HOUSE PRICE INFORMATION SYSTEM IN JAVA BASED ON APPLICATION USING JFRAME

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ABSTRACT

The use of technology and information at this time is a human need in realizing various activities, by using appropriate information technology facilities, information will be obtained according to needs. The use of information systems in the business world is needed as a strategic medium for development and exchange of information through electronic media. Java Island is an island with a high population density creating increased property development. Purchasing a property such as a house is an important requirement that must be met. The purpose of this paper is to contain an information container that is able to determine the amount of the purchase price of a house in the Java region based on market demand and cost analysis. This research is based on the demand curve, the varying purchase price of each housing unit makes consumers currently relatively confused with the types of houses that vary in the price offered. So that the analysis method of BEP (Break Even Point) is used, then it is carried out using the Comparable Sales Approach method. The result of using this method is an application-based home purchase information system that can be used as a medium of information for prospective home owners by displaying building specifications and prices based on home market prices in the desired area. The conclusion based on the analysis and design of this home buying system is that this buying system can help by simplifying the house data collection process and can meet the important information needs that have been difficult to fulfill. The suggestion to support this system is to develop a further system regarding the addition of other functional assets so that an integrated system will be formed that involves more aspects in the operational activities of buying a house.

Keywords: Applications, Properties, House Price.

1. INTRODUCTION

Home or residence is one of the basic needs for humans (primary) in addition to clothing and food needs. Said to be a basic need (basic human needs) because it is an element that must be met in order to ensure human survival. Where this basic need will determine the level of welfare as well as the quality of human life itself, therefore a dwelling in essence can affect the quality of life of the people who live in it. Along with the development of big cities in Indonesia in the effort to provide housing for their citizens, they are often faced with problems. The increase in urban population is due to birth and urbanization, which is not balanced by R with the capacity of the city. So that it causes irregularity in urban spatial planning and can grow areas or settlements that are densely populated, slum and tend to be wild. Price is one of the most important variables in determining the range of facilities in buying a residential house. Therefore we need a review of the purchase price in home marketing so that factors that can support the construction of an ideal and comfortable home are found. Therefore, the role of a consumer is also needed to get a house that suits each individual. Therefore, to meet the needs of a place to live, it is necessary to establish proper housing and activities to organize a house that is healthy, safe, comfortable, peaceful, and also harmonious for the community for survival. And therefore housing development is the right solution. According to the Department of Settlements and Spatial Planning (Kimtaru: 2004), the need for housing can basically be divided into two main things, namely: 1. Housing needs based on trends (trends) of natural population growth. 2. Housing needs and provision are based on the number of habitable houses. From the basis of the first point above, according to the needs of the house, according to the trend, many residential property developers offer cluster type housing. Along with the lifestyle or the lifestyle of a dynamic modern society, it is more likely to need a house with various facilities such as sports facilities (clube house), security, recreation in one area with a one-door access system or what is called a cluster. Java Island is one of the islands with a fairly high economic growth and population growth rate. Population growth that occurs either naturally or through the process of urbanization has resulted in a growth in the demand for housing. This has encouraged the growth of housing development in Java, including simple houses, medium-sized houses to luxury housing. Seeing the high demand for housing on the island of Java, the growth of the population's economic rate which is increasing every year, and the location for housing development which is quite strategic. This makes the emergence of an application that is able to search for a house, not having to see directly what the desired form of housing is, people only need to access house data in the application to get a safe and comfortable residential house.

2. METHOD

In this study, we used the Comparable Sales Approach method. This comparative analysis focuses on the similarities and differences between the properties under study and the transactions that affect value. These differences include existing rights to property, motivation of buyers and sellers, terms of financing, market conditions at the time of sale, size, location, shape of the property, economic characteristics, and income derived from the property that becomes the income producing property. From this method, an approach is made to market data or sales data, to process an estimate of the market value of a property obtained from a market analysis of similar properties and then to compare it to the properties to be valued. Estimated market value by comparing similar property to property at value that has a signed contract. After valuing property assets with the previous method, then proceed with the use of the break-even analysis method. Break event point analysis is an analysis in a way to find out the minimum sales volume so that a business does not suffer a loss, but also has not made a profit (in other words, the profit is equal to zero). In break even point analysis requires information about sales and costs incurred. In using the breakeven analysis research method, this can be interpreted as a research method used in the business world without prioritizing profit or profit, the company only benefits from a small amount of revenue so that sales do not experience a loss in running the business. This happens because the company in operation uses only fixed costs, and enough sales volume to cover fixed costs and variable costs that are earned.

2.1 Inspiration

In making this application inspired by an application called mamikos.com, an information system based on applications and websites that contain data about boarding houses and boarding houses provided to consumers with data presentation in the form of prices, house locations, and also the availability of boarding owner contacts. As a comparison medium, the following table is provided.

Table 1. Comparison table

Mamikos applications	Home buy application
Boarding house	specifically to buy a house
There are direct web and price differences	displays home market prices and developer contacts
as a media of consumer information	as a third party in the transaction so it is safer
only provides the availability of empty rooms	displays the specifications of the house with legal arrangement

2.2 Market

Price The price displayed from this application is the market price that has been analyzed based on the results of research from the Comparable Sales Approach method then carried out by the BEP (Break Even Point) method, so that it can be used as information to consumers that house prices with certain locations and types of houses have different prices. This information is needed by consumers as a medium of comparison for each house obtained by consumers, the data obtained is used to determine the purchase of a house based on the budget of the prospective buyer while remaining based on the consumer's dream house. The concept of the display presented is in the form of a light and informative display so that consumers when using the application there are no misunderstandings of use, this application implements a systematic system service so that a display is able to make it easier for consumers to determine the location of the house and the appropriate type of house.

2.3 Flowchart

In making this application, there is a basic design that acts as a reference so that the application concept remains in accordance with the initial basic design. The following is the application flowchart.

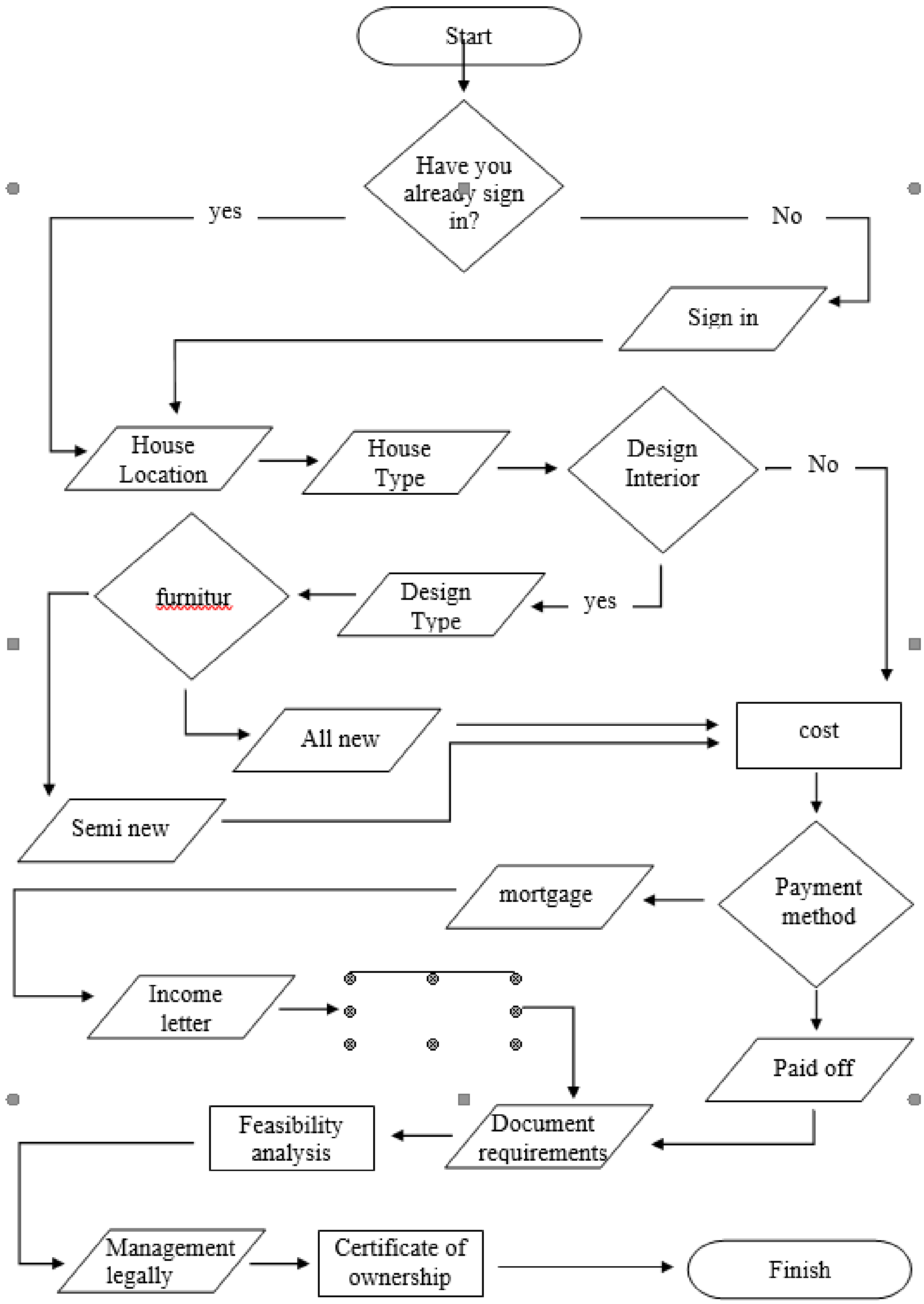

Figure 1. A Flowchart

2.4 Research Steps

After determining the flowchart structure as a path in an application, a concept stage description of the shape of an application is needed. The formation of this application concept will be a design guide for us in creating an application.

3. RESULT & DISCUSSION

The result of using this method is an application-based home purchase information system that can be used as a medium of information for prospective home owners by displaying building specifications and prices based on home market prices in the desired area. This application works by displaying information needed by consumers regarding the location of the house, the type of house provided, then the availability of the number of bedrooms, bathrooms, living room, family room, garden area, garage, and other rooms that may be specially provided in the house certain type. Then a question is displayed regarding the availability of consumers for the addition of interior design to complement the house, from the appearance of this design will be shown several design choices that are quite popular as a reference for consumers in choosing. This application will be declared complete by displaying the total costs incurred from the choice of home location, type of house, and design choices that have been selected by consumers.

In the output that is displayed from this application is when the consumer chooses the location of the house you want, the system will automatically save the market price range for the choice of house, then the system will display the type of house that the consumer will choose based on the previous location. has been selected by consumers and followed by a question about the availability of consumers in accepting the application of interior design as a complement to the house. Then the final result will be displayed in the form of house prices based on location and type of house, the cost will increase if consumers receive additional in the form of additional interior designs. From the results displayed, consumers can receive the results of information that has been collected by the system as a reference to the market price range of houses in certain locations, consumers get an overview in the form of prices that can be used as a basis for buying a house, this picture will help consumers in sorting out prices houses so that consumers get a dream house at a standard price in a residential house.

4. CONCLUSION

The conclusion based on the analysis and design of this home buying system is that this home buying system was created as an application that can help and make it easier for consumers to get the desired house data collection process and can fulfill important information needs regarding house specifications which are also accompanied by house prices which have been difficult so far. to be fulfilled.

5. REFERENCES

Junaedy Cipto (2020). *6 Bulan Bisa Beli Properti Kontan! Tanpa Uang Tanpa KPR, ngga perlu harga miring*, Jakarta, PT Gramedia Pustaka Utama. 24.

Jones Robert E, Edmondson Ed, Thompson T. A., Robison Howard W., Kunkel John C., Quillen James H., Clausen Don H., *Study of Compensation and Assistance For Persons Affected By Real Property Acquisition In Federal And Federally Assisted Programs*, US Government Printing Office, Washington. 314-136.

Mulyani Sri, (1992). *Metode Analisa Dan Perancangan*, Bandung, Abdi Sistematika, 200.

Tjiptoherijanto Prijono, 1996. Adapting lot-sizing techniques to stochastic demand through production scheduling policy. *Ketenagakerjaan, Kewirausahan Dan Pembangunan Ekonomi: Analisa Dan Persepsi Peneliti Muda*, University of California, 27.

TOPIC

Innovation on Application

DETECTION OF BREAST CANCER USING MACHINE LEARNING

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ABSTRACT

In 2018-2020 breast cancer is a disease with the second-highest mortality rate (11% according to 2018 global cancer observatory data) in Indonesia. When compared to other countries in the world, the incidence rate of breast cancer in Indonesia is lower (fourth level), but inversely proportional to the mortality rate which is the second-highest. Breast cancer is a disease caused by the cells in the breast start growing out of control and forming a tumor. Detection of breast cancer using machine learning is an effort to the early diagnosis, that can be done by examining and classifying the nucleus cells in the breast tumor as malignant (cancerous) or benign (non-cancerous) tumors in order to significantly increase the survival rate of this disease. The approach method used in this research is the supervised learning method, viz support vector machine (SVM), logistic regression (LR), and linear discriminant analysis (LDA), also unsupervised learning with the K-Nearest Neighbors (KNN) method. This research will go through five stages, viz descriptive analysis, correlation testing, classifying data using predetermined machine learning methods, interpreting the result, and comparing both results of the empirical and managerial analysis. The result of this research as follows. The support vector machine method is considered the most appropriate for processing the breast cancer dataset. The size and shape of the cell nucleus affect the malignancy of a tumor. The larger the size of the cell nucleus, the higher the probability of tumor malignancy, and the more hollows in the cell nucleus the higher the chance of tumor malignancy. The major components that lead to the difference between Indonesian and international breast cancer guidelines treatment procedures (for patients) are the number of health infrastructure, the number of human resources (in this case are specialists), and the state finance.

Keywords: Breast Cancer, Classification, Support Vector Machine (SVM), Logistic Regression, Linear Discriminant Analysis (LDA), K-Nearest Neighbors (KNN), Treatment Guidelines Procedure.

1. INTRODUCTION

In 2018-2020 breast cancer is a disease with the second-highest mortality rate (11% according to 2018 global cancer observatory data) in Indonesia. When compared to other countries in the world, the incidence rate of breast cancer in Indonesia is lower (level four worldwide), but inversely proportional to the mortality rate which is the second-highest worldwide. Breast cancer is a disease caused by the cells in the breast start growing out of control and forming a tumor. Classification and detection of breast cancer using machine learning is an effort to the early diagnosis, that can be done by examining and classifying the nucleus cells in the breast tumor as malignant (cancerous) or benign (non-cancerous) tumors in order to significantly increase the survival rate of this disease.

Data for this classification are abnormal breast tissue or nucleus cells data taken using the Fine Needle Aspiration (FNA) tool. The results are computed so that the characteristics of the cell nucleus are obtained viz 30 data variables. The approach method used in this research is the supervised learning method viz. support vector machine (SVM), logistic regression (LR), and linear discriminant analysis (LDA), also unsupervised learning with the K-Nearest Neighbors (KNN) method. The results from this research are getting the descriptive analysis of the whole data, the result of point-biserial correlation test (between response variables and predictor variables), the result of Pearson correlation test (between predictor variables), the most influential predictor variables, the analysis of classification and prediction using for methods of machine learning (support vector machine, logistic regression, linear discriminant analysis, and k-nearest neighborhood), the best method to processing breast cancer dataset, and the comparison of breast cancer patient treatment guidelines procedure between Indonesia ministry of health and World Health Organization (WHO).

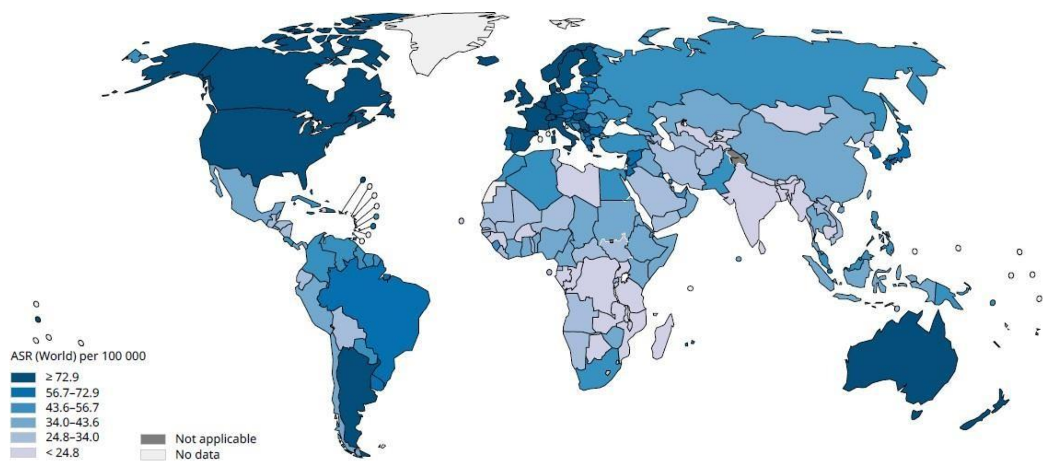

Figure 1. Age standardized (worldwide) incidence rates, breast, all ages

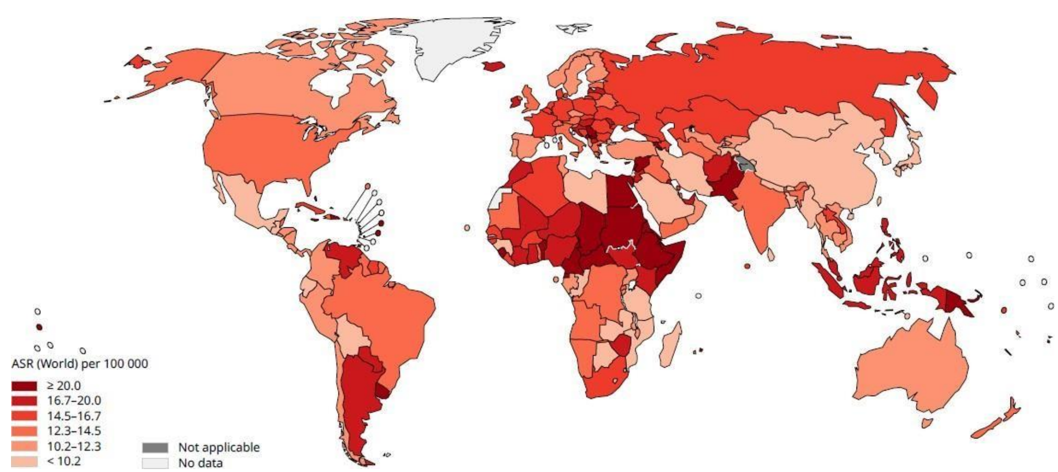

Figure 2. Age standardized (worldwide) mortality rates, breast, all ages

2. LITERATURE STUDY

2.1 Breast Cancer

Breast cancer is a type of cancer that occurs in the breast area. Almost all breast cancer sufferers are women, but there are some rare cases where men also contract this disease. Most breast cancers begin in the lobules or in the ducts that connect the lobules to the nipple. There are two types of breast cancer, viz non-invasive breast cancer (breast cancer that does not spread and attacks) and invasive (breast cancer that spreads and attacks).

2.2 Support Vector Machine (SVM)

First introduced by Vapnik in 1992 as a harmonious series of leading concepts in the field of pattern recognition. This method is a method from supervised learning, which is an algorithm that works using nonlinear mapping to convert the original training data to a higher dimension. This new dimension will look for the optimal linear hyperplane separator (the "decision boundary" separating tuples from one class from another).

2.2 Logistic Regression (LR)

First was discovered and popularized by Pierre François Verhulst around 1830 and 1840. This method is a method from supervised learning, which is an approach to making prediction models that can predict the dichotomous scale of dependent variables. This method is used to obtain odds ratios (statistical data that measures the strength of the relationship between two events, A and B) in the presence of more than one explanatory variable. The result of this method is the impact of each variable on the odds ratio of the observed events (Hidayat, 2015).

2.3 Linear Discriminant Analysis (LDA)

First developed by Sir Ronald Fisher in 1936. This method is a method from supervised learning, which uses the principle of dimensionality reduction, which is to eliminate redundant and dependent variables by changing the dataset into lower-dimensional space (certain data sets) to classify data (Mehta, 2019).

2.4 K-Nearest Neighborhood (KNN)

First introduced by Thomas Cover in the early 1970s. This method is often referred to as instance-based learning or lazy learning because the algorithm for this method is only based on distance and increasing its accuracy can be done only by normalizing training data. K-Nearest Neighborhood is an unsupervised learning method, but it is known that it can be used for data classification whose response variables are dichotomous.

3. METHOD

3.1 Flowchart Diagram

This research will go through five stages, viz descriptive analysis (for all data variables), correlation testing (Point-biserial correlation test for response variable and predictor variable, Pearson correlation test for predictor variables only), classifying data using predetermined machine learning methods (support vector machine, logistic regression, linear discriminant analysis, k-nearest neighbors), interpreting the result, and comparing both results of the empirical and managerial analysis. The steps taken to complete this research are summarized in the following flowchart.

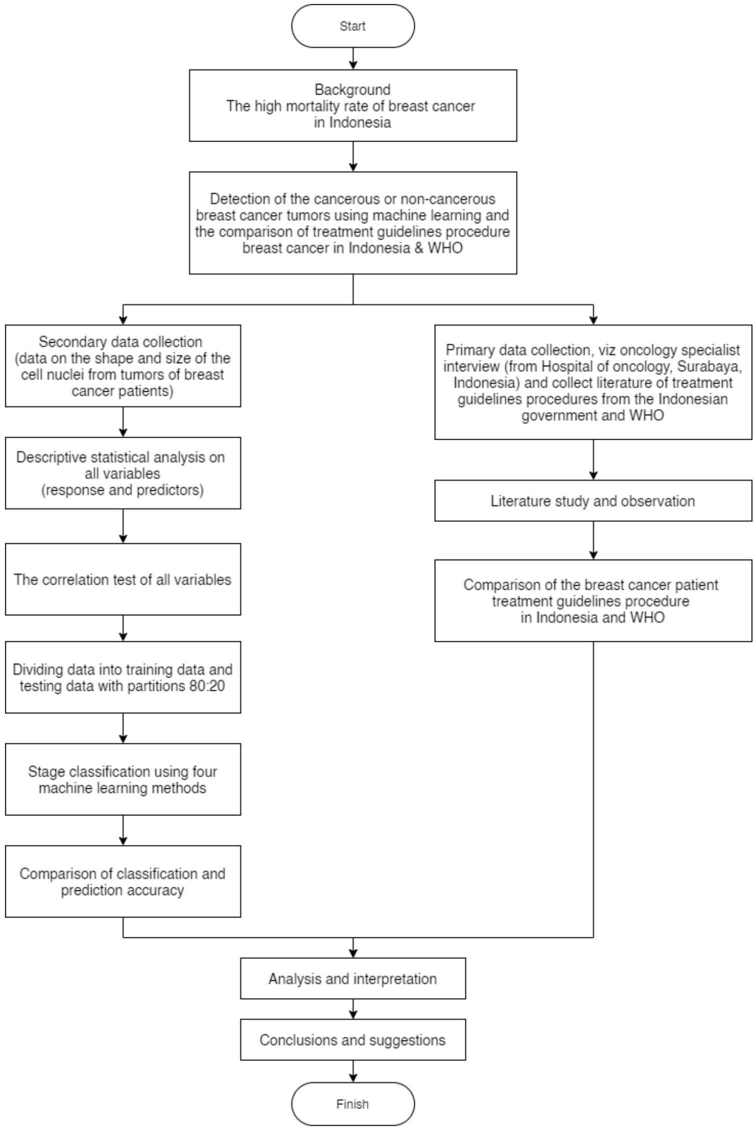

Figure 3. The research flowchart

3.2 Observational Data Structure

This research using open-source data, which obtained from the UCI Machine Learning Repository (open-source data). The data was taken by Dr. William H. Wolberg, W. Nick Street, and Olvi L. Mangasarian from the University of Wisconsin, Madison, United States. The data came from 569 breast cancer patients, where the tumor tissue in the patients was taken using the fine needle aspiration (FNA) method. Furthermore, a few drops of fluid from the tumor were observed using a microscope and recorded, so that a rough outline of some visible cell nuclei (boundary). In order to determine the real boundary, an active contour model or commonly known as a snake is carried out, so that variable numerical data is obtained. The observational data structure from the response variable and some predictor variables are as follows below.

Table 1. Observational data structure

Patient	**Y**	$\mathbf{X_1}$	$\mathbf{X_2}$	$\mathbf{X_3}$	…	$\mathbf{X_{30}}$
1	Y_1	$X_{1.1}$	$X_{2.1}$	$X_{3.1}$	…	$X_{30.1}$
2	Y_2	$X_{1.2}$	$X_{2.2}$	$X_{3.2}$	…	$X_{30.2}$
3	Y_3	$X_{1.3}$	$X_{2.3}$	$X_{3.3}$	…	$X_{30.3}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮
569	Y_{569}	$X_{1.569}$	$X_{2.569}$	$X_{3.569}$	…	$X_{30.569}$

4. RESULTS AND DISCUSSION

4.1 Empirical Analysis

Figure 2 (on the left side) shown that the data distribution between benign and malignant on the response variable is not balanced, where the benign data is more than the malignant data. Figure 2 (on the right side) also shown that all the predictor variable data have normal distributions with different descriptive statistics.

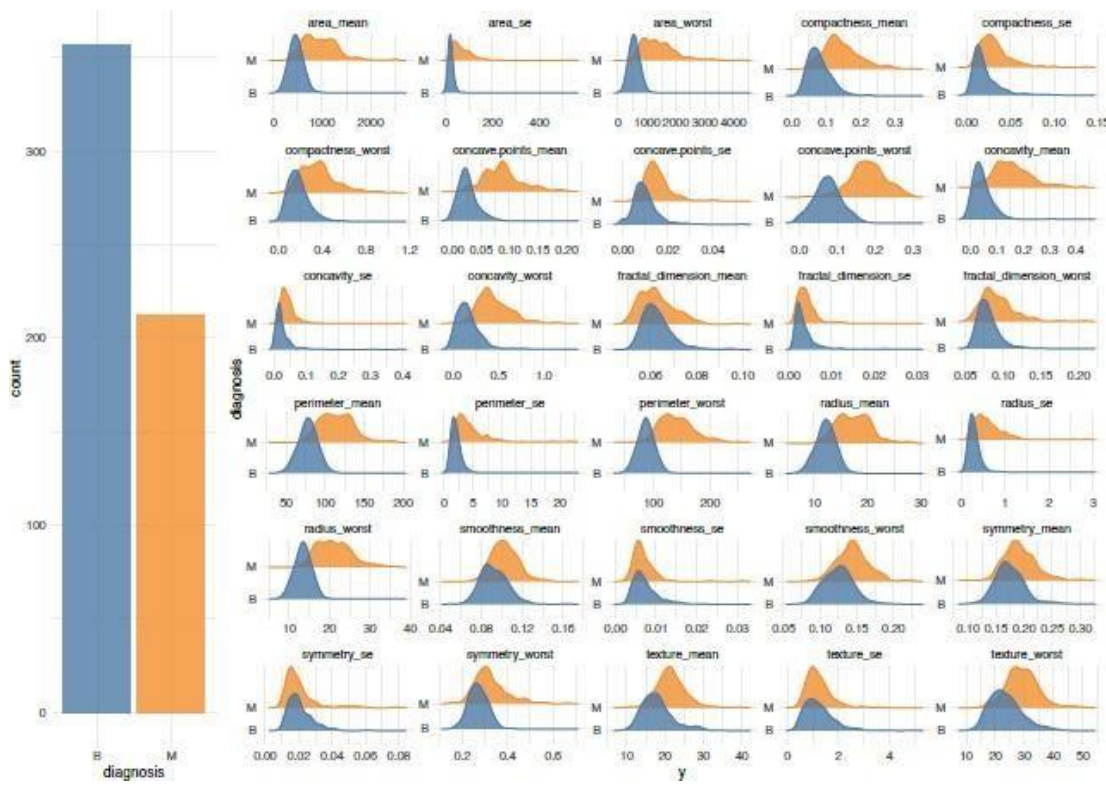

Figure 4. Exploratory data analysis (EDA) breast cancer dataset

The data was processed using four machine learning methods, viz. support vector machine, logistic regression, linear discriminant analysis, and k-nearest neighborhood. Table 2 contains a summary of the data processing results of the four machine learning methods. It shown in table 2 that the value of the derivation confusion matrix for all machine learning methods. It is known from the existing thirteen terminologies, the support vector machine (SVM) has the highest number of terminologies, which means that the support vector machine method is considered the most appropriate for processing the breast cancer dataset, with seven terminologies. Other methods that have the highest to lowest number of terms are as follows: linear discriminant analysis (LDA) with four terminologies, logistic regression (LR) with two terminologies, and finally k-nearest neighborhood (KNN) with one terminology.

Table 2. Summary of confusion matrix all methods

Methods	Logistic Regression	Linear Discriminant Analysis	Support Vector Machine	K-Nearest Neighborhood
ROC	95.3%	99.0%	99.6%	99.5%
AUC	97.9%	98.6%	98.4%	96.5%
Sensitivity	97.6%	83.3%	98.6%	81.0%
Specificity	94.4%	98.6%	92.9%	98.6%
Pos Pred Value	91.1%	97.2%	95.9%	97.1%
Neg Pred Value	98.5%	90.9%	97.5%	89.7%
Precision	91.1%	97.2%	95.9%	97.1%
Recall	97.6%	83.3%	98.6%	81.0%
F1	94.3%	89.7%	97.2%	88.3%
Prevalence	37.2%	37.2%	62.8%	37.2%
Detection Rate	36.3%	31.0%	61.9%	30.1%
Detection Prevalence	39.8%	31.9%	64.6%	31.0%
Balanced Accuracy	96.0%	91.0%	95.7%	89.8%

4.2 Managerial Analysis

The results of an interview with a pathologist from the Hospital of Oncology, Surabaya, Indonesia, namely dr. Alphania Rahniayu, Sp.PA, are as follows. There are three main components that cause differences in treatment procedure guidelines in Indonesia and Worldwide (American Cancer Society and World Health Organization), viz the number of health infrastructure, the number of human resources (in this case are specialists), and the state finances. In Indonesia, tt is known that the health allowance from the government is only for patients with late-stage cancer (metastasis has occurred), so it frankly says that the health allowance from the Indonesian government never helps breast cancer patients to make an early diagnosis.

The solution offered by the author to help the Indonesian government is creating a breast cancer fund-raising to help the government fulfill health infrastructure in all hospitals in Indonesia, more technology and health infrastructure will cover the shortage of human resources in the health sector (in this case medical specialist).

5. CONCLUSION

The results of the highest point-biserial correlation test are as follows. Perimeter worst with a correlation value of 1, concave points worst with a correlation value of 1, concave points mean with a correlation value of 0.99, and radius worst with a correlation value of 0.99. The Pearson test results are as follows. Perimeter, radius, and area are variables with strong correlation, with a correlation value of 1.

The support vector machine method is considered the most appropriate for processing the breast cancer dataset. The size and shape of the cell nucleus affect the malignancy of a tumor. The larger the size of the cell nucleus, the higher the probability of tumor malignancy, and the more hollows in the cell nucleus the higher the chance of tumor malignancy. The major components that lead to the difference between Indonesian and international breast cancer guidelines treatment procedures (for patients) are the number of health infrastructure, the number of human resources (in this case a specialist), and the state finance.

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6. REFERENCES

American Cancer Society. (2019). *Breast Cancer: Treatment Guideline for Patients*. NCCN, September, 6.

American Cancer Society. (2019). *What Is Breast Cancer?* | Breast Cancer Definition. American Cancer Society.

GLOBOCAN 2018. (2020). *Indonesia - Global Cancer Observatory. WHO; International Agency for Research on Cancer*, 2018, In Who (Vol. 256).

Globocan Observatory 2019, W. I., (IARC), I. A. for R. on C., & (WHO), W. H. O. (2019). Breast Cancer. Source: Globocan 2018. *In World Health Organization International Agency for Research on Cancer* (Vol. 876).

Hidayat, A. (2015). *Regresi Logistik - Uji Statistik*. Statistikian.Com. Accessed 11 November 2020, Retrieved from https://www.statistikian.com/.

Kementerian Kesehatan RI. (2015). Kementerian Kesehatan Republik Indonesia. In Kementerian Kesehatan RI. Accessed 31 October 2020, Retrieved from http://www.depkes.go.id/resources/download/info-publik/Renstra-2015.pdf

Labrèche, F., Goldberg, M. S., Hashim, D., & Weiderpass, E. (2020). *Breast cancer. Occupational Cancers*, 417–438.

Mehta, A. (2019). *What Is Linear Discriminant Analysis* (LDA)? Accessed 11 November 2020, Retrieved from https://www.digitalvidya.com/terms-of-use/.

The American Cancer Society medical and editorial content. (2017). *About Breast Cancer. Breast Cancer Facts and Figures*, 1–19. Accessed 2 November 2020, Retrieved from https://www.cancer.org/

Wolberg, W. H., Street, W. N., & Mangasarian, O. L. (1999). *Importance of nuclear morphology in breast cancer prognosis*. Clinical Cancer Research, Vol.5(11), 3542–3548.

DESIGN LIBRARY APPLICATIONS USING JAVA NETBEANS AND MYSQL DATABASE

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ABSTRACT

The rapid development of the world of computer technology has created many applications that help humans, one of which is in education especially for libraries so that during the pandemic, students do not have to worry. For example, when students want to borrow books, they no longer need to have physical contact with the librarian. Therefore, the solution needed is the design of an adequate library application to log in, register, register, and borrow books. Where this library application design will produce fast, precise, and accurate information. The data contained in the library application project comes from official data on the related campus. The research method used is the method of application analysis, data collection and preparation, application development, and application testing. In this library application, to be precise on the loan menu, writing the date is still done manually. This does not reduce the advantages of designing this application. The design of this application aims to facilitate library users such as members and librarians and to provide an overview for ordinary people who want to know about this library application regarding how it works and the results of the application. The simple application design that we created uses My Sql for the database and NetBeans for making the application. This application design produces a work system that can be used in conventional libraries.

Key word : Application, Library, Design.

1. INTRODUCTION

Background

The world of education cannot escape life, because life is learning. So that with the covid-19 virus, education and learning must continue to flow. One source of education is books which are usually provided in libraries. By utilizing increasingly mushrooming technology, libraries have emerged to carry out social distancing.

This application is expected to reduce physical contact in visiting the library. Like the situation during this pandemic, some libraries still open their place. It can be given a solution by using this application for students who are visiting or want to borrow some books from the library without having to make physical contact with the librarian.

This library application can be applied to conventional libraries. In addition, the benefits obtained are to make it easier for librarians in coaching data such as book data, loan data and member data. Therefore, we created a library application project for use in conventional libraries. Where later we will know the input design of this book loan application and know the output design of the book loan application.

2. METHOD

2.1 Application Analysis

Conduct a concept analysis regarding the course of the application to be designed and made. In the sense of determining the content of this application, there is everything in it.

2.2 Data Collection and Preparation

Collecting data in the form of student data containing name, nim, gender, study program, and class as well as collecting book data containing book code, book title, author, publisher, and year of publication, then making it a database on my sql.

2.3 Making Applications

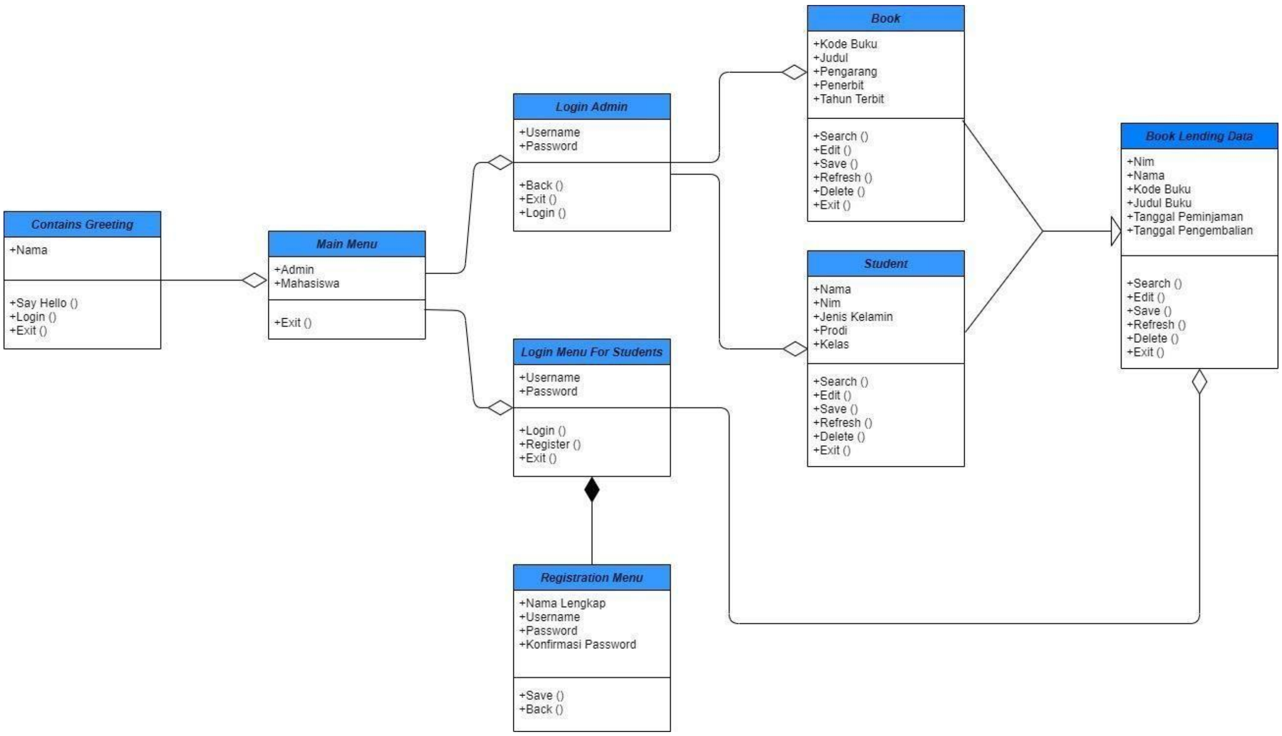
This stage is done by designing a menu design in this library application, then entering the required source code, and connecting it to the my Sql database.

2.4 Test Application

This stage is to check that this application is running properly, correctly and there are no errors. Checking the application starts from the opening screen, the main menu, the admin and student log-in menu, registration to the final view of the book lending.

3. DISCUSSION RESULT

Class Diagram



Display the opening sentence to start the program.

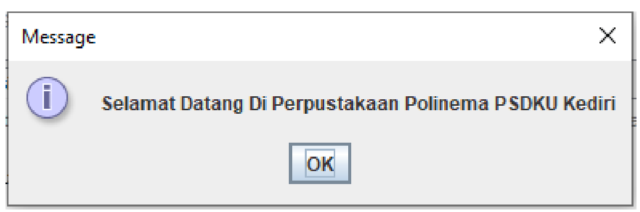


Figure 1. Display Opening

3.1 DESIGN INPUT

The program display contains greeting students while visiting the library page. This program will work when we start entering our name.

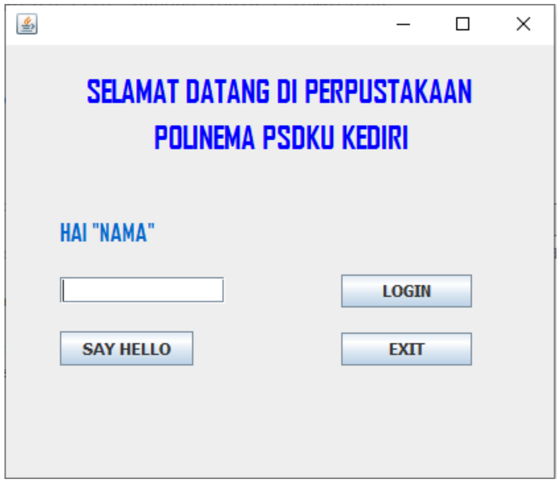


Figure 2. Display Contains Greeting

Display the main menu of the library program

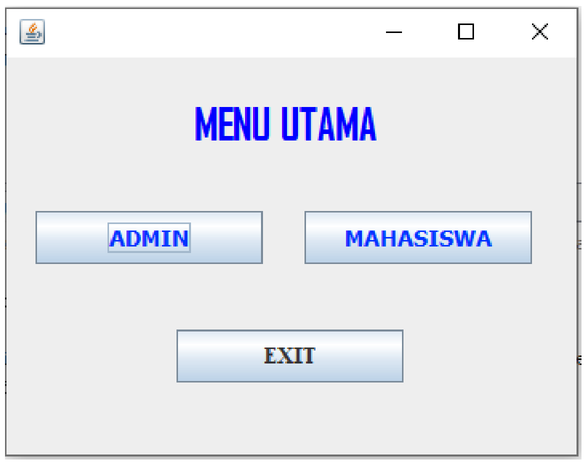


Figure 3. Display Main Menu

Admin login menu display for librarian

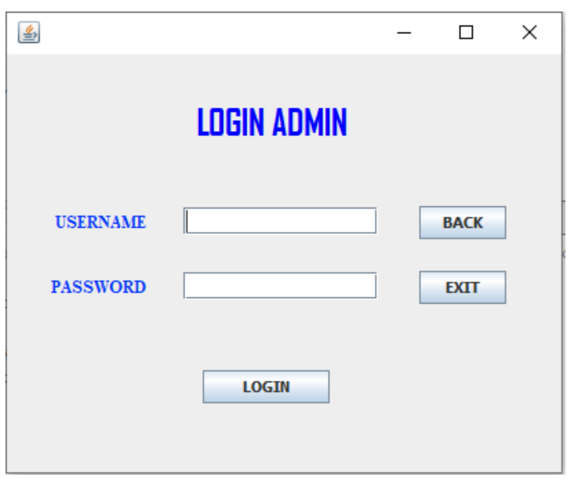


Figure 4. Display Admin Login

The login menu for students displays the username and password.

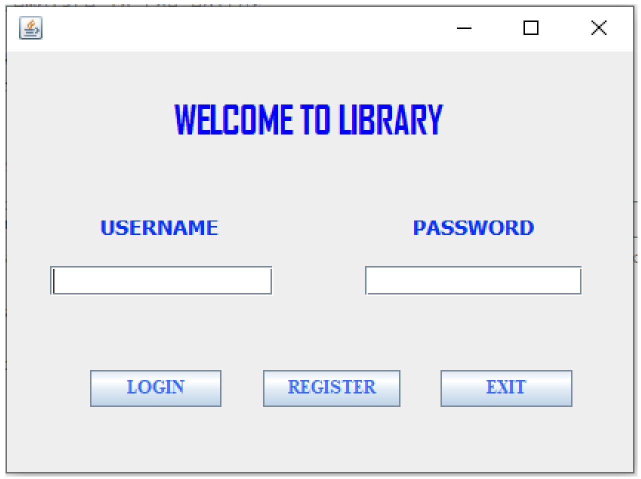


Figure 5. Display Login Menu for Students

The registration menu displays for students who have not saved their accounts

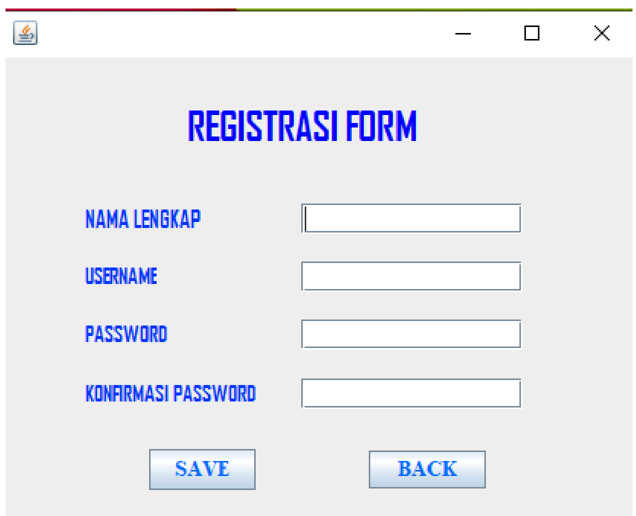


Figure 6. Display Registration Menu

Display of book lending data, which contains tables of students borrowing books and tables of borrowed books

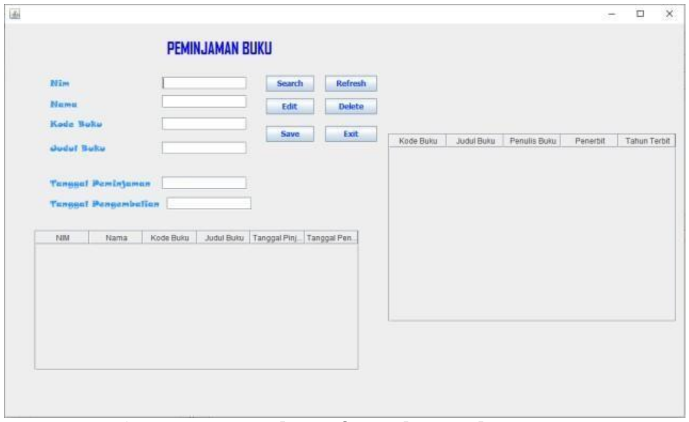


Figure 7. Display of Book Lending Data

Display of student data recorded as library information.

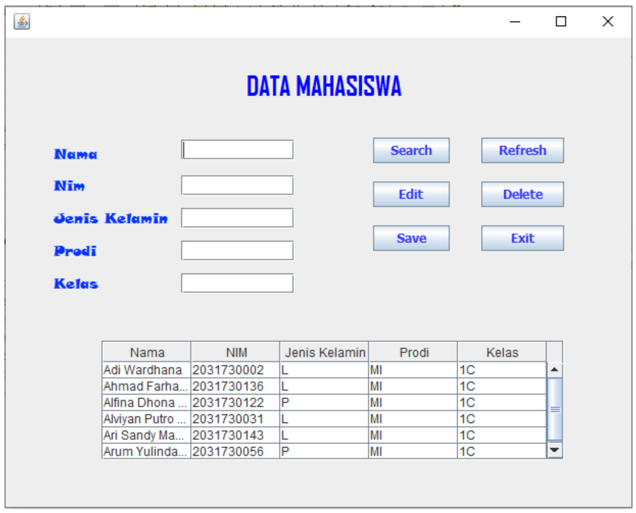


Figure 8. Display of Student Data

Display book data that contains book descriptions

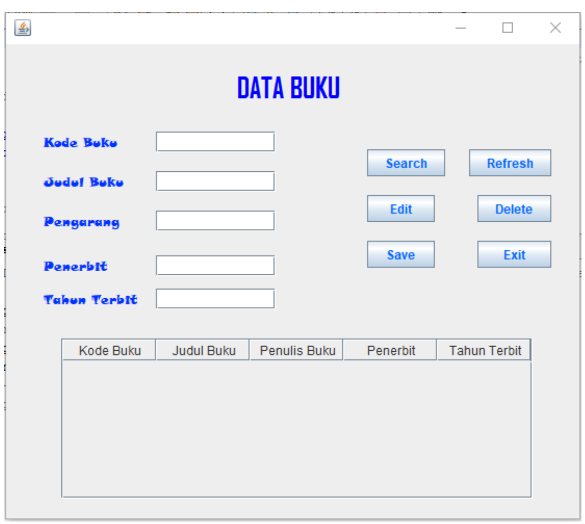


Figure 9. Display Book Data

Display book data output

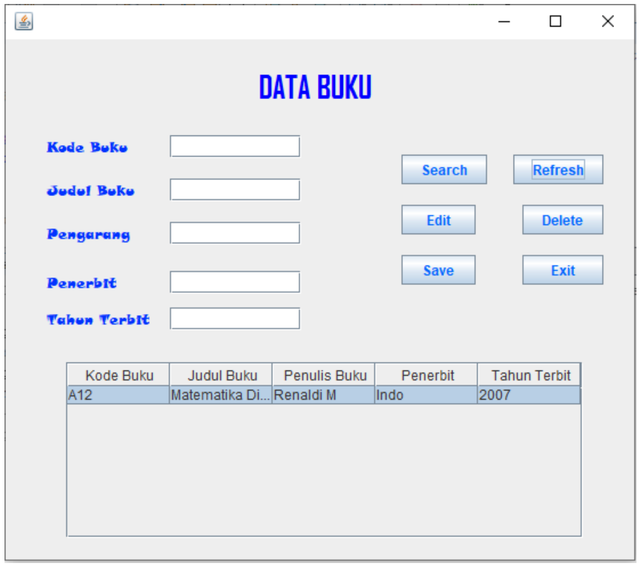


Figure 10. Display Book Data Output

4. CONCLUSION

In this simple library application program can provide an overview of how the application process runs by paying attention to each login account. The application is also connected to the my sql database, which contains data from students, loan data and a list of available books. Use this application itself to provide our learning on each project design that is made that will determine the success of an application. In making the application itself, it must also have different features compared to the usual application. Therefore, we are here to create a simple application project that can be used for libraries with its own unique features such as a display program that can greet visitors to the library. The design of this application is also expected to provide benefits for students and ordinary people who want to learn about making simple applications such as libraries.

5. REFERENCES

Susanto C, Hardi. 2015. *Perancangan Aplikasi Perpustakaan Berbasis Web Pada Madrasah Aliyah Darul Ihsan Kota Makassar*. 162-163.

Fatmawati E. 2017. *Pemanfaatan Aplikasi Perpustakaan Digital Ijateng Melalui Smartphone.* 10 (2) : 64

Setiawan S. H. 2017. *Program Aplikasi Perpustakaan Menggunakan Java Netbeans 8.0.2. Dan Catalogue Online Dengan Database Mysql*. 3 (1) : 4

Media. 2018. *Mengenal Kumpulan Library Java Programming Dalam Pembuatan Database.*

Februariyanti H, Zuliarso E. *Rancang Bangun Sistem Perpustakaan untuk Jurnal Elektronik.* 17 (2) : 128-129.

CASE EXPLORATION OF GAMIFICATION BASED IN HIGHER EDUCATION LEARNING SYSTEM MODEL

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ABSTRACT

Education nowadays is not just sitting and listening to mentors, but several methods can be used. One of the methods is gamification which using game elements in a non-game context. In this study, the context of gamification is for education. Gamification is considered as one of the methods of e-learning and is suitable for use in distance learning such as during the COVID-19 pandemic. In its application, gamification encounter obstacle that each learner has different learning styles. One of learning style classification is often used is Felder-Silverman Learning Style. In the previous study that using Felder-Silverman Index of Learning Style (ILS) Questionnaire, most of learner in higher education has visual learning style. The learner with visual learning style perceived playfulness from the study with any visual presentation like picture or video. Because of that, author use perceived playfulness as an external variable in this research. Visual learning style influence in gamification will be tested with technology acceptance model (TAM) to define acceptance level from learners. TAM is a theory that usually uses to measure the behavior of people about the technology used. This theory explains the correlation between external cause from user to technology information acceptance with certain dimensions. TAM originally use an external variable that potentially affect Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). These variables will define Attitude (A) and Behavior Intention (BI) in using a system. This research uses perceived playfulness (PP) as an external variable. The result of this study shows perceived playfulness that student gets from gamification make them feel gamification is useful. This useful condition leads their attitude and triggers their intention to using gamification. It can be concluded that perceived playfulness is affecting the student's intention to using gamification in educational use.

Keywords: Gamification, Perceived Playfulness, Technology Acceptance Model.

1. INTRODUCTION

Innovation in education always developing in many aspects. Many methods have been explored to make learning easier. Education nowadays is not just sitting and listening to mentors, but several methods can be used. One of the methods is gamification that using the elements of game in not-game need (Deterding et al., 2011). Gamification still using game elements just like the other game. Game elements can be points, levels, badges, leader boards, experience, and many more (Sailer et al., 2017). In this research, the aim of gamification is for education. The COVID-

19 pandemic makes the learning system that commonly applied no longer can be used. Any educational institution is forced to adapt to this situation. Learning activities need to do in long- distance learning, so gamification becomes a quick solution to this problem.

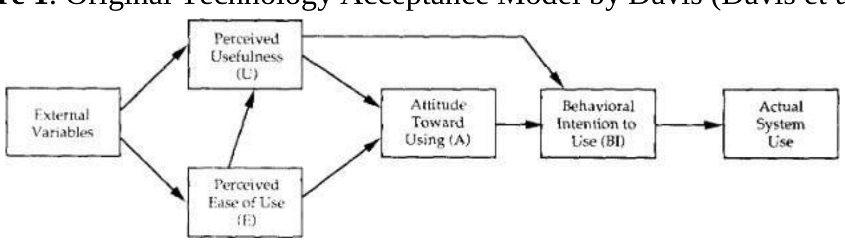
In its application, gamification encounter obstacle that each learner has different learning styles. Commonly, the learner learning style doesn't' match with the gamification that is used. Learning style is a method or a tendency that most effective for learners to understand the process and remind them what they learn (James and Gardner, 1995). Learning style is the most basic to know because it can help the teacher to define an effective teaching style (Awla, 2014). One of learning style classification is often used is Felder-Silverman Learning Style. It divides learning styles into four dimensions, that is processing, perception, input, and understanding (Felder and Silverman, 1988). This learning style is the most suitable for technology-based education like from websites or software (El-Hmoudova, 2015). In the previous study that using Felder-Silverman Index of Learning Style (ILS) Questionnaire, most learners in higher education have visual learning style. Visual learning style prefers to use pictures, videos, graphics, timelines, and many others to understand something (Felder, 1996). Learners with it is easier to study with visual presentation from lesson material.

Learners with visual learning style perceived playfulness from the study with any visual presentation like picture or video. Because of that, author use perceived playfulness as an external variable in this research. As known that gamification using some game elements and any visual presentation that make the user feel playful, author will test the acceptance level from learners in gamification with technology acceptance model (TAM) with perceived playfulness as an external variable. TAM is a theory that usually uses to measure the behavior of people about the technology used. This theory explains the correlation between external cause from user to technology information acceptance with certain dimensions (Widhiastuti and Yulianto, 2017). Of many studies, this will give contribution to the education sector, especially from the teacher's point of view. Author expected this study will provide a new perspective in higher education.

2. METHOD

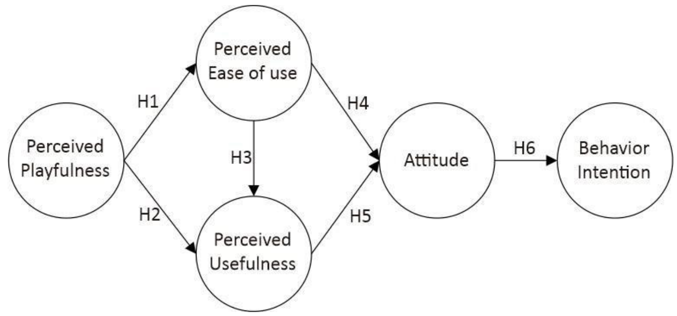
As explained in the previous section, this research will use TAM to analyze the acceptance level of learners in gamification. This theory was invented by Davis in 1989. This theory was developed from TRA (Theory of Reasoned Action) to specifically focused for modeling acceptance of users in a system of information. TAM originally use an external variable that can affect Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). These variables will define Attitude (A) and Behavior Intention (BI) in using a system (Davis et al., 1989). This basic model is shown in Fig.1. TAM is a method that is commonly used to predict use and acceptance from a system of information technology. From some literature, TAM has been verified to define individual technology acceptance in a different system (Surendran, 2012).

Figure 1. Original Technology Acceptance Model by Davis (Davis et al., 1989)



As stated by Davis (1989), PEOU defined as a level when users think that using a system is easy. An acceptable system is a system that can easily to use (Venkatesh et al., 2003). PU is defined as a degree that users feel using a system will increase their performance. Higher perceived usefulness means a system that is believed give a positive impact to users (Csikszentmihalyi, 1990).

Figure 2. Research Model in That Use in Research



An external variable that will be used is perceived playfulness. The research model can be seen in Fig. 2. Perceived playfulness (PP) is defined as an additional motivation that is often used in using a new system (Padilla-Meléndez et al., 2013). Playfulness is a variable that consists of personal satisfaction, psychological stimulation, and interest from users (Csikszentmihalyi, 1990). Playfulness is often defined as a self-motivation that shape personal experience with surrounding (Lee, 2018). In this research, perceived playfulness can be defined as how user feel enjoys and amuse with gamification. Because of attitude (A) affected by PEOU and PU, the following hypotheses were made:

H1: Perceived playfulness (PP) positively related to perceived ease of use (PEOU) in gamification use.

H2: Perceived playfulness (PP) positively related to perceived usefulness (PU) in gamification use.

Perceived ease of use (PEOU) in this study is defined as the situation when students feel using gamification is free effort using gamification and easy to understand how to use gamification. Perceived usefulness (PU) is defined as when students feel gamification can help them study and provide an advantage for them. Both PU and PEOU can affect attitude (A) to using gamification. Attitude can be interpreted as the degree of students like or not for using gamification. Because of that, these following hypotheses are made:

H3: Perceived ease of use (PEOU) positively related to perceived usefulness (PU) in gamification use.

H4: Perceived ease of use (PEOU) positively related to attitude (A) in gamification use.

H5: Perceived usefulness (PU) positively related to attitude (A) in gamification use.

Attitude can affect student's behavior intention to use gamification. Behavior intention (BI) is defined as user's perception that related targeted behavior (Venkatesh et al., 2003). In this study, BI is defined as student perception to using gamification. BI means student's motivation to use gamification for education need. From these, we can made hypotheses that:

Attitude can affect student's behavior intention to use gamification. Behavior intention (BI) is defined as the user's perception that is related to targeted behavior (Venkatesh et al., 2003). In this study, BI is defined as student perception of using gamification. BI means student's motivation to use gamification for education needs. From these, we can make hypotheses that:

H6: Attitude (A) positively related to behavior intention (BI) gamification use.

From six hypotheses that were made, author will analyze these hypotheses with TAM to explain student's behavior using gamification. The result will be presented in the next section.

3. RESULT AND DISCUSION

3.1 Demographics

This study use data from 198 respondents who have filled out the questionnaire. 198 respondents are consisting of 70 males and 127 females. 9 respondents are in diploma's degree education, 169 in bachelor's degree education, and 19 from master's degree education. All the respondents have experience in using gamification for education activity.

3.2 Data Analysis

This study will use SPSS AMOS 20 for measure the research model. Reliability and validity test need to do before doing analysis. Reliability test is to define respondents understanding to calculated context. This study will state as reliability if respondents answer the questionnaire consistently (Malhotra, 2010). Then validity test performed to make sure that data that collected are covering all area of study (Ghozali, 2006). Reliability and validity test are performed by measuring Factor Loadings, Cronbach's Alpha, Construct Reliability, and Average Variance Extracted (AVE). This study's data will state as valid if AVE > 0.5 (Ismail, 2017) and for standard value for Cronbach's Alpha is > 0,6 and for Construct Reliability > 0.6 (Malhotra, 2010). The result of this test can be seen in Table 1.

Table 1 Questionnaire Reliability and Validity Test Result

Variables	Items	Factor Loadings (>0.5)	Average Variance Extracted (AVE) (>0.5)	Cronbach's Alpha (>0.6)	Construct Reliability (>0.6)
PP	PP1	0.74	0.609	0.862	0.909
	PP2	0.82			
	PP3	0.79			
	PP4	0.77			
PU	PU1	0.84	0.669	0.886	0.928
	PU2	0.84			
	PU3	0.78			
	PU4	0.81			
PEOU	PEOU1	0.68	0.616	0.857	0.913
	PEOU2	0.83			
	PEOU3	0.78			
	PEOU4	0.84			
A	A1	0.83	0.618	0.864	0.902
	A2	0.87			

Variables	Items	Factor Loadings (>0.5)	Average Variance Extracted (AVE) (>0.5)	Cronbach's Alpha (>0.6)	Construct Reliability (>0.6)
	A3	0.75			
	A4	0.68			
BI	BI1	0.83	0.698	0.901	0.922
	BI2	0.89			
	BI3	0.80			
	BI4	0.82			

Table 1 Shown the result of reliability and validity test for every variable use in this study. Each of the variables has four parameters. Observed parameters of PP as external variables are provided by PP1, PP2, PP3, and PP4. Next variable is PU that has presented parameters as PU1, PU2, PU3, and PU4. Next is PEOU that has presented parameters by PEOU1, PEOU2, PEOU3, and PEOU4. After that, there is A that observed parameters as A1, A2, A3, and A4. The last variable is BI that has observed parameter include BI1, BI2, BI3, and BI4.

Table 1 shows the value of factor loading in this study has fulfilled the minimum requirement of 0.5 as recommended from recent study. This indicates that questionnaire that uses in this study can explain the dimensionality of all variables. Next is AVE which measurement of the overall variance. The result of AVE measurement provides a good result that can surpass the minimum value 0.5, this represents the latent construct can be showed by questionnaire well and can be stated that this study's data is valid. Next is Cronbach's Alpha that can surpass the minimum value 0.6. This means every question in questionnaire has consistency in describing variables, so respondents can answer it well. And the last is Construct Reliability (CR). The CR results convince the questionnaire that use has a good consistency.

After measuring the questionnaire, next is testing the model with model fit analysis. Model fit analysis is to evaluate the suitability model with overall data. This analysis using Confirmatory Factor Analysis (CFA) that compare the latent construct of model with Goodness-of-Fit value (GOF) (Latan, 2013). GOF is comparative value of model and covariance matrix of each variables. Model will accept if GOF value can fulfill requirement (cut-off value). GOF that used in this study consist of several parameters. Cut-off value of each parameter and result of GOF are shown in Table 2.

After measuring the questionnaire, next is testing the model with model fit analysis. Model fit analysis is to evaluate the suitability model with overall data. This analysis using Confirmatory Factor Analysis (CFA) that compares the latent construct of the model with Goodness-of-Fit value (GOF) (Latan, 2013). GOF is the comparative value of the model and covariance matrix of each variable. The model will accept if GOF value can fulfill the requirement (cut-off value). GOF that used in this study consist of several parameters. Cut-off value of each parameter and the result of GOF are shown in Table 2.

Table 2 Model Fit Analysis Result

GOF	*Cut-off Value*	Result
RMSEA	n < 0,1	0.082
GFI	n ≥ 0,7	0.825
AGFI	n ≥ 0,7	0.776
RMR	n ≤ 0,1	0.037
CFI	n ≥ 0,7	0.92
IFI	n ≥ 0,7	0.921

As shown in Table 2, all GOF parameter results met the cut-off value. This means the model use in this study is robust and capable to describe the real condition through GOF parameters. So, we can analyze hypotheses that were made in the previous section with structural equation model (SEM). The result of the analysis of hypotheses is shown in Table 3.

Table 3 Hypotheses Analysis Result

Variabel				β	P-value
H1	PP	→	PEOU	0.579	0.011
H2	PP	→	PU	0.609	0.005
H3	PEOU	→	PU	0.236	0.04
H4	PEOU	→	A	0.132	0.117
H5	PU	→	A	0.777	0.014
H6	A	→	BI	0.865	0.028

As seen in Table 3. We can see that every variable has positively related from β value. Positive β value means these variables are positively related. P-value <0.05 symbolize these variables are significance related, so hypotheses are accepted if it has positive β value and P-value
<0.05. In this study, we can see that H1, H2, H3, H5, and H6 are accepted, and H4 not accepted because the P-value not met the requirement. We can say perceived ease of use (PEOU), not significantly positively related to attitude (A) in gamification use.

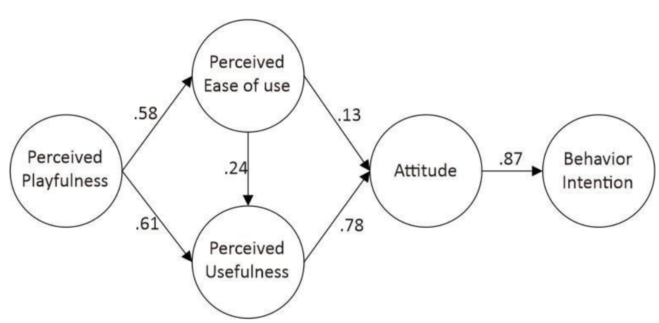


Figure 3. Structural Equation Model Result

From Fig.3, we can see the pattern that the biggest influence of behavior intention to use gamification is PP-PU-A-BI. This pattern represents that the student's intention of using gamification in higher education is strongly caused by playfulness of gamification. Perceived playfulness that student gets from gamification makes them feel gamification is useful. This condition leads to their attitude and triggers their intention to using gamification.

4. CONCLUSION

Base on the result of SEM analysis, we can conclude that perceived playfulness is affecting the student's intention to using gamification in educational use. Perceived playfulness that users feel can increase the intention to reuse gamification. This can be seen from the hypotheses analysis result that perceived playfulness will affect perceived usefulness, perceived usefulness affecting attitude, and attitude will affect behavior intention. To increase student's interest in using gamification for education, we can use game elements to increase playfulness. These game elements can be trophies, badges, levels, points, leaderboard, and many more. Other than game elements, we can combine the game stories with learning materials to make students feel playful with gamification.

5. ACKNOWLEDGMENTS

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6. REFERENCES

Awla, H.A. (2014), "Learning Styles and Their Relation to Teaching Styles", *International Journal of Language and Linguistics*, Vol. 2 No. 3, p. 241.

Csikszentmihalyi, M. (1990), *Flow : The Psychology of Optimal Experience*, Harper & Row, New York.

Davis, F.D. (1989), "Perceived usefulness, perceived ease of use, and user acceptance of information technology", *MIS Quarterly: Management Information Systems*, Vol. 13 No. 3, pp. 319–339.

Davis, F.D., Bagozzi, R.P. and Warshaw, P.R. (1989), "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models", *Management Science*, Vol. 35 No. 8, pp. 982–1003.

Deterding, S., Dixon, D., Khaled, R. and Nacke, L. (2011), "From game design elements to gamefulness: Defining 'gamification'", *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2011*, No. September, pp. 9–15.

El-Hmoudova, D. (2015), "Innovation of CB Achievement Professional English Language Course in Blackboard", *Procedia - Social and Behavioral Sciences*, Elsevier B.V., Vol. 171, pp. 166–171.

Felder, R. and Silverman, L. (1988), "Learning and Teaching Styles in Engineering Education.", *Engineering Education*, Vol. 78 No. 7, pp. 674–81.

Felder, R.M. (1996), "Matters of Style", *ASEE Prism*, Vol. 6(4) No. January 1997, pp. 18–23.

Ghozali, I. (2006), *Aplikasi Analisis Multivariate Dengan Program SPSS*, Badan Penerbit Universitas Diponegoro.

Ismail, A.R. (2017), "The influence of perceived social media marketing activities on brand loyalty: The mediation effect of brand and value consciousness", *Asia Pacific Journal of Marketing and Logistics*, Vol. 29 No. 1, pp. 129–144.

James, W.B. and Gardner, D.L. (1995), "Learning Styles: Implications for Distance Learning", *New Directions for Adult and Continuing Education*, No. 67, pp. 19–31.

Latan, H. (2013), *Structural Equation Modeling: Konsep Dan Aplikasi Menggunakan Program LISREL 8.80*, Alfabeta, Bandung.

Lee, H. (2018), "Intrinsic and extrinsic motivations affecting impulse-buying tendency in mobile shopping", *Social Behavior and Personality*, Vol. 46 No. 4, pp. 683–694.

Malhotra. (2010), *Marketing Research: An Applied Orientation*, Pearson Education Australia.

Padilla-Meléndez, A., Del Aguila-Obra, A.R. and Garrido-Moreno, A. (2013), "Perceived playfulness,

gender differences and technology acceptance model in a blended learning scenario", *Computers and Education*, Elsevier Ltd, Vol. 63, pp. 306–317.
Sailer, M., Hense, J.U., Mayr, S.K. and Mandl, H. (2017), "How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction", *Computers in Human Behavior*, Elsevier Ltd, Vol. 69, pp. 371–380.
Surendran, P. (2012), "Technology Acceptance Model: A Survey of Literature", *International Journal of Business and Social Research*, Vol. 2 No. 4.
Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D. (2003), "User Acceptance of Information Technology: Toward a Unified View", *MIS Quarterly*, Vol. 27 No. 3, pp. 425– 478.
Widhiastuti, R. and Yulianto, A. (2017), "Analysis of Technology Acceptance Model in Understanding of Students Behavior Intention in Use of Sikadu", *Dinamika Pendidikan*, Vol. 12 No. 1, pp. 20–27.

PREDICTIVE ANALYTICS AND CLUSTERING AS EARLY WARNING SYSTEM FOR OPTIMIZING DISRUPTION HANDLING IN SATELLITE NETWORKS

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ABSTRACT

The need for data connectivity in the digital era is currently very much needed by the people of Indonesia, especially those in rural or blankspot areas with a large archipelago topology. Solutions that use satellite technology are the best alternative to support equal distribution of internet access, so a reliable service guarantee is needed by the public. Speed, smoothness and convenience of access to data users are a measure of the success of service delivery provided by a provider, so optimization is needed from the side of Aftersales which is able to increase Service Level Agreement by minimizing disturbances on the network and predicting when the network will experience interference by paying attention to network parameters and Satellite transmission. The grouping process can be processed by means of grouping a number of Signal quality factor data from remote sites in several clusters. After the cluster results are obtained, it is processed again with binary logistic regression to obtain the results of the data testing in the form of a model used to analyze how strong the influence of several transmission variables is on the signal quality in the satellite network. The model used was tested using the ROC and AUC values as the feasibility value in testing the data model. Then from these results, a model is also obtained to look for an opportunity or prediction value by using the odds ratio value. The process carried out by this research will become a smart system for early warning in the world of providers so that it can assist in preventive efforts to handle and even minimize disruptions from occurring, eventually creating services with a higher Service Level Agreement and Guarantee.

Keywords:*Satelit Service, SLA &SLG, Clustering dan predictive analytics, Early warning system*

1. INTRODUCTION

One thing that cannot be separated from people's daily lives is the internet. Currently the internet has become a very important part along with technological advances. In addition to doing work, people use the internet to connect with colleagues or relatives who live far away through social media. Seeing the development of digital transformation, equitable distribution of telecommunication infrastructure and services throughout Indonesia is said to be a challenge that must be faced today. Satellite internet services with fast interconnection and can support all the needs in the world of education, health, regional government, defense and security, to improve the regional economy is urgently needed today. This is what will be done in this study to add value to the best service provided by the provider to customers, namely from the side of Aftersales or the handling of problems that occur in customers so that the commitment made by a provider must support network stability, reliability and speed in handling. distraction. Thus, Telkomsat as the best satellite provider in Indonesia will be able to provide solutions to the obstacles to data access needs that exist in Indonesia.

2. Literature Study

2.1 Satellite Networks

In general, VSAT works in the following way, the information to be sent will be passed to the hub and then transmitted via VSAT on earth to the satellite. The satellite part will work as a frequency repeater. The information received will be amplified and sent back with a higher frequency (retransmission). After the information is transmitted, the hub on earth controls the entire operation of the communication network. The hub station controls the entire communication network operation. On the hub there is a Server Network Management System (NMS) which provides access to network operators to monitor and control network communications through the integration of hardware and software components.

The Hub Station consists of Radio Frequency (RF), Intermediate Frequency (IF), and baseband equipment. This station manages multiple channels of inbound and outbound data. RF equipment consists of an antenna, low noise amplifier (LNA), down-converter, up-converter, and high-power amplifier. The IF and baseband equipment consists of the IF combiner / divider, modulator and demodulator.

2.2 Clustering

Clustering or clustering is a method of grouping data. According to Tan, 2006 clustering is a process to classify data into several clusters or groups so that the data in one cluster has a maximum similarity level and data between clusters has a minimum similarity. Clustering is the process of partitioning a set of data objects into subsets called clusters. Objects in a cluster have similar characteristics to each other and are different from other clusters.

Partitioning is not done manually but with a clustering algorithm. Therefore, clustering is very useful and can find unknown groups or groups in the data. Clustering is widely used in various applications such as business intelligence, image pattern recognition, web searches, in the field of biology, and for security. In business intelligence, clustering can organize many customers into many groups. For example, grouping customers into several clusters with strong characteristics in common. Clustering is also known as data segmentation because clustering partitions multiple data sets into groups based on their similarity. In addition, clustering can also act as outlier detection.

2.3 Logistic Regression

One theory to support prediction is to use linear regression, which is one of the types of predictions that is often used in quantitative scale data (interval or ratio). The objectives of the logistic regression include, Whether a set or set of predictor variables is significant in predicting the response variable, Which predictor variable is significant in explaining the response variable. This is indicated by the regression estimation coefficient. This estimation coefficient will form the regression equation.

The assumptions in the logistic regression:

a. Does not assume a linear relationship between the dependent and independent variables
b. The dependent variable must be dichotomous (2 variables)
c. Independent variables do not have to have the same diversity between groups of variables
d. Categories in independent variables must be separate from each other or be exclusive

3. Research Methodology

3.1 Flowchart diagram

The data that will be used in this research is secondary data from the results of data retrieval from the Satellite Hub Network located in Surabaya which has information, parameters from the network side and satellite transmission. The group of data taken from the scope of the HUB Network. Data was taken from September 2020 - October 2020 which consisted of a sample of 3123 Government, Enterprise, and Business customers with specifications for VSAT IP 1.8 M. The steps taken to complete this research are summarized in the following flowchart :

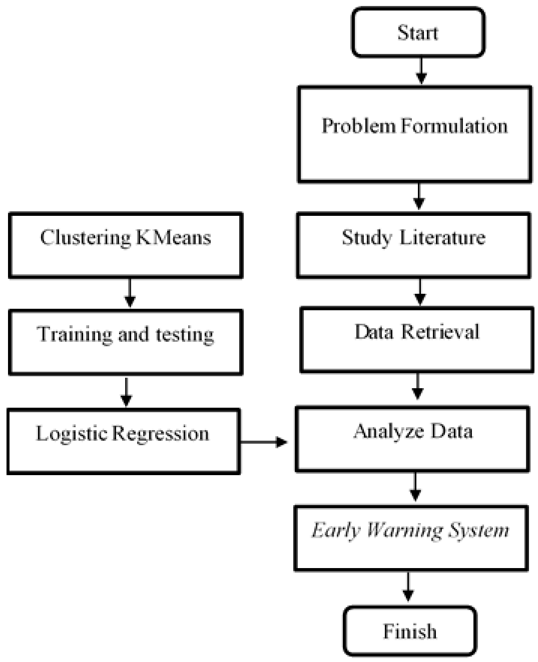


Figure 1. Research Methodology

3.2 Observational Data Structure

The analysis used to determine the characteristics of the signal quality on the Satellite Network at HUB Network Surabaya is to use descriptive statistics. Descriptive statistics is a method that deals with collecting or presenting data to provide useful information. By using descriptive statistics, various data sets can be presented concisely and neatly and can provide core information from existing data sets. The information obtained from descriptive statistics includes the size of data concentration, the size of data distribution, and also the trend of a data set. The data to be analyzed is as many as 3123 remote sites or commonly referred to as customers who are included in the NMS Remote Monitor. Of the 3123 total customers, there are 12 variables that become references from the engineer for troubleshooting. The 12 variables in question are as follows

Table 1. Observational Data

	SQF	FEC Rate	Average Esno	Ranging SQF	Ranging Init Esno	Ranging Final Esno	Ranging Power	Average PWM	Total Transmit	Current BIN	Number Stream Burst	Stream Error Rate
Min	0	2	0	0	0	0	0	0	0	-2076	0	0
Max	91	4	180	93	180	169	178	177.96	542718	1027	187106	7747
Average	67.4627	3.219661	76.36599424	69.7105347	132.6388088	73.35158501	111.1184758	61.19907781	382.7321371	130.092539	10158.27474	291.5238553
Median	71	3	69	80	154	70	124	60.2	95	107	4977	128

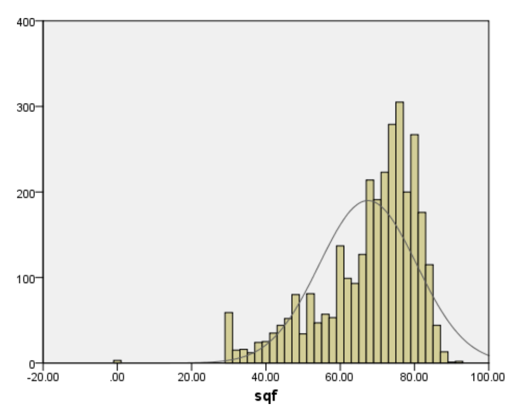
4. ANALYSIS AND DISCUSSION

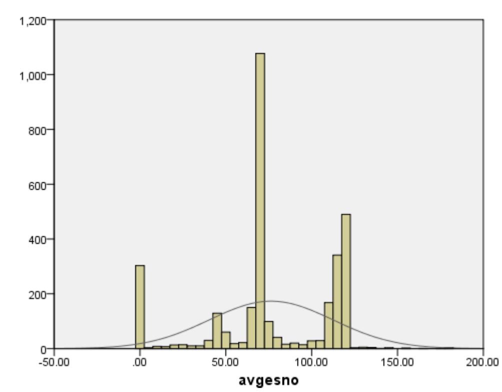
4.1 Empirical Analysis

Table 2. Emprical Analysis

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statisti	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
sqf	3123	91	0	91	67.4627	0.2347	13.11618	172.034
fecrate	3123	2	2	4	3.2197	0.01238	0.69161	0.478
avgesno	3123	180	0	180	76.366	0.64403	35.99086	1295.342
rangingsq	3123	93	0	93	69.7105	0.51359	28.70118	823.758
ranginginit	3123	180	0	180	132.6388	1.02171	57.09687	3260.052
rangingfin	3123	169	0	169	73.3516	0.65444	36.57234	1337.536
rangingpo	3123	178	0	178	111.1185	0.99593	55.65627	3097.62
avgpwm	3123	177.96	0	177.96	61.1991	0.77216	43.15151	1862.053
totaltrans	3121	542718	0	542718	382.7321	174.04788	9723.3434	94543406.82
currentbir	3123	3103	-2076	1027	130.0925	2.87714	160.78553	25851.985
numstrea	3123	187106	0	187106	10158.27	244.63165	13670.94836	186894829.1
strmerror	3123	7747	0	7747	291.5239	7.92449	442.85068	196116.724
Valid N (lis	3121							

From the table above, it can be seen that the maximum value on the Signal Quality factor or SQF is 91 and the minimum value is 0. SQF is a representation of the signal strength transmitted by the hub to the remote site and read through a network monitoring system from the satellite control center. . The stronger the signal, the greater the service that will be delivered to customers, where typical of a wireless transmission system is the influence of the weather. So if the value of sqf gets bigger it is likely that the drop level will also decrease in the vsat system itself.





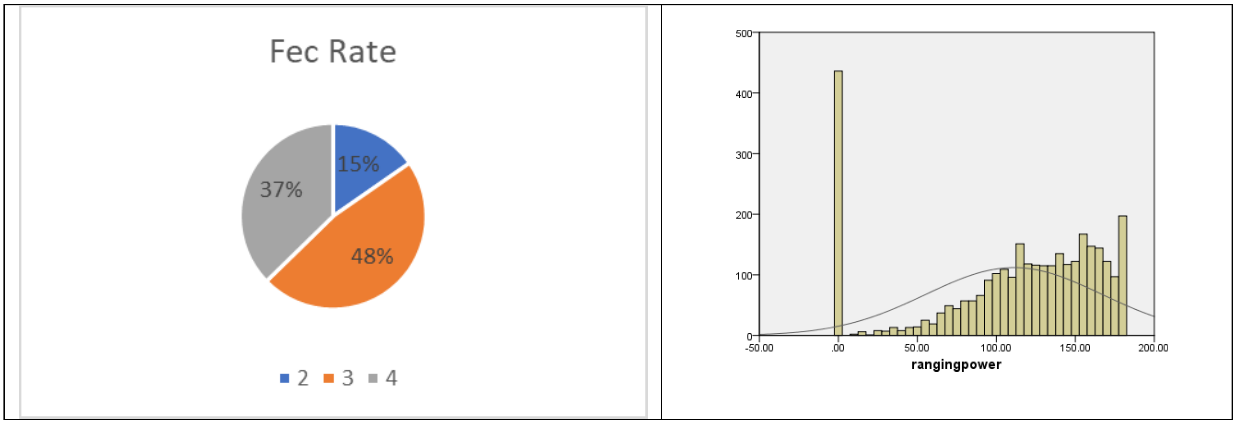


Figure 2. Distribution chart of SQF, avg esno, fec rate and ranging power

From the graph above, it can be related to the results of the previous descriptive statistical analysis that the highest signal strength is at a value of 91 and a minimum of 0. If you look at the sqf graph it can be seen that for the sqf value above 40 points is quite a lot. This value is a conventional reference for the engineer team to check whether the condition of the customer must be allocated a technician visit for repair or not. Because if the signal is continued, it will drop and the service will be interrupted. If we relate it to other parameters that are used as conventional references, such as Esno, for example, it can be seen that the esno values around the 80 to 90 range have the most frequencies. This can happen because if the receive signal received by the remote is the result of being transmitted by the earth station hub. So, the bigger the esno signal received by the remote site, the bigger it will be, or the better transmission data passed through the satellite channel. Then it can be seen through the fec rate graph, where these parameters are parameters of a hub modulation coding to the remote site. It can be seen that the largest in the fec rate is coding 3 and 5 at 48% and 37%. This relates to the previous sqf factor where the distribution of the sqf value which has a high receive value is very large, the data frequency will then be coded into a larger fec rate. The smaller sqf will also automatically enter a lower fec rate. Another fact that was found in accordance with the data is that a ranging power value of 0 has the highest value where if the results of the receive on the remote already have a high sqf value then the power required by a satellite hub does not need to be large, and it can be seen from the data that the movement of power to a large value will also increase with decrease. But this condition also tentatively changes if there is a different attenuation or weather event at a remote site, resulting in a high sqf value that is monitored suddenly the power required is also large. From this explanation, what will be the determining variable in seeing signal quality is sqf which will be categorized in several analysis processes with the aim that remote site conditions that have decreased levels must be optimized with limitations that are also maximized to obtain a better SLA. After knowing the information for each variable, a clustering process is carried out to see the distribution of SQF values for further analysis. This cluster process uses K-Means with a target of 2 Signal quality factor clusters. The results of the clustering are as follows:

Table 3. Final Cluster

Final Cluster Centers		
	Cluster	
	1	2
sqf	46.48	73.12

Number of Cases in each Cluster

Cluster	2	2454.000
	1	669.000
Valid		3123.000
Missing		0.000

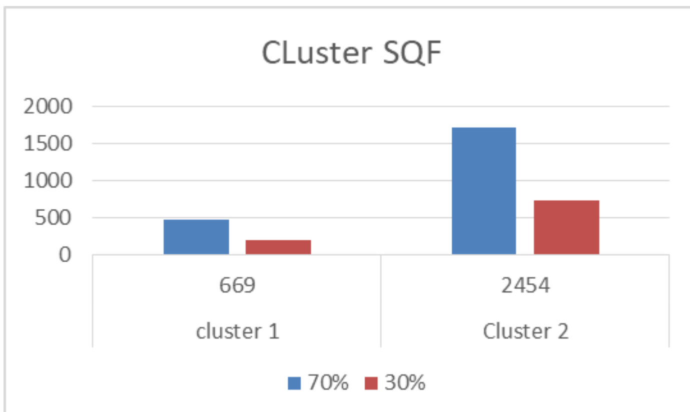


Figure 3. Cluster SQF

After knowing the information on each variable, to determine the relationship between the predictor variable and the response variable, an independence test was performed. The hypothesis used is as follows:

H0: There is no relationship between the variables Y and X

H1: There is a relationship between the variables Y and X

Likewise, each figure should be numbered and have a caption centered below it.

Table 4. Hypotesis

No	Variabel	Chi Square	Phi Value	Keputusan
1	FecRates	2.196	0.000	Tolak H0
2	average Esno	1.019	0.000	Tolak H0
3	Ranging SQF	1.042	0.000	Tolak H0
4	Ranginginitesno	0.999	0.917	Gagal Tolak H0
5	rangingfinalesno	0.970	0.000	Tolak H0

6	rangingpower	0.982	0.000	Tolak H0
7	averagepwm	1.018	0.000	Tolak H0
8	totaltransmit	1.000	0.217	Gagal tolak H0
9	currentbin	0.990	0.000	Tolak H0
10	numstrumburst	1.000	0.000	Tolak H0
11	streamerrorrate	0.999	0.001	Tolak H0

The method used to determine the risk factors that affect SQF performance at the Hub VSAT Network Surabaya is binary logistic regression. In this modeling we want to know the pattern of the relationship between the response variables which are divided into 2, namely the case in the Signal Quality factor or SQF, namely Low Quality Signals which are clustered with Kmeans with code 1 and Signal Quality Response with high quality which are clustered using code 2. Of course Of course, the next analysis will regress with the 11 predictor variables. Among them are FecRates, average Esno, Ranging SQF, Ranginginitesno, rangingfinalesno, rangingpower, averagepwm, totaltransmit, currentbin, numstrumburst, streamerrorrate. The method used to determine the risk factors that affect SQF performance at the Hub VSAT Network Surabaya is binary logistic regression. In this modeling we want to know the pattern of the relationship between the response variables which are divided into 2, namely the case in the Signal Quality factor or SQF, namely Low Quality Signals which are clustered with Kmeans with code 1 and Signal Quality Response with high quality which are clustered using code 2. Of course Of course, the next analysis will regress with the 11 predictor variables.

The hypothesis used is as follows.

H0: $\beta 1 = \beta 2 = ... = \beta 11 = 0$

H1: there is at least one $\beta j \neq 0$ where $j = 1,2,......11$

Significant Level

$\alpha = 5\%$

The test statistics are shown in the previous equation and the results are shown in the table below as follows.

Table 5. Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	718.505	8	.000
	Block	718.505	8	.000
	Model	718.505	8	.000

	B	S.E.	Wald	df	Sig.	Exp(B)
fecrate	0.679	0.129	27.535	1	0.000	1.971
averageesno	0.015	0.004	16.893	1	0.000	1.015
rangingsqf	0.026	0.006	18.453	1	0.000	1.026
ranginginitesno	-0.020	0.004	30.346	1	0.000	0.981

averagepwm	0.015	0.002	35.749	1	0.000	1.015
currentbin	-0.010	0.001	287.211	1	0.000	0.990
streamerrorrate	-0.001	0.000	12.972	1	0.000	0.999
Constant	0.185	0.357	0.270	1	0.603	1.204

The form of the logit transformation obtained is as follows:

$$g(x) = 0{,}185 + 0{,}010(x1) + 0{,}015(x2) - 0{,}001(x3) + 0{,}015(x4) + 0{,}679(x5) + 0{,}020(x6) + 0{,}026(x7)$$

So that the model obtained for signal quality events in the HUB Network vsat Surabaya is as follows:

$$\pi(x) = \frac{\exp(0{,}185 + 0{,}010(x1) + 0{,}015(x2) - 0{,}001(x3) + 0{,}015(x4) + 0{,}679(x5) + 0{,}020(x6) + 0{,}026(x7)}{1 + \exp(0{,}185 + 0{,}010(x1) + 0{,}015(x2) - 0{,}001(x3) + 0{,}015(x4) + 0{,}679(x5) + 0{,}020(x6) + 0{,}026(x7)}$$

Based on the model, it is explained that the probability of a signal quality factor condition in the Hub vsat Network Surabaya which is stated in general is influenced by 8 significant variables, namely the three variables that have the greatest influence in the contribution of SQF performance at the Hub VSAT Network Surabaya are FecRates, average Esno , Ranging SQF, Ranginginitesno, rangingfinalesno, rangingpower, averagepwm, totaltransmit, currentbin, streamerrorrate. The interpretation of the SQF model in the VSAT Network surabaya is as follows:

a. The chances of performance from SQF at Hub VSAT Network Surabaya if it is influenced by all significant variables, namely the current bin to the stream error rate is 0.72.

b. The chances of performance from SQF at the Hub VSAT Network Surabaya if not influenced by all significant variables, namely current bin to stream error, are 0.50.

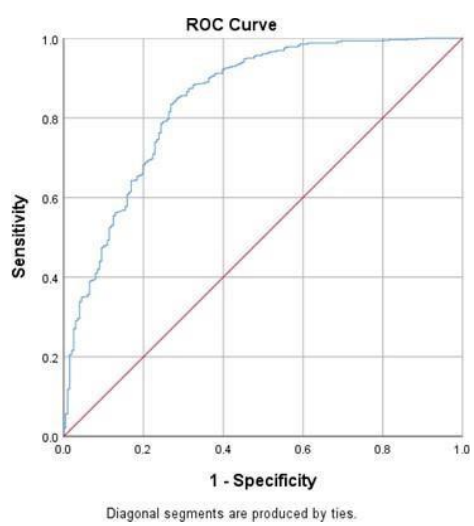
Based on the results of logistic regression analysis simultaneously, it can also be used to explain partially logistic regression and odds ratio analysis as follows:

Table 6. Logistic Regression and Odds ratio Analysis

Variable	Exp Beta(B)
fecrate	1.971
averageesno	1.015
rangingsqf	1.026
ranginginitesno	0.981
averagepwm	1.015
currentbin	0.990
streamerrorrate	0.999

a. current Bin (x1)
The probability of SQF being affected by the CurrentBIN variable is 0.54 where other variables are considered constant and influence on SQF performance of 0,991 times greater than other factors
b. averagesesno (x2)
The probability that SQF is influenced by the average esno variable is 0.53 where other variables are considered constant and influence on SQF performance of 1,015 times greater than other factors
c. streamerrorrate (x3)
The probability of SQF being influenced by the streamerrorrate variable is 0.54 where other variables are considered constant and influence on SQF performance of 0,999 times greater than other factors
d. average pwm (x4)
The chances of SQF being influenced by the averagepwm variable are 0.53 where other variables are considered constant and influence on SQF performance of 1,015 times greater than other factors
e. fecrate (x5)
The probability of SQF being influenced by the variable fecrate is 0.70 where other variables are considered constant and influence on SQF performance of 1,971 times greater than other factors
f. ranginginitesno (x6)
The probability of SQF being influenced by the Ranginginitesno variable is 0.55 where other variables are considered constant and influence on SQF performance of 0.981 times greater than other factors
g. rangingsqf (x7)
The probability of SQF being influenced by the RangingSQF variable is 0.55 where other variables are considered constant and influence on SQF performance of 1,026 times greater than other factors

The results of testing the data above, we can analyze the ROC and AUC curves to describe, organize and classify several categories that are determined in a statistical model based on their performance



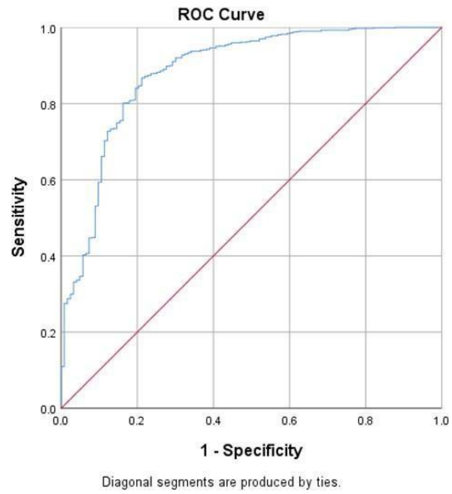


Figure 4. ROC Curve

Table 7. AUC Result

Auc Cluster	Sqf Category	AUC Result
0,844	<=50	0,883

From the table above, it can be explained that for the AUC value on the SQF cluster it has a value of 0.844 and for the AUC value where the SQF value we carry out the categorization process produces a value of 0.883. From here there is an interval or difference in the value of clusterization and categorization of 43 points where the AUc value in categorical SQF is greater than the clusterization process. But we can see that the results of the analysis for the AUC show that the data used have excellent criteria.

4.2 Managerial Analysis

From the results of the analysis carried out above, we can see that the highest variable that affects the signal transmission quality is the FEC Rate with a value of 1.971 times greater than other factors. fec rate itself is the modulation factor of a VSAT transmission system that has a specific code. where the greater the modulation value code that affects the transmission, the better the quality. From the FEC rate distribution data, it can be seen that for the fec rate below the maximum value there is still a value of 43%, meaning that almost half of the customers who are in the network have transmission problems, so to overcome this, a visit or repair of the network must be made at the location by improving the transmit value on the carrier and receiving side. so that the fec rate will be higher.

5. Conclusion

From testing the data, it can be concluded that of the 11 variables, there are 7 variables that greatly affect the signal quality. The fec rate is one of the biggest factors in this influence. By looking at the fec rate means to improve service to customers, providers must pay attention and increase the value of carrier modulation by making repeated visits to improve the transmit and receive signals so that services that harm customers do not occur.

6. REFERENCES

Alharthi, H., 2018, *Healthcare predictive analytics: An overview with a focus on Saudi Arabia,* University of Dammam (UoD), Saudi Arabia, Elsevier B. V.

Chen, W., Lu, T., Wu, J., & Zhao, Y., 2020, *An Improved Genetic FCM Clustering Algorithm*, Air Force Engineering University, Shaanxi.

Ciliberti, M. G., Albenzio, M., Annicchiarico, G., Sevi, A., Muscio, A., & Caroprese, M., 2015, *Alterations in sheep peripheral blood mononuclear cell proliferation and cytokine release by polyunsaturated fatty acid supplementation in the diet under high ambient temperature*, Foggla, Italy, Elsevier B. V.

D. Rofiqoh, V. Wiwi, H. Dahriani, L. Sri Rahayu, 2018, *Application of AHP Method Based on Competence for Determining the Best Graduate Students*, Universitas Potensi Utama, Medan, Indonesia.

Deprez, L., Antonio, K., & Boute, R., 2020, *Pricing service maintenance contracts using predictive analytic,* Belgium, Elsevier B. V.

Devi, M., 2015, *Optimization Weather Parameters Influencing Rainfall Prediction Using Adaptive Network-based Fuzzy Inference Systems (ANFIS) and Linier Regression*, Institut Teknologi Bandung, Indonesia.

Dinis, D., Teixeira, A. P., & Barbosa-Póvoa, A., 2019, *ForeSim-BI: A predictive analytics decision support tool for capacity planning*, Portugal, Elsevier B. V.

Jinhui, H., Yingxue, S., Long, H., Wenxian, L., & Feixue, W., 2016, *An Optimized Snapshot Division Strategy for Satellite Network in GNSS*

Joan, A., Hyuk, P., & Adriano, C., 2020, *Assessment of Satellite Contacts Using Predictive Algorithms for Autonomous Satellite Networks*, Barcelona, Spain.

Juan, W., Wei, W., & Xuejun, F., 2011, *Study on Synthetic Evaluation Model of Emergency Logistics Network Scheme based on AHP- Entropy Technology*, Honai University, China.

Lure, A. C., Du, X., Black, E. W., Irons, R., Lemas, D. J., Taylor, J. A., …, Neu, J., 2020, *Using Machine Learning Analysis to Assist in Differentiating between Necrotizing Enterocolitis and Spontaneous Intestinal Perforation: A Novel Predictive Analytic Tool,* Florida, United States, Elsevier B. V.

Márquez, A. C., de la Fuente Carmona, A., Marcos, J. A., & Navarro, J., 2020, *Designing CBM Plans, Based on Predictive Analytics and Big Data Tools, for Train Wheel Bearings,* Spain, Elsevier B. V.

Muhammad, M., Nunik, D., Ahmad, H., Dudih, G., Samsul, P., Ayunis, R., …, Ria, D., 2017, *Marketing Strategy With Linier Regression to The Interest of New Students,* STT Nusa Putra, Indonesia.

Ngo, J., Hwang, B. G., & Zhang, C., 2019, *Factor-based big data and predictive analytics capability assessment tool for the construction industry,* Singapore, Elsevier B. V.

Oo, M. C. M., & Thein, T., 2019, *An efficient predictive analytics system for high dimensional big data,* King Saud University, Saudi Arabia, Elsevier B. V.

Pearson, T. A., Califf, R. M., Roper, R., Engelgau, M. M., Khoury, M. J., Alcantara, C., …, Mensah, G. A., 2020, *Precision Health Analytics With Predictive Analytics and Implementation Research,* The American College of Radiology, United States, Elsevier B. V.

Sabu, K. M., & Kumar, T. K. Manoj, 2020, *Predictive analytics in Agriculture: Forecasting prices of Arecanuts in Kerala,* Kerala, India, Elsevier B. V.

Sen, W., & Li, Z., 2020, *A Supervised Correlation Coefficient Method: Detection of Different Correlation*, Shaanxi Normal University.

Shweta, K., & Kuldeep, S.J., 2020, *Improved Performance Using Fuzzy Possibilistic C-Means Clustering Algorithm in Wireless Sensor Network*, India.

Zhu, L., Qu, S., & Du, T., 2020, *Adaptive fuzzy clustering based on genetic algorithm*, University of Jinan, China.

TESTING THE ALGORITHM OF WEB-BASED TRANSPORTATION DECISION TOOLS ASSISTANCE

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ABSTRACT

In the 4.0 era, industry players competed to develop technology and information to form a digitalization system with the help of various applications and the internet that growing rapidly in basic theories such as SCM which develops into E-SCM. The request for product delivery from 1097 retails is a problem that happened in PT. X which is a Japanese motorcycle and spare parts distributor at a high random rate of location requests, determining delivery locations, and time in the delivery process. The solution to this problem is creating a web-based program that automatically provides optimal solutions based on the generalization of VRP, namely Heterogeneous Vehicle Routing Problem with Time Windows (HVRPTW). Furthermore, the test algorithm shown the simulation of the program giving better result comparing the results of the existing system.

Keywords: Transportation Information System, Vehicle Routing Problem (VRP), Heterogeneous Vehicle Routing Problem with Time Windows (HVRPTW), hybrid cluster base heuristic.

1. INTRODUCTION

In the era of Industry 4.0, adding value to supply chain management (SCM) is very important for the development of a company for operational strategy in increasing operational strategy in increasing organizational competence and responding to change the market condition (Pal, 2017). The purpose of SCM is to compile the supply network to maximize competitive advantage and benefits for the consumers (Heizer, Render, & Munson, 2017, p. 477). According to Coyle et al (2013) distribution is no longer focused on storing inventory in a warehouse, but on meeting customer needs with minimal cost utilization. The distribution network is seen as an integral part of supply chain activities which have a strategic role as a point of distribution for products and information and creating added value for the service levels that should be achieved (Pujawan, 2010, p. 192). According to AMR Research and Forrester Research in Boiko et al (2019) that states the implementation of SCM in the company could increase competitive advantages such as reducing time and costs in processing orders by 20-40%, reducing purchasing costs 5-15%, reducing circulation time on the market by 15-30%, reducing inventory that settles in warehouse 20-40%, reduce production costs by 5-15%, and increase profits by 5-15%. The breakthrough of the internet gave another impact to the development of SCM concept which called the E-SCM. E-SCM is based on information technology and organizational engineering relation with the partners (retail) through the internet (Pulevska-ivanovska & Kaleshovska, 2013). Tan et al (2019) said this new dimension was the evolution and reengineering of business process and information technology which supported by the internet connection that operated between the companies as a result of efficient information exchange. This research uses the Supply Chain Management to test the algorithm of the web base transportation tools assistance to create some distribution decision by using the Heterogenous Vehicle Routing Problem with Time Windows (HVRPTW). The program has an impact for optimizing the distribution problem in PT. X which is a motorcycle spare part distributor that having 1098 retails in East Java with the complexity of orders, delivery planning, routing, truck capacity, and delivery cost control.

2. LITERATURE REVIEW

2.1 E-Supply Chain Management

Supply Chain Management is a method used for manage the flow of products, information, and money in an integrated manner by several parties (Pujawan & Er, 2017). Chopra and Meindl (2014) said parties are not only from the manufacturing aspect between the company and supplier, but also the distributors, warehouse, retailer, and the customer themselves. With the definition which already declared above, E-SCM was the integrated and technology solution to make the communication works around the retailer and the application in the system with the support of Internet connection and networks. Figure 1. will explain how retailer, transporter, and supplier carry out the information transaction without physical in-person meeting. In addition, through the web server will simplify the communication flow for retrieving important data, developing products, supervising sales, marketing, and coordination flows (Tan et al., 2019).

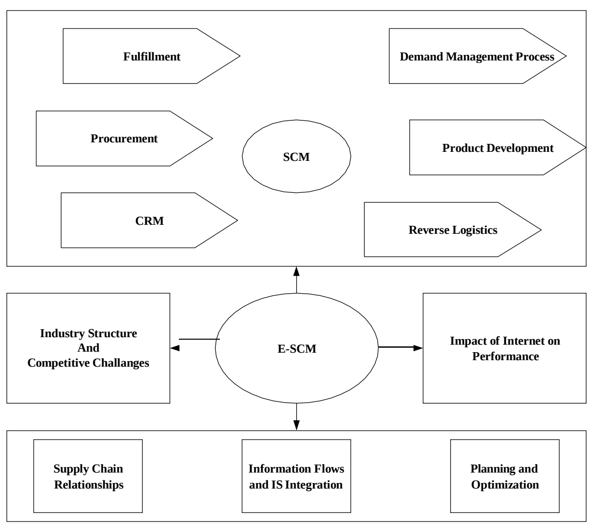

Figure.1 Framework of E-SCM Source: (Tan et al., 2019)

2.2 Vehicle Routing Problem

Laporte (1992b, p. 345) defines VRP as a solution in designing optimal delivery or collecting routes from one or several depots to several geographically dispersed points of shops or customers with some attention to additional constraints. There are a lot of additional requirements and operational constraints that arise such as services provide include two types of service namely delivery and collection, the cargo carried on a route did not exceed the capacity of the vehicle, the total distance traveled from each route was not greater than the predetermined limit, services to customers must be carried out within the time window range, the vehicle fleet consists of several heterogeneous vehicles, there is precedence relations between customers, customer request is not known at the beginning, services to one customer may be separated in different vehicles, characteristics of problem such as demand and travel times can be very dynamic (Toth & Vigo, 2002). The improvement of VRP that used in the research was Heterogenous Vehicle Routing Problem with Time Windows (HVRPTW) because it used more than one trucks with different capacity than a lot of routes that also need to race against time because of the retailer time of open and close windows.

2.3 Algorithm to Solve Vehicle Routing Problem

Fisher (1995) on Kumar (2018, p. 670) had classify to three category to solve VRP problem simple heuristic or classic heuristic, exact algorithm, and metaheuristic algorithm. Saving Matrix was one of the classic heuristics that well known for solving the VRP Problem (Laporte, et al., 2000, p.287). This algorithm always used for initial solution in construction heuristic to solving VRP problem. Steps to solve the VRP were identified distance matrix, identified the saving matrix, allocate the customer to the route or transport, and determined the order of customer visit in the routes. The determined order to the routes used to algorithm, nearest insertion and nearest neighbor. After the construction heuristic and routing determined, there will need improvement heuristic for repeating all the routing to find the best solution. There were 2-OPT and 3-OPT in this heuristic. Cluster based optimization approach would be the complementary of the problem that used the principal of cluster first route second. This algorithm was a hybrid because of the combination two different algorithm. The heuristic algorithm will used to create the cluster than the exact algorithm sorting the route to visit in every cluster to simplify the process.

2.4 Information System in Transportation

Kroenke et al in Jacobsson, Arnäs, & Stefansson (2020) said that information system consists of human and computer interactions that generate, collect, process, filter, distribute, and interpret information. According to Siminică & Traistaru in Grabara, Kolcun, & Kot (2014) explaining that delivery time is the most important factor in the transportation process, where the shorter the turnaround time the better (the shorter the better). However, with the advancement of the times, service quality is also a very important requirement in determining the quality of the transportation system. The form in which the service is delivered will have an additional effect as important as delivery time. In SCM, information systems are designed to automatically manage all stages of organizational inventory maintenance and control the distribution of products within an organization (Boiko et al., 2019).

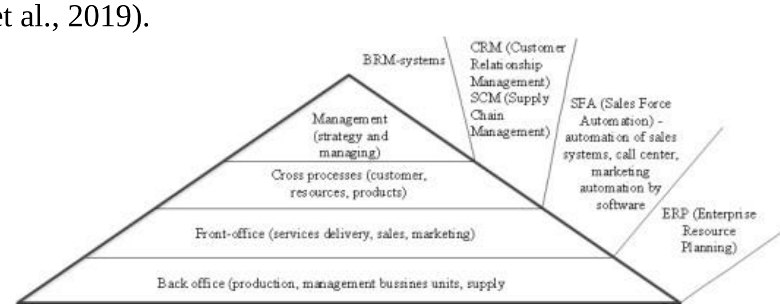

Figure 2. Stages of SCM Source: Boiko et al., (2019)

There are 6 main areas that can be optimized in the SCM information system, namely helping to improve the planning system, optimizing warehouse inventory, delivering products on time, ensuring supply is on demand, reducing costs, and providing market added value to the company. In addition, the access service element is also important in measuring how precise the information system is able to facilitate the initiation of transportation in the form of flexibility in exchanging information in real time which changes according to the conditions of transportation (Jacobsson et al., 2020). Jacobsson added that interoperable information usually includes various information communication technology (ICT) applications that are able to develop collaboration between various parties involved in a transportation. There are 4 important applications in transportation, namely transport management (TM), supply chain execution (SCE), field force automation (FFA), and fleet and freight management (FFM).

2.5 Web-Based Application in Supply Chains

The development of the internet changed the perspective of companies in doing business, where there was a transition from an industrial economy to a network economy. Short in Chou & Tan (2014) explains that SCM has carried out convergence which refers to the integration of computers and communication technology. This convergence is described in two aspects first a widespread and low-cost network of connections enables small and medium-sized companies to take advantage of SCM. And second, Fast and precise network transmission helps companies achieve seamless transactions in real time. In addition, a web-based virtual organization will be formed, which will provide competitive advantages that add value to customers to send goods in the right amount, in the right location, and at the right time (Adriana & Cristian, 2011). According to Wade and Hulland in Wang (2010, p. 160) integrating with the web will facilitate the development of the supply chain to be more effective in adjusting supply needs to demand. With the adoption of various web-based applications in managing SCM, it has been proven to improve performance in various areas such as reducing costs, being more responsive, financial performance, and increasing competitiveness. There are several theories about the Web and the framework for preparing the Website as follows.

3. METHODOLOGY

This research is descriptive research, namely research that describes a number of data that is analyzed by certain methods and interpreted into a design that works in accordance with predetermined requirements. The research was conducted to find and collect a number of data as a description of the facts about circumstances and situations in the company. In quantitative research, descriptive analysis is used to explain the results of research in the form of numbers in a narrative manner so that the basis for the conclusions given is a factual basis and can be returned directly based on the data obtained (Pandey et al, 2015). With a literature study, a gap is obtained as a research development so that problems can be analyzed and goals can be determined by focusing on testing the algorithm for designing web-based transportation decision aids using the VRP method.

4. RESULT

The result of web base program would be displayed with an entity relation diagram, clustering results according to the request of PT. X, Data Flow Diagram, examples of program interface images, Workflow Process, comparison analysis of existing and simulation routes as shown below.

4.1 Entity Relation Diagram

In order to solve the description of distribution problems, PT. X DC management gave a suggestion to form a program with a web-based system that was relate with the existing process flow. DC party asked external parties outside PT. X in designing and working on the web-based program in order to produce more optimal results. The program has been successfully designed and is in the prototype stage which is functioning according to the expected stages. Researchers will describe how the prototype flow is formed and in accordance with the problems that occur at PT. X. In order to make it easier to understand the model in the database arrangement as an illustration of the relationship between data, an entity relationship diagram (ERD) is formed that shown in figure 3.

Figure 3. *Entity Relationship Diagram*

4.2 Clustering

Complexity of TSP problems cannot be solved in a short time, so the clustering process can be a solution in the characteristics of selection and clarification data with 7 clarifications based on distance, density, model, data image, data seed, spectrum, and hierarchy used in data processing (Fuentes, Gress, Mora, & Marín, 2018). Clusters are determined by sales at the request of PT. X is based on the route that has been followed by reference to the regional boundary or in an area that does not have an area boundary with a route that is usually taken by the driver as in Table 1.

Tabel 1. Result of the Clustering

Cluster	Wilayah
BJB	Bondowoso-Jember-Banyuwangi
GLTB	Gresik-Lamongan-Tuban-Bojonegoro
KBTT	Kediri-Blitar-Tulungagung-Trenggalek
MNMN	Mojokerto-Nganjuk-Madiun-Ngawi
MPP	Madiun-Ponorogo-Pacitan
PPS	Pasuruan-Probolinggo-Situbondo
SDA	Sidoarjo
SM	Surabaya (Utara)-Madura
SUB	Surabaya

That clustering data could be upload into the program to simplify the process of determining the saving matrix by determining the west, east, south, north, and center of an area. Figure 4. will provide an overview of how the clusters were formed.

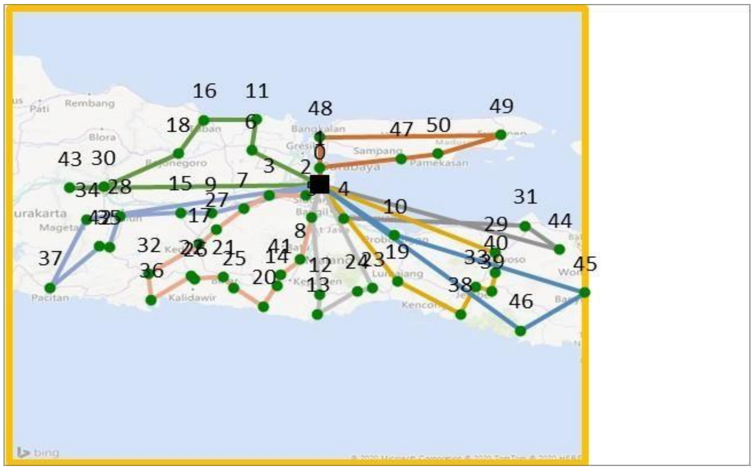

Figure 4. Clustering Data

Here the example of calculating saving matrix to shown the all the distance of 1048 retail and the DC.

J(A0000100U, A0000200P) = $\sqrt{(xX - xY)^2 + (yX - yY)^2}$

J(A0000100U, A0000200P) = $\sqrt{(-8.215206986) - (-8.365002906)^2 + (114.3712969) - (114.1386674)^2}$

J(A0000100U, A0000200P) = 37.73 km

For the next route, the distance is entered in the savings matrix with a combination of the nearest insert and nearest neighbor.

S(A0000100U, A0000200P) = J(DC, A0000100U) + J(DC, A0000200P) − J(A0000100U, A0000200P)

S(A0000100U, A0000200P) = (275.94) + (250.56) - (37.73)

S(A0000100U, A0000200P) = 488.77

4.3. Data Flow Diagram

The value of savings matrix calculated then upload it to the program for determine the shortest path that produces the shortest route. Cluster-based optimization approach and linear programming will be a reference for how this program runs so that the program will be processed automatically in determining the most optimal route to be followed. An overview of the data flow design and process is described in the Level 0 Data Flow Diagram as follows.

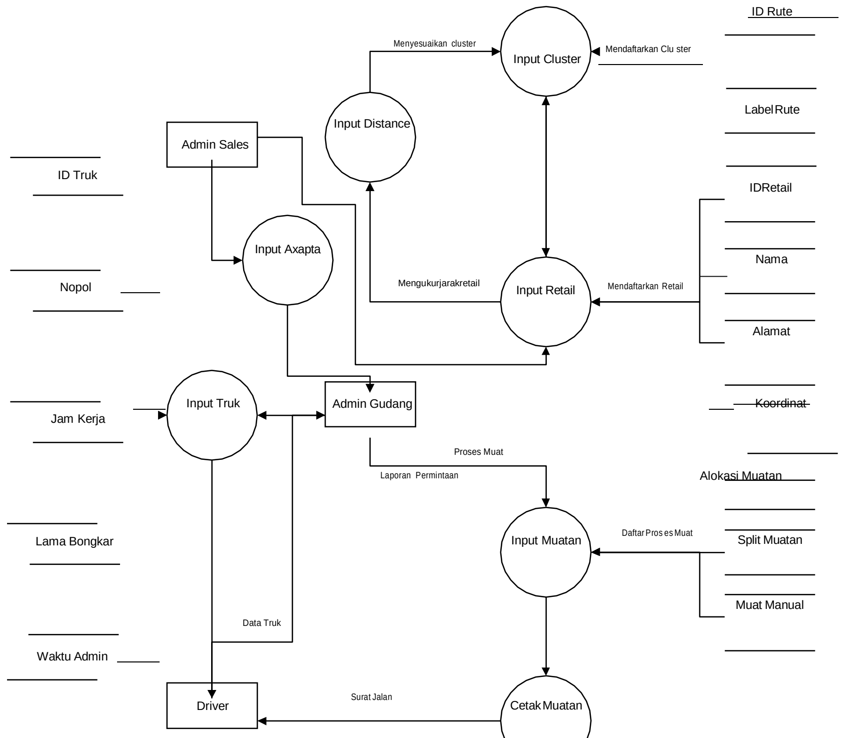

Figure 5. Data Flow Diagram Level 0

4.4 Program Interfaces

This web base program has an overall impact on the existing work system at PT. X. Before describing the impact on the work cycle that occurs, an overview of the user interface design in this web base program will be given to get a visual about this program as follows.

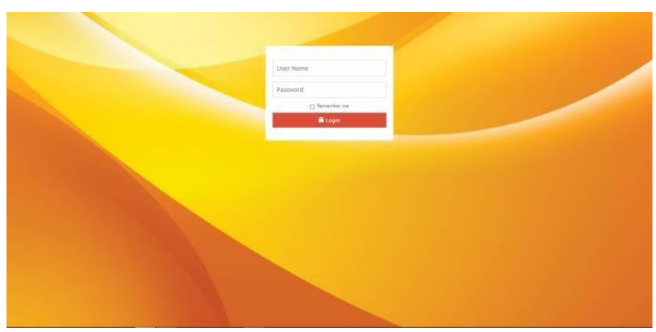

Figure 6. Log In Interface

Figure 7. Result Interface

4.5 Workflow Process

The results of the implementation of this program change the work flow process that occurs in this division. The workflow process that occurs after the program is formed seems to increase the effectiveness and efficiency of the document distribution flow because of the shortened document collection processes and automatic sorting processes which greatly reduce the previous 2-3 days to 1 day, even less than 1 hour.

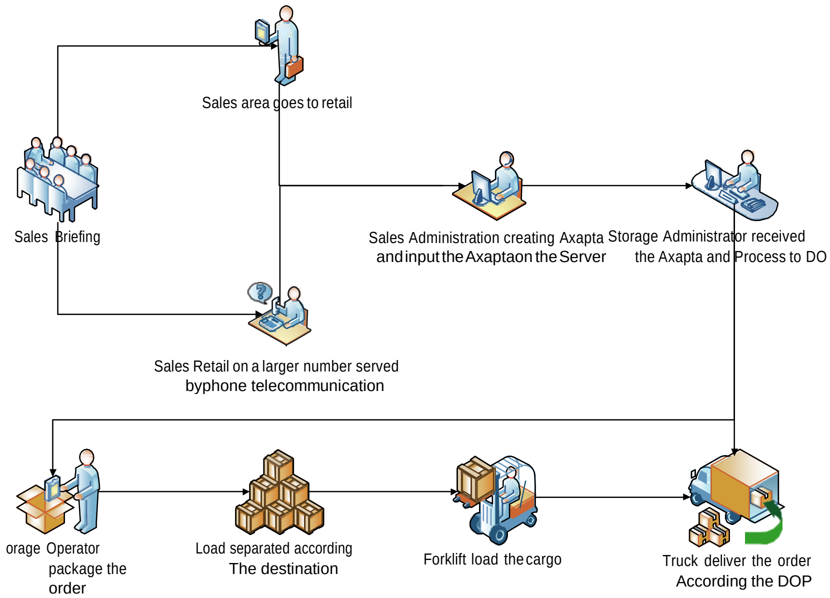

Figure 8. *Workflow Process*

4.6 Comparation of Existing Data and Result of the Simulation

The example of the delivery order that will be simulated had 57 orders that occurred on December 18 to 21, 2020 and were processed for delivery on December 22, 2020. The "fee" is the cost of the benefits that the driver and helper got when making deliveries, and there are fines due to the process from administration to delivery. takes up to more than 3 days. Furthermore, the existing shipping data will be explained from questions and the answers of the driver with the data below.

Table 2. Route of Truck L 9004 PQ

Delivery Date	Route	Time	Colie	Status
22 Desember 2020	Distribution Center	07.00	164	Load
	PT. Nusantara Surya Sakti	08.15	19	Deliver
	Surya Motor	09.00	1	Deliver
	Undaan Jaya Motor	09.45	144	Deliver
	Break and Back to DC	11.15	303	Load
	Bengkel Ambar	14.00	4	Deliver
	UD. Yota Motor	15.00	29	Deliver
	CV. Mitra Pratama	15.30	28	Deliver
	Nasional Motor	16.45	44	Deliver
	Back to DC	18.00	198	Done
23 Desember 2020	Distribution Center	07.00	198	-
	Makmur Motor	08.00	1	Deliver
	PT. Utomo Cipta Sentosa	08.30	61	Deliver
	PT. Ramayana Jaya Motor	09.00	55	Deliver
	Makmur Jaya	09.30	81	Deliver
	Back to DC	11.00	0	Finish

Chilmon & Tipi (2020) stated that simulation is a well-known methodology in understanding supply chain, especially in solving complex problems in the system. The simulation is carried out on a web base program using data that has been adjusted as the delivery order.

Table 3. Delivery order simulation results in the Web Base Program

T001	Batch Number BN-SBY-2101-0011	Date 23/12/2020	ID Truck L 9004 PQ	T. Profit Rp 189,762	Late Penalty -	Notes:					
	Location to Visit 11	Total Distance 109.721	Solar Rp 50,288	T. Drivet 6:35	T. Admt 4:00	Work Time 10:35	Truck C apacity 18.10354	Total Volume 34.67	B P O	170 154 142	Net profit Rp 240,050
No Delivery Order	**Location name**	**Distance travelled**	**Driving time**	**Arrival time**	**Depart time**	**Adm time**	**Pickup**	**Delivery**	**Part**	**Load**	**Profit**
DO-2101-0022	Depot	0.00	0:00	0	07:00	0:00	16.848	0	B P O	53 109 97	Rp 26,500 Rp 32,700 Rp 24,250
DO-2101-0023	PT. UTOMO CIPTA SENTOSA	15.071	0:54	7:54	8:14	0:20	0	3.849	B P O	13 18 30	Rp 6,500 Rp 5,400 Rp 7,500
DO-2101-0024	CV. MITRA PRATAMA	5.1	0:18	8:32	8:52	0:20	0	1.694	B P O	5 3 15	Rp 2,500 Rp 2,400 Rp 3,750
DO-2101-0025	UD. YOTA MOTOR	5.69	0:20	9:13	9:33	0:20	0	1.655	B P O	5 4 20	Rp 2,500 Rp 1,200 Rp 5,000
DO-2101-0026	BENGKEL AMBAR	5.98	0:21	9:54	10:14	0:20	0	0.329	B P O	2 1 1	Rp 1,000 Rp 300 Rp 250
DO-2101-0027	MAKMUR JAYA	7.55	0:27	10:41	11:01	0:20	0	6.449	B P O	28 53 0	Rp 14,000 Rp 15,900 Rp -
DO-2101-0028	PT. RAMAYANA JAYA MOTOR	3.6	0:12	11:14	11:34	0:20	0	2.81	B P O	0 24 31	Rp - Rp 7,200 Rp 7,750
DO-2101-0029	MAKMUR MOTOR	3.82	0:13	11:48	12:08	0:20	0	0.063	B P O	0 1 0	Rp - Rp 300 Rp -
DO-2101-0030	Depot	14.5	0:52	13:00	13:20	0:20	17.818	0	B P O	117 45 45	Rp 58,500 Rp 13,500 Rp 11,250
DO-2101-0031	UNDAAN JAYA MOTOR	19.1	1:08	14:29	14:49	0:20	0	14.43	B P O	111 32 0	Rp 55,500 Rp 9,600 Rp -
DO-2101-0032	SURYA MOTOR	4.08	0:14	15:04	15:24	0:20	0	0.042	B P O	0 0 1	Rp - Rp - Rp 250
DO-2101-0033	PT. NUSANTARA SURYA SAKTI	1.5	0:05	15:29	15:49	0:20	0	0.904	B P O	0 5 14	Rp - Rp 1,500 Rp 3,500
DO-2101-0034	NASIONAL MOTOR	4.23	0:15	16:04	16:24	0:20	0	2.44	B P O	6 3 30	Rp 3,000 Rp 2,400 Rp 7,500
DO-2101-0035	END	19.5	1:10	17:35	17:35				B P O	0 0 0	Rp - Rp - Rp -

The calculation of some data in existing data above calculated manually because there still no measurement that measured such as total distance, working hour, solar consumed, transportation cost. After all the data set, the comparison to evaluate the result explained below on table 4.

Table 4. Result of the comparasion Existing Data with Result of Simulation

	Existing	*Web Base Program*
Waktu Bekerja	15 jam	10.35 jam
Jarak Tempuh	144.6 km	109.7 km
Volume Kiriman-1	15.4 kg^3	16.8 kg^3
Volume Kiriman-2	6.1 kg^3	17.8 kg^3
Volume Kiriman-3	6.7 kg^3	-
Konsumsi Solar	12.05 Liter	9.14 Liter
Biaya Solar	Rp. 66.275,00	Rp. 47.088,00
Total Biaya	Rp. 232.975,00	Rp. 213.788,00

5. CONCLUSION

The Web Base System program had a significant impact in shortening the administrative flow by cutting route planning tasks and loads that were still calculated manually and took 3-4 working days to be automatically calculated by the program in no time. The HVRPTW function used in the program is very helpful for the program in achieving its main objectives, namely finding the optimal route and cargo by forming delivery strategies with consideration of retail opening and closing hours, shipping routes, and cargo carried. Optimizing routes and distances will greatly affect working time, diesel consumption and costs incurred in the distribution process. This is evidenced from the results of the comparison of existing data to the simulation program in Table 4.6. There is a difference in the distance of 34.9 km in the shorter route formed by the program with a more optimal load capacity. By determining the right route strategy, the driver can cut working time by 4 hours 25 minutes and always arrive according to retail opening and closing hours, saving 2.91 liters of gasoline which has an impact on cost savings incurred by the driver with the difference in spending 19,187 rupiah.

REFERENCES

Adriana, M. D., & Cristian, V. (2011). *Using Web Technologies for Supply Chain Management*.

Boiko, A., Shendryk, V., & Boiko, O. (2019). Information systems for supply chain management: uncertainties risks and cyber security. *Procedia Computer Science*, *149*, 65-70. https://doi.org/10.1016/j.procs.2019.01.108

Chilmon, B., & Tipi, N. S. (2020). Modelling and simulation considerations for an end-to-end supply chain system. *Computers and Industrial Engineering*, *150*, 106870. https://doi.org/10.1016/j.cie.2020.106870

Chopra, S., & Meindl, P. (2014). Demand Forecasting in a Supply Chain. *Supply Chain Management: Strategy, Planning, and Operation*.

Chou, D. C., & Tan, X. (2014). *Web technology and supply chain management*. (May). https://doi.org/10.1108/09685220410553550

Coyle, J. J., Langley, C. J. J., Novack, R. A., & Gibson, B. J. (2013). Managing Supply Chains: A Logistics Approach. In *South-Western, Cengage Learning*.

Fuentes, G. E. A., Gress, E. S. H., Mora, J. C. S. T., & Marín, J. M. (2018). Solution to travelling salesman problem by clusters and a modified multi-restart iterated local search metaheuristic. *PLoS ONE*, *13*(8), 1–20. https://doi.org/10.1371/journal.pone.0201868

Grabara, J., Kolcun, M., & Kot, S. (2014). The Role of Information Systems in Transport Logistic. *ASA Refresher Courses in Anesthesiology*, *2*(February 2014), 205–214. https://doi.org/10.1097/00126869-199826000-00016

Heizer, J., Render, B., & Munson, C. (2017). *Twelfth Edition Operations Management*.

Jacobsson, S., Arnäs, P. O., & Stefansson, G. (2020). Automatic information exchange between interoperable information systems: Potential improvement of access management in a seaport terminal. *Research in Transportation Business & Management*, *35*(March), 100429. https://doi.org/10.1016/j.rtbm.2020.100429

Kumar, V. (2018). *Issues in Solving Vehicle Routing Problem with Time Window and its Variants using Meta heuristics - A Survey Issues in Solving Vehicle Routing Problem with Time Window and its Variants using Meta heuristics - A Survey*. (June 2013).

Laporte, G. (1992). The traveling salesman problem: An overview of exact and approximate algorithms. *European Journal of Operational Research*, *59*(2), 345–358. https://doi.org/10.1016/0377-2217(92)90138-Y

Pal, K. (2017). A Semantic Web Service Architecture for Supply Chain Management. *Procedia Computer Science*, *109*, 999–1004. https://doi.org/10.1016/j.procs.2017.05.442

Pandey, P., & Pandey, M. M. (2015). *Research Methodology: Tools and Techniques*. Romania: Bridge Center.

Pujawan, I. N. (2010). *Supply Chain Management* (2nd ed.). Surabaya: Guna Widya. Pujawan, I. N., & Er, M. (2017). *Supply Chain Management* (3rd ed.). Yogyakarta: Andi. Pulevska-ivanovska, L., & Kaleshovska, N. (2013). *Implementation of e-Supply Chain Management*.

2(4), 314–322.

Tan, T. Le, Thi, D., & Trang, D. (2019). *Issues of Implementing Electronic Supply Chain Management (E-SCM) In Issues of Implementing Electronic Supply Chain Management (E- SCM) In Enterprise*. (January 2017). https://doi.org/10.11648/j.ebm.20170305.13

Toth, P., & Vigo, D. (2002). *The Vehicle Routing Problem* (P. Toth & D. Vigo, eds.). Philadelphia: University City Science Center.

Wang, J. (2010). *Innovations in Supply Chain Management Information System: Novel Approaches* (United Sta; K. Klinger, ed.). IGI Global.

TOPIC

Finance Management

THE EFFECT OF FINANCIAL RATIOS TO THE PRICE AND VALUATION OF STOCKS BASED ON BENJAMIN GRAHAM'S CRITERIA USING REGRESSION ANALYSIS

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ABSTRACT

Stock valuation is the fair value of stocks and used as a consideration for whether the stocks are worth buying. The calculation of financial ratios is one of the fundamental analysis steps of a company to determine the valuation of stocks. This study aims to analyze the effect of financial ratios on stock prices and valuations as a basis for fundamental analysis to minimize investment risk. This study analyzed basic industries sector companies listed on the LQ45 index of the Indonesia Stock Exchange during the period 2014 to 2019. Fundamental analysis focuses on the macro and micro economic conditions of a company. The company's financial statements form the basis of analysis. Stock valuation assesses the intrinsic value of a stock, one of the criteria is buying stocks below the intrinsic value. Calculating intrinsic value can be done by several methods, one of which is the criteria and formula proposed by Benjamin Graham. This study analyzed Graham's financial ratio criteria for stock prices. Regression analysis method is used to analyze the relationship between financial ratios and stock prices. The financial ratios analyzed are earning per share, price earning ratio, dividend yield, price to book value, net current asset value, and current ratio. The results of this study are that there are three financial ratios that have a significant effect on stock prices, namely earnings per share, price earning ratio, and current ratio. Investors need to analyze these financial ratios in making investment decisions in the stock market. A feasibility assessment based on Graham's criteria containing elements of significant financial ratios and company valuation was carried out. The results obtained in the basic industries sector stocks LQ45 index that feasible to be included in the investment portfolio are BRPT, JPFA, and TKIM.

Keywords: Benjamin Graham, financial ratios, regression analysis, stocks valuation.

1. INTRODUCTION

The number of SID owners in Indonesia has grown rapidly in the last three years. Based on the data released by KSEI (2019), the number of capital market investors has grown from 894,116 people in 2016 to 2,409,075 people in 2019. Single Investor Identification (SID) is the way the Indonesia Central Securities Depository records the number of investors investing in the Indonesian capital market. The total ownership of investment assets in the Indonesian capital market is dominated by domestic ownership by 56.46% and dominated by the 21-30 years old group by 44.31%. Along with the rapid growth of capital market investors, the risk of fraud on the capital markets also increases. Firdausi (2018) stated, during 2018, there were 113 cases of investment fraud recorded. Cases like this are triggered by the lack of knowledge of investors about their investment instruments. More in-depth and easy-to-understand guidelines for investors are needed to help make decisions. Stock analysis can be done using technical analysis and fundamental analysis. Fundamental analysis focuses on analyzing company performance and assessed from the company's financial condition through the company's financial statements. One of the uses of fundamental analysis is to assess the intrinsic value or fair price of stocks. There are several methods that can be used to assess intrinsic value, one of which is the method proposed by Benjamin Graham.

The research scope was carried out on companies listed on the Indonesian stock exchange in the basic industries sector in the LQ45 index during 2014-2019 period. The purposes of this research are to analyze the financial ratio variables that contained in Graham's criteria that significantly influenced the movement of stock prices, analyze the valuation of stocks that are worth buying based on the calculation of intrinsic value using the Benjamin Graham formula, and to analyze companies that has the eligibility to be included in an investment portfolio based on financial ratio assessment and stock valuation.

2. LITERATURE REVIEW

2.1 Stock Analysis

Based on Wira (2010), there are two general methods that can be used to analyze stocks, namely technical analysis and fundamental analysis. Technical analysis is generally carried out by analyzing candle charts that represent stock price movements in a certain period. Parameters used in technical analysis are technical indicators, including bollinger bands, stochastic, moving average, moving average convergence divergence, etc. Fundamental analysis focuses on the company's performance as assessed by the financial condition contained in the company's financial statements. The parameters used in fundamental analysis are financial ratios that can provide an overview of the company's financial condition. Commonly used financial ratios are earnings per share, debt to equity, price to book value, dividend yield, etc.

According to Hidayat (2017), fundamental analysis can form a value investing method which are considered to have low investment risk. The concept of value investing is to buy stocks at a price below the intrinsic value or what is called undervalued condition. Intrinsic value is the fair price of stocks assessed from the company's financial condition which can be represented by financial ratios. One of many method for calculating intrinsic value is the intrinsic value calculation proposed by Benjamin Graham (1949).

2.2 Recent Studies

A research was conducted by Rakesh (2016) with a purpose to determine the intrinsic value of stocks based on the Benjamin Graham method (focusing on current earnings per share and book value growth), compared to the discounted cash flow method (focusing on free cash flow to firms and company growth based on on the value of reinvestment and return on capital). The study was conducted on two stocks on the Finland Stock Exchange in 2016, YIT and Marimeko. The result of this study indicate that the two methods of calculating intrinsic value have similar results with a deviation of 1.08.

A Research with a purpose to assess the reliability of the Graham's Criteria was conducted by Rachmatullah (2016). The research carried out ten stock selection criteria to assess the effect of the combination of criteria on stock prices. The data is taken from the financial statements of companies on the Indonesia Stock Exchange in 2001-2006. This research concludes that companies that meet the criteria of Benjamin Graham have a significant increase in stock prices, even overcome the overall index itself. Two out of ten criteria have no significant effect to stock prices, namely discount to net current asset value and past earnings stability.

Widayanti (2017) conducted a study with the aim of looking at the effect of financial ratios (current ratio, debt to equity ratio, total asset turnover, return on equity and earnings per share) on stock prices using the multiple linear regression method. The data is taken from the financial statements of stocks in the LQ45 index on the Indonesia Stock Exchange in the period of 2011-2015. The results showed that the financial ratios that had a significant effect on stock prices were debt to equity ratio and earnings per share.

2.3 Benjamin Graham's Method

Graham (1949) compiled several criteria as a guide for choosing a company that is worth buying. There are ten criteria put forward, and Benjamin Graham stated that at least two of the ten criteria are met. The ten criteria are as follows,

1. Earning to price yield is at least twice that of AAA bond yield.
2. Price earning ratio is less than 40 percent of the highest price earning ratio owned by shares for the last five years.
3. Dividend yield of at least two thirds of the AAA bond yield.
4. The share price is below two thirds of the price to book value.
5. The share price is below two thirds of the net current asset value.
6. Total liabilities are less than book value.
7. The current ratio is more than two.
8. Total liabilities are less than twice the net current asset value.
9. Income growth for the previous 10 years was at least at an annual (compound) 7 percent rate.
10. Stable income growth of no more than two 5 percent or more declines in year-end earnings in the previous 10 years are allowed.

In addition to the criteria required above, Benjamin Graham also compiled an equation that can be used to assess the valuation or intrinsic value of stocks. The Graham equation is written as follows,

$$Intrinsic\ Value = \frac{[earning\ per\ share\ \times (8.5 + 2g) \times 4.4]}{Y}$$

Where the variable g is the estimated growth rate, the constant 4.4 is the risk free rate used by Benjamin Graham in 1962 on the American stock market, this constant value can be adjusted by calculating government bonds with a tenor of 10 years. The variable Y is the AAA corporate bond rate in a country. These parameters can be fitted with current economic condition of a country.

2.4 Regression Analysis

Lind (2012) explained that regression analysis is a method used to develop mathematical equations from a data consist of dependent and independent variables. The purpose of regression analysis is to obtain a linear line that represents the relationship between two variables. The determination of this line uses the ordinary least square (OLS) principle. OLS is a mathematical procedure that uses data to position linear lines with the aim of minimizing the sum of squares of the vertical distance between the actual Y value and the predicted Y value. Assessment of the accuracy of the modeling determined by obtaining the p-value and adjusted R-squared of the model. The steps in conducting regression analysis are correlation analysis, residual normality assumption test, and multicollinearity test. Correlation analysis is used to see the relationship between two variables contained in the modeling, expressed in the coefficient of correlation parameter. The value of the coefficient of correlation ranges from -1 to 1. The closer coefficient of correlation to 1 indicates that the two variables have a strong relationship, the negative and positive notations indicate the type of the variable relationship, directly proportional if the notation is positive and inversely proportional if the notation is negative. The residual normality assumption test is used to assess whether the modeling is acceptable, this test requires that the residuals from modeling are normally distributed. The multicollinearity test is used to see whether there is a strong relationship between the independent variables in the modeling, the presence of multicollinearity should be avoided in a modeling. The parameters assessed from the multicollinearity test were the tolerance value and variance inflating factor (VIF). The allowable tolerance value is > 0.1, and the allowable VIF value is < 10.

3. RESEARCH METHODOLOGY

3.1 Data Source

Data is taken from basic industries sector companies listed on the LQ45 index for the period of July 2019. The eight companies selected based on these criteria can be seen in Table 1. The company's financial statements are taken from the Q3 2014 period to the Q2 2019 period. Data obtained from the financial statements are net profit, total assets, total equity, total liabilities, current assets, current liabilities, and outstanding stocks. The net profit data is put into annualized format to see a better movement of net profit. This is based on the fact that in data analysis, the financial statements analyzed in each quarter of the current year, while the net profit data from the financial statement is the cumulative figure for the current year. The pre-processing stage equates the currency unit from the data taken into IDR currency units, with the exchange rate USD/IDR taken during the same period as the financial statements are released.

Table 1. Selected Companies

Number	Stock Code	Company Name
1	BRPT	Barito Pacific Tbk.
2	CPIN	Charoen Pokphand Indonesia Tbk.
3	INKP	Indah Kiat Pulp and Paper Tbk.
4	INTP	Indocement Tunggal Prakasa Tbk.
5	JPFA	Japfa Tbk.
6	SMGR	Semen Indonesia (Persero) Tbk.
7	TKIM	Pabrik Kertas Tjiwi Kimia Tbk.
8	TPIA	Chandra Asri Petrochemical Tbk.

3.2 Financial Ratios Calculation

Based on Graham's criteria, there are six elements of financial ratios required for analysis. These financial ratios are earnings per share (EPS), price earning ratio (PER), dividend yield (DY), price to book value (PBV), net current asset value (NCAV), and current ratio (CR). The calculation of financial ratios is done using the following equation.

$$Earning\ per\ Share = \frac{net\ profit}{outstanding\ shares}$$

$$Price\ Earning\ Ratio = \frac{stock\ price}{earning\ per\ share}$$

$$Dividend\ Yield = \frac{dividend\ per\ share}{stock\ price} \times 100\%$$

$$Price\ to\ Book\ Value = \frac{stock\ price}{book\ value}$$

$$Net\ Current\ Assets\ Value = \frac{(current\ assets - total\ liabilities)}{outstanding\ shares}$$

$$Current\ Ratio = \frac{current\ assets}{current\ liabilities}$$

3.3 Data Analysis

The dataset is compiled with the price variable as the dependent variable, and six financial ratios (EPS, PER, DY, PBV, NCAV, and CR) as the independent variable. The dataset consist 160 rows of data. The quoted price is the closing price of the following quarter since the financial statements are published. For example, the price used for the financial statements for the Q2 2015 period is the market closing price for the Q3 2015 period. This is done to see the market response after the financial statements are published. The analysis begins with correlation analysis, regression analysis, residual normality assumption test, and multicollinearity test. Analysis was performed using r software. Financial ratios that have a significant effect on stock prices are used as a reference for selecting Benjamin Graham's criteria. The selected Graham criteria is used to assess the worthiness of stocks to be included in an investment portfolio.

3.4 Intrinsic Value Calculation

The calculation of intrinsic value was carried out on the eight companies analyzed. The coefficients and constants in the equation are adjusted to Indonesia's economic conditions in July 2019. Stocks with undervalued valuation (price position below intrinsic value) are considered worthy to be included in an investment portfolio. The adjusted Graham equation is used to calculate the intrinsic value as follows.

$$Intrinsic\ Value = \frac{[earning\ per\ share \times (8.5 + 2g) \times 7.2]}{8.49}$$

4. ANALYSIS RESULT

4.1 Correlation Analysis

The correlation test on seven variables was carried out using the Pearson method. The results of the correlation test can be seen in Figure 1. Looking at the correlation to the PRICE variable, the EPS variable has a coefficient of correlation value of 0.59, the PER variable has a coefficient of correlation value of 0.43, the DY variable has a coefficient of correlation value of 0.41, the PBV variable has a coefficient of correlation value of 0.47, the NCAV variable has a coefficient of correlation value of 0.49, and the CR variable has a coefficient of correlation value of 0.68. All independent variables have a positive correlation to the dependent variable PRICE with the order of correlation strength from low to high, namely DY, PER, PBV, NCAV, EPS, and CR.

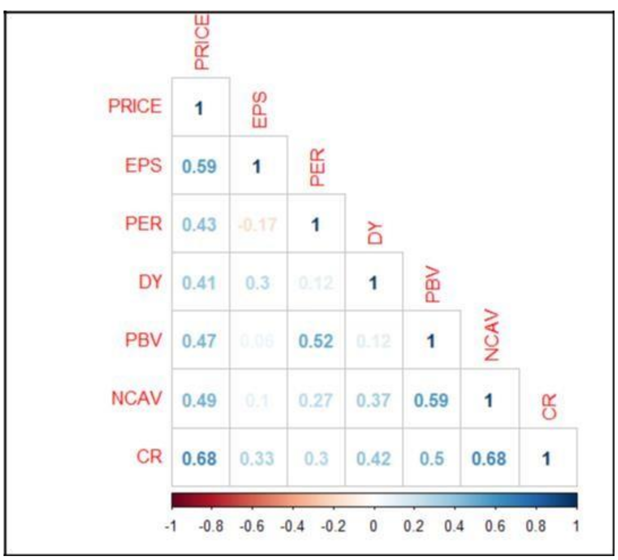

Figure 1. Correlation analysis result

4.2 Data Analysis

The initial stage is visualizing the histogram with distribution line of PRICE, which can be seen in Figure 2. The distribution line forms an asymmetrical and right skewed curve, with data ranges from 0 to 25,000. The distribution line forms a right skewed curve with a minimum value of 13, 1st quartile at 883.8, median at 3,325, mean at 6,114.6, 3rd quartile at 10,137.5, and a maximum value at 25,000. The complete data distribution of all variables can be seen in Table 2.

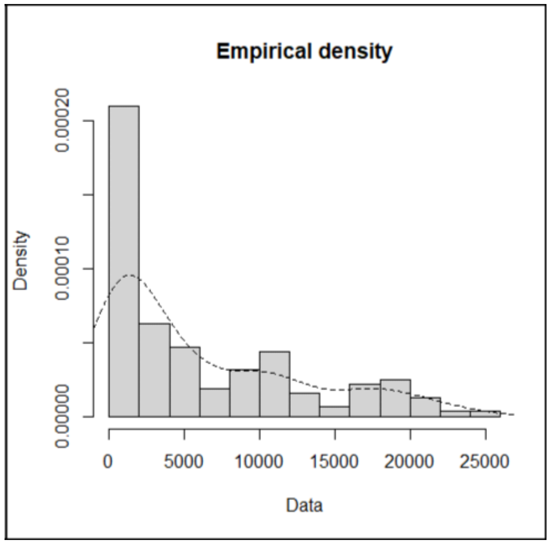

Figure 2. Histogram with distribution line of PRICE

Table 2. Data Distribution

Variables	Minimum	1st Q.	Median	Mean	3rd Q.	Maximum
PRICE	13	883.8	3,325	6,114.6	10,137.5	25,000
EPS	-80.63	127.21	245.37	452.28	711.4	1,874.96
PER	-23.35	3.91	12.56	16.46	21.06	100.48
DY	0	0.0071	0.0153	0.0199	0.0287	0.0996
PBV	0.0051	0.1988	1.7965	1.7843	2.9249	6.3731
NCAV	-6,117.9	-2,207.4	-327.3	-1,028.6	96.5	3,316.6
CR	1.06	1.49	1.79	2.20	2.39	7.25

Furthermore, modeling is carried out using the linear model method. The results of the linear model analysis resulted in three dependent variables that had a significant effect on the PRICE variable. The three variables are EPS, PER, and CR. Furthermore, three variables that had no effect, namely DY, PBV, and NCAV were removed from the modeling. The results of the linear model with three variables EPS, PER, and DY can be seen in Figure 3.

```
Residuals:
     Min       1Q   Median       3Q      Max
-11030.5  -1713.2   -508.7   2081.9   9978.1

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -4419.0827   572.2795  -7.722 1.29e-12 ***
EPS             7.7541     0.6414  12.089  < 2e-16 ***
PER           139.1373    14.8430   9.374  < 2e-16 ***
CR           2150.2050   253.0894   8.496 1.47e-14 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3252 on 156 degrees of freedom
Multiple R-squared:  0.7549,    Adjusted R-squared:  0.7502
F-statistic: 160.2 on 3 and 156 DF,  p-value: < 2.2e-16
```

Figure 3. Linear modeling result

The modeling resulted in a p-value of $-2.2e^{-16}$ and an adjusted R-Squared value of 0.7539, which means that this modeling is acceptable. The estimated values in the modeling are included in the equation, so the resulting equation from the regression analysis is as follows.

$$PRICE = -4{,}419.08 + 7.75\ EPS + 139.13\ PER + 2{,}150.20\ CR$$

The residual normality test was performed on the residual value of the modeling results. The histogram with distribution line, and cumulative distribution function plot can be seen in Figure 4. Visually it can be seen that the residuals of the regression analysis are normally distributed. The distribution line forms a symmetrical curve with a minimum value of -11,030.5, 1st quartile at -1,713.2, median at -508.7, mean at 0, 3rd quartile at 2,081.9, and a maximum value at 9,978.1. Goodness of fit test was performed on the residuals. The results show that with the Kolmogorov-Smirnov and Anderson-Darling methods, the residuals are normally distributed with a value of $\alpha > 0.1$. It can be concluded visually and from the results of the goodness of fit test that the residuals are normally distributed, so that the modeling is acceptable.

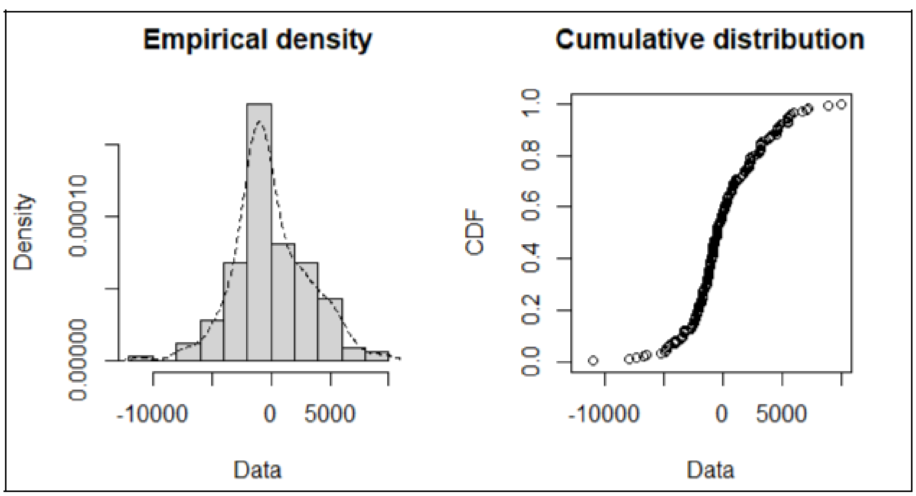

Figure 4. Histogram, distribution line, and cummulative distribution function plot

The multicollinearity test is carried out on the modeling results to see if there is collinearity between the independent variables in the modeling. The multicollinearity test results can be seen in Figure 5. The parameters seen in these results are the variance inflation factor (VIF) and tolerance parameters. All variables have a VIF value <10, and a tolerance value> 0.1, so it can be concluded that there is no multicollinearity in modeling and the modeling is acceptable.

```
All Individual Multicollinearity Diagnostics Result

       VIF    TOL      Wi      Fi Leamer     CVIF Klein   IND1   IND2
EPS 1.2321 0.8116 18.2221 36.6762 0.9009 -82.4485     0 0.0103 0.9404
PER 1.2087 0.8273 16.3823 32.9733 0.9096 -80.8802     0 0.0105 0.8619
CR  1.3157 0.7601 24.7812 49.8781 0.8718 -88.0397     0 0.0097 1.1977

1 --> COLLINEARITY is detected by the test
0 --> COLLINEARITY is not detected by the test

* all coefficients have significant t-ratios

R-square of y on all x: 0.7549
```

Figure 5. Multicollinearity test result

4.3 Intrinsic Value Calculation

Graham's equation required a financial ratio, EPS. Based on the results of regression analysis, the EPS variable has a significant effect on stock prices. So the Graham equation can be used to assess stock valuation. Intrinsic value calculation using adjusted Graham's equation is carried out on the company's financial statement data for the period of Q2 2019. The results of the calculation of intrinsic value, compared to the closing price of Q2 2019 period, along with stock valuations can be seen in Table 3.

Table 3. Stock Valuation

Stock Code	Q2 2019 Closing Price	Intrinsic Value	Valuation
BRPT	640	8,585	Undervalued
CPIN	4,730	1,703	Overvalued
INKP	9,375	7,917	Overvalued
INTP	20,000	2,069	Overvalued
JPFA	1,550	1,866	Undervalued
SMGR	11,575	942	Overvalued
TKIM	12,575	20,736	Undervalued
TPIA	4,970	685	Overvalued

4.3 Stock Feasibility Analysis Based on Graham's Criteria

Based on the ten criteria proposed by Benjamin Graham, there are three criteria that contain elements of three financial ratios that are significant to stock prices. The three criteria are, earning to price yield at least twice that of AAA bond yield, price earning ratio less than 40 percent of the highest price earning ratio owned by stocks in the last five years, current ratio more than two. Stocks that meet at least two of these criteria are labeled "Feasible", and those that do not meet the criteria are labeled "Not feasible". Stocks with an undervalued valuation based on intrinsic value calculations are labeled "Feasible". Stocks that meet these three criteria and are in an undervalued valuation are concluded to be eligible to be included in an investment portfolio. The results of the stock feasibility analysis can be seen in Table 4.

Table 4. Stock Feasibility Analysis

Stock Code	Criteria				Conclusion
	EPS	**PER**	**CR**	**Valuation**	
BRPT	Feasible	Not feasible	Feasible	Feasible	Feasible
CPIN	Feasible	Not feasible	Feasible	Not feasible	Not feasible
INKP	Feasible	Not feasible	Feasible	Not feasible	Not feasible
INTP	Not feasible	Not feasible	Feasible	Not feasible	Not feasible
JPFA	Feasible	Feasible	Not feasible	Feasible	Feasible
SMGR	Not feasible	Not feasible	Not feasible	Not feasible	Not feasible
TKIM	Feasible	Feasible	Not feasible	Feasible	Feasible
TPIA	Not feasible	Not feasible	Feasible	Not feasible	Not feasible

5. CONCLUSION

After analyzing the effect of financial ratios on stock prices and valuations, the following conclusions are obtained. Financial ratios that have a significant effect on stock price movements are earning per share, price earning ratio, and current ratio. EPS refers to the level of a company's net income, so the higher the EPS value, the stock has the potential to experience an increase in price. PER refers to the ratio of the share price to company profits or the rate of return on capital of stock investors. In financial science, the lower the PER value the better because it provides a faster rate of return on capital. CR refers to the level of security or the strength of the company's capital, the higher the value of CR means that the company's capital structure is stronger and will make investors more confident about investing in these stocks.

Based on the feasibility assessment of the three Graham's criteria which contain elements of significant financial ratios and Graham's stock valuation, from the eight companies analyzed, there are three companies that eligible to be included in the investment portfolio, namely BRPT, JPFA, and TKIM. The intrinsic value can be used as the target price to sell the stocks.

The most important and significant financial ratio is the earning per share. It is proven by the results of regression analysis, feasibility assessment, and stock valuation calculations, the most important aspect is the EPS financial ratio. Stock investors can use the EPS value as a basis for consideration in making decisions.

6. REFERENCES

This research was conducted based on several references. The references used in the study are listed below.

Firdausi, A. (2018). *Hindari investasi bodong dengan literasi finansial. AKRAB! Vol. VI 2nd edition*, 97-105.

Graham, B. (1949). *The Intelligent Investor : The Definitive Book on Value Investing*, Harper & Brothers, United States.

Hidayat, T. (2017). *Value Investing : Beat The Market in Five Minutes!*, 1st Edition, Elex Media Komputindo, Jakarta.

KSEI. (2019). *22 Tahun KSEI : Mendukung Pengembangan Infrastruktur Untuk Kenyamanan Investasi di Pasar Modal*. *Indonesia Central Securities Depository Press Release*, 2–3.

Lind, D. A., Marchal, W. G., Wathen, S. A. (2012). *Statistical Techniques In Business & Economics*, McGraw-HillIrwin, United States.

Rachmattulah, M. F., Faturohman, T. (2016). The implementation of Benjamin Graham criteria (A case in Indonesia market). *Journal of Business and Management*, *Vol. 5 No. 6*, 773–782.

Rakesh,D. (2016). Intrinsic Value Calculations for Long Term Investment : Company X. *Laurea University of Applied Sciences – Degree Programme in Business Management Bachelors's Thesis*, 8-31.

Widayanti, R., Colline, F. (2017). *Pengaruh Rasio Keuangan Terhadap Harga Saham Perusahaan LQ45 Periode 2011-2015. Universitas Wacana Krida*, *Vol. 21 No. 1*, 35–49.

Wira, D. (2010). *Analisis Teknikal untuk Profit Maksimal*, 1st Edition, Exceed, Jakarta.

INTELLECTUAL CAPITAL MEASUREMENT AND EFFECT ANALYSIS ON FINANCIAL PERFORMANCE OF COMPANIES IN INDONESIA PERIOD 2015 - 2019

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ABSTRACT

The importance of knowledge contribution in new economic era by creating economic value and competitive advantage drives company to manage their intellectual capital (IC) efficiently and sustainably. An efficient IC management will increase IC performance and help achieve competitive advantage which would positively affect the companies financial performance. This study aims to measure IC performance and its impact towards financial performance of 77 manufacturing companies listed on Indonesia Stock Exchange from 2015 to 2019. In addition, this study also examines firm size as a moderating variable in the relationship between IC and financial performance. The IC performance of manufacturing company is measured using modification of value added intellectual coefficient (M-VAIC) model while the impact of IC towards financial performance measured by ROA and ATO, is analyzed using partial least square (PLS). The result of this study shows that IC proven to have a significant positive impact towards company's financial performance consistently during 2015 until 2019. CEE and SCE are the only indicators that proven significant in measuring the intellectual capital variable, while the ROA indicator is the only indicator that proven to be significant in measuring the company's financial performance. This study also proves that firm size does not significantly moderate the relationship between IC and financial performance of companies in Indonesia’s manufacturing sector during 2015-2019 period.

Keywords: ATO, Intellectual Capital, M-VAIC, PLS, ROA.

1. INTRODUCTION

Economic globalization and advancements in information and communication technology that occurred in the last few decades have led to the birth of a new economic era, in which knowledge-based capital replaced the role of physical capital as an entity that creates added value and competitive advantage for companies. The replacement of the role of physical capital by knowledge-based capital makes knowledge become the main factor of economic value and competitive advantage creation (Kianto, Andreeva and Pavlov, 2013). The contribution of knowledge in creating economic value and competitive advantage in the new economic era is considered important. This statement was discussed in the 1998 World Development Report published by The World Bank. In the report, the World Bank stated that in determining standard of living, the balance between knowledge and resources is no longer the most important factor, but knowledge (Gho, 2005). In the same report, the international financial institution stated that the most advanced economy was an economy in the field of knowledge-based technology.

A study conducted by Cabrita et al., (2011) states that knowledge that creates value is defined as intellectual capital (IC), where companies or organizations that apply IC will get a sustainable competitive advantage (Brien, Clifford and Southern, 2011). IC was first introduced by John Kenneth Galbraith in 1969 as a process of creating value and part of assets (Talebnia and Aliari Erdi, 2018). A popular opinion about IC stated by Stewart (1997) explained that IC is knowledge that can be used as a tool to change raw material and make it more valued (Suherman, 2017).

IC has three constituent components, the International Federation of Accountants (IFAC) classifies ICs into three components which are human capital (HC), structural capital (SC), and relational capital (RC). HC refers to knowledge, especially tacit knowledge or skills, knowledge, expertise, experience, and abilities that each employee of a company has (Lee and Wong, 2019). SC is described as everything that stay behind in the company when all employees leave (Wang *et al.*, 2014). SC acts as an infrastructure that supports the HC component by providing facilities needed by employees to invest their knowledge. Some experts define RC as the company's ability to interact positively with external stakeholders. Competitors, shareholders, customers, governments, distributors, suppliers, brands and company reputation are some examples of RC.

IC is an important factor to obtain company’s competitive advantages and become the center of value creation activities for companies. The company has an important role to manage IC efficiently, because without good management the benefits of IC cannot be obtained. Company’s management carried out an important task to improve IC efficiency so that it can achieve competitive advantage that will positively impact the company's financial performance (Lee and Wong, 2019).

The relation between IC and financial performance cannot be separated from the Resource Based Theory (RBT) and Stakeholder Theory. Wernerfelt (1984) explained that based on RBT, Companies that use and manage resources in the form of tangible and intangible assets or intellectual capital effectively will obtain competitive advantage. (Ermawati *et al.*, 2017). Companies that have a competitive advantage can create added value that greatly benefits the company and affects financial performance. RBT is supported by stakeholder theory which has the main objective to assist company management in increasing the creation of value added as a result of activities that carried out, in addition to minimize the losses that may arise for stakeholders. The creation of value added will increase the company's financial performance in order to provide benefits for stakeholders (Herdyanto *et al.*, 2013).

In a research journal entitled "Capability and efficiency of intellectual capital: The case of fabless companies in Taiwan" Lu et al., (2010) stated that there have been many studies that prove that IC has a positive effect on company performance (Lu *et al.*, 2010). Research results from Chen, Cheng, and Hwang (2005) show that the company's IC has a positive impact toward market value and financial performance, and can be used as indicator for future performance. Nuryaman (2015) supports the statement of Lu et al., (2010) by stating that based on previous research, IC has a positive influence on financial performance as measured by profitability, namely: ROA, ROE, EPS of the company (Nuryaman, 2015).

Resource-based theory is the reference used in determining hypotheses about the impact of IC toward company's performance measured using ROA and ATO. Based on resource-based theory, companies that can manage and utilize their resources can achieve a competitive advantage which leads to company’s performance improvement (Herdyanto *et al.*, 2013). The preceding research discussing impact of IC on financial performance in particular indicate that there is a significant positive impact of IC measured by the VAIC^{TM} toward ROA (Nuryaman, 2015), besides that a significant positive effect is also found in research that analyzes the effect of IC which is calculated using M-VAIC model with ROA in 50 companies that have the largest market capitalization (Ulum, Kharismawati and Syam, 2017).

Research on Islamic banks in Malaysia shows that IC measured using VAIC^{TM} has no impact toward ATO (Ab. Aziz and Meor Hashim, 2017), this result is different from other research conducted by Mondal and Gosh (2012) which show an influence between IC with ATO. Research conducted at several companies that are included in the high intellectual-intensive category shows the same results as Mondal and Gosh (2012), that IC has a significant positive impact on ATO (Mehri *et al.*, 2013). From the explanation previously described, the first hypothesis to be tested in this research study is as follow:

H1: Intellectual Capital has a significant positive impact on performance Corporate Finance

Several studies have shown that firm size has an impact on IC and financial performance. Abas et al., (2013) revealed that company performance is influenced by company size, where this statement is supported by research from Safarova (2010) which examines the performance of companies that listed on the New Zealand stock exchange (Mohammad and Bujang, 2019a). Amin's research (2011) shows that there is no significant impact between firm size and IC, on the other hand a positive significant impact of firm size is found on company performance (Amin, 2011). Kartikasari and Merianti's research (2016) supported by Niresh and Velnampy (2014) shows a significant negative effect between company size as measured using total assets and ROA which is used to measure the profitability of manufacturing companies in Indonesia (Kartikasari and Merianti, 2016).

The relationship of company size on financial performance and IC is based on the idea that larger companies have bigger assets, which makes larger companies able to secure or get quality assets. Based on the opinion of Hadianto (2008), the reputation of a large company makes the company have more access to various sources of funding from various parties. In addition, companies with large assets will use their resources to the maximum extent possible to generate profits for the company, while companies with small assets will certainly also make profits according to the assets they have. These results indicate the possibility of company size become a moderating variable in the relationship between company's IC and financial performance.

When compared toward similar companies that have a smaller size, large companies have several advantages. According to Setiawan (2009), the advantage of large companies is the possibility of obtaining funds from the capital market to be greater, because large companies have broad connections and access. In addition, having a large asset value makes it easier for large category companies to obtain quality assets that the company will manage and use to generate profits.

Mohammad and Bujang's research conducted in 2019 shows that company size positively moderates the relation between IC and financial performance. The research was conducted on 41 construction companies registered on the Malaysian stock exchange (Mohammad and Bujang, 2019a). The same results are shown by research that examines the moderation of firm size on the relationship between IC and financial performance in manufacturing companies (Rosaria, 2014). In this study, financial performance is represented by ROA and ATO. Based on this explanation, the second hypotheses to be tested in this study is:

H2: Firm size moderates positively the relation between IC and company financial performance

Based on the theoretical references and hypotheses that have been explained, the conceptual model that confirmed in this study is shown in Figure 1.

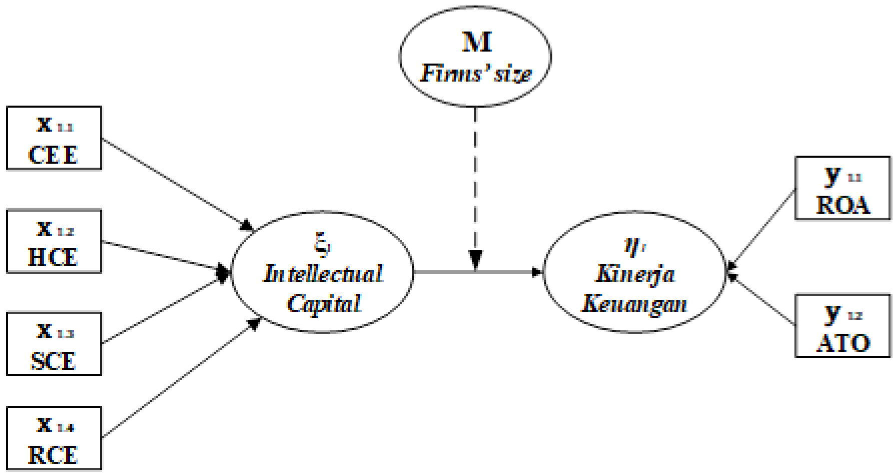

Figure 1. Conceptual Model for The Research

2. METHODOLOGY

This research is carried through using M-VAIC model and Partial Least Square (PLS) to answer the research objectives. This study began by collecting data in the form of annual financial statements of manufacturing companies which are listed on the Indonesia Stock Exchange (IDX) for period of 2015 until 2019.

The M-VAIC model is used to estimate IC performance in manufacturing companies in this research study. The main purpose of IC performance measurement using the M-VAIC is to find out the efficiency results of the creation of value from tangible assets and intangible assets. M-VAIC components which consist of HCE, SCE, RCE and CEE are used as manifest indicators of exogenous latent variable Intellectual Capital. M-VAIC is calculated as follows:

$$M - VAIC = HCE + SCE + RCE + CEE \qquad (1)$$

M-VAIC shows the overall level of efficiency of a company in value creation and displays its intellectual abilities. Human Capital Efficiency or HCE which represents the number of value added generated from one unit of funds issued by the company to its employees. SCE or Structural Capital Efficiency aims to measure how many SCs are needed to produce one (unit of money) VA. RCE or Relational Capital Efficiency is additional component in M-VAIC model and CEE is an indicator that shows how much VA is generated from a unit of physical and financial capital. In order to calculate these variables, the total VA creates by the companies need to be calculated. The VA is calculated by reducing total sales with costs incurred to purchase raw materials and other components that support the product sales process.

$$VA = OUT - IN \qquad (2)$$

Following the calculation of VA, the M-VAIC components are calculated as follows:

$$HCE = \frac{VA}{HC} \qquad (3)$$

$$SC = VA - HC \qquad (4)$$

$$SCE = \frac{SC}{VA} \quad (5)$$

$$RCE = \frac{RC}{VA} \quad (6)$$

$$CEE = \frac{VA}{CE} \quad (7)$$

The components of M-VAIC model are used to measure IC and for the purposes of this research study, two financial ratios are selected to measure company's financial performance which act as dependent variable. These covers return on asset (ROA) and asset turnover (ATO).

ROA is categorized as profitability ratio. Profitability ratio used by the company to measure the ability in generating profits. In addition, the profitability ratio can represent company's effectiveness in running its operational activity (Sarno and Gunarta, 2017). The use of ROA as a measure of company profitability can show how well a company controls it expenses and uses its resources to make a profit. Higher value of ROA indicates better company's ability to manage its assets. A good asset and resource management will create a competitive advantage for the company which will lead to increase of company performance.

$$ROA = \frac{Net\ Income}{Total\ Aset} \quad (8)$$

Asset Turnover is included in the category of productivity or efficiency ratios, where this ratio is used to measure how productively the company uses and utilizes its assets. ATO is measured by dividing total income by total assets (Firer and Mitchell Williams, 2003; Gunarta, 2020). Companies that can manage and utilize their assets or resources will achieve a competitive advantage which will have an impact on company performance (Herdyanto *et al.*, 2013). Higher ATO value indicates the company efficiency in using its asset to support sales activities.

$$ATO = \frac{Total\ Penjualan}{Total\ Aset} \quad (9)$$

As in this study hypothesis, firm size is included as moderator variable which is measured based on total assets (Ozkan, Cakan and Kayacan, 2017) using this following equation:

$$Ukuran\ perusahaan = Ln\ (Total\ Aset) \quad (10)$$

In this study, the research hypotheses are tested and analyzed using PLS. The company financial performance is treated as an endogenous latent variable with ROA and ATO as indicators while IC measured by M-VAIC components and firm size are treated as exogenous latent variables.

PLS is an alternative of non-parametric analysis for Structural Equation Modeling (SEM) technique. The PLS model is called soft modeling and considered a strong model because it does not depend on fulfilling assumptions, such as SEM and OLS (Ordinary Least Square) models or regression, where data must be normally distributed, no multicollinearity between variables, have large number of samples and specific data scale. According to Ghozali (2012), PLS can be used to test theories and confirm theories, beside that PLS is also used to explain whether there is a relationship between latent variables (Prasetio, 2015). The use of the PLS model to analyze the impact of IC on financial performance has been conducted in several previous studies (Tan, Plowman and Hancock, 2007; Ulum, Ghozali and Chariri, 2008; Rosaria, 2014; Sabrina, 2015; Ulum, Kharismawati and Syam, 2017; Mohammad and Bujang, 2019).

3. RESULTS AND DISCUSSION

The data is gathered from 77 companies that publicly listed in IDX from 2015 until 2019. Out of 184 manufacturing companies listed, these 77 companies fulfill the requirements specified in this study which are consistently published financial reports, does not experience equity deficiency and has positive net income during 2015-2019.

Table 1 displays the annual mean value of IC indicators which are HCE, SCE, RCE, CEE and also the value of M-VAIC. Based on results in Table 1, the average M-VAIC value from 2015 to 2019 fluctuated. Starting in 2015, mean of 77 manufacturing companies were at a value of 2.9757 and then increased in 2016 to 3,2181. In 2017, the average of M-VAIC value decreased by 0.1789 to 3.0392, then increased again by 0.0098 in 2018. Unable to maintain its position in the range of 3.0490, in 2019 the efficiency value of intellectual capital and physical assets decreased to a value of 2.9543.

Table 1. Descriptive Statistics

	HCE	SCE	RCE	CEE	M-VAIC
2015	1,9580	0,3962	0,2731	0,3484	2,9757
2016	2,2189	0,4361	0,2095	0,3536	3,2181
2017	2,0883	0,4054	0,2180	0,3275	3,0392
2018	2,1101	0,4181	0,2029	0,3179	3,0490
2019	2,0495	0,4004	0,1993	0,3050	2,9543
2015-2019	2,0850	0,4112	0,2206	0,3305	3,0472

Figure 2 shows the result of PLS Model using data from 2015 and 2016. The output of the collinearity test for PLS model in 2015 and 2016 show that the indicators on the outer model and endogenous latent variables have a VIF value less than 10 and it can be concluded that there is no collinearity problem in the indicators of exogenous or endogenous latent variables in the model. This result of collinearity test occurs in models in other years. Based on Figure 2, it suggests that CEE, ROA and FS are the only indicators that significant at level 5% for PLS model year 2015 while the result of PLS Model using data from 2016 suggests that the t-statistics is significant only for CEE, SCE, ROA and FS.

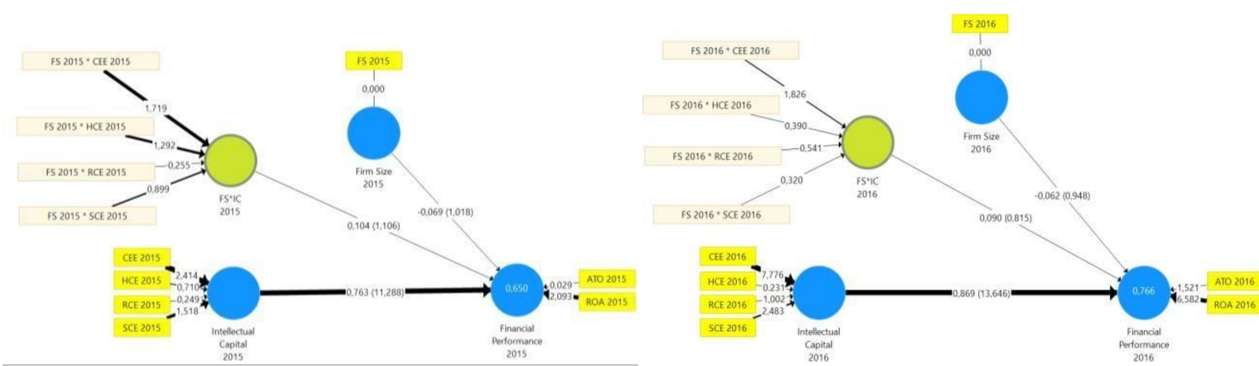

Figure 2. Result of PLS Model Year 2015 and 2016

The indicators that proven to be insignificant, have -statistic value less than 1,96, to measure exogenous IC variables and endogenous financial performance variable such as HCE and ATO are not excluded from the model. This is done considering that formative indicators are used in outer models. Removing indicators from outer models that use formative indicators are at risk of changing the meaning of the latent variables (Hair *et al.*, 2017).

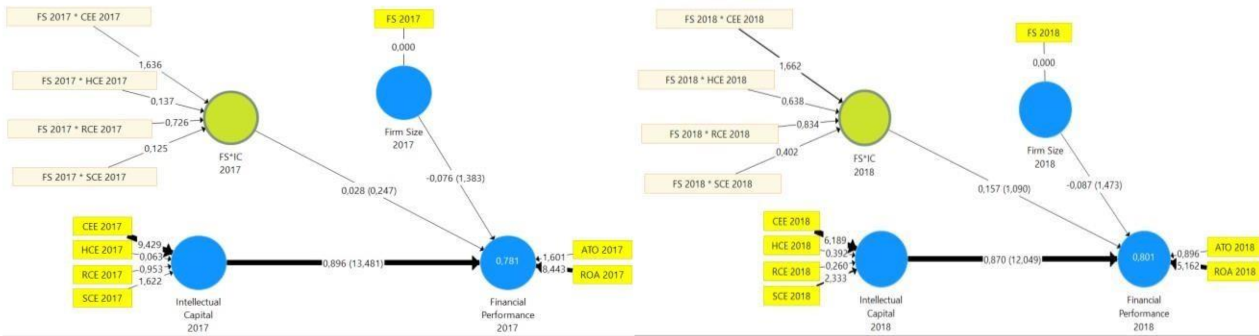

Figure 3. Result of PLS Model Year 2017 and 2018

Figure 3 shows the result of PLS Model using data from 2017 and 2018. The result of PLS model in year 2017 shows that CEE, ROA and FS are the only indicators that significant to measure the latent variables, because their t-statistics ≥ 1,96. Different result from PLS model in year 2018, not only CEE, ROA and FS but also SCE are proven to be significant in level 5%.

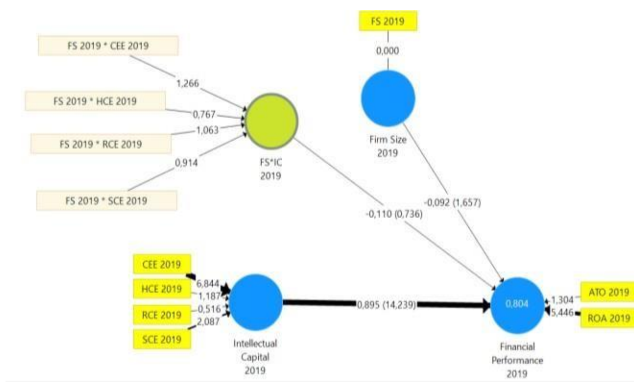

Figure 4. Result of PLS Model Year 2019

Similar with the result of model in year 2016 and 2018, PLS model in year 2019 suggest that the t-statistics is significant for CEE, SCE, ROA and ATO.

3.1 Results of Hypothesis Testing

Hypothesis testing is done by comparing the t-statistic value of the inner model from the bootstrapping results with the t-table value of 5% significance level, 1.96. If the t-statistic value exceeds 1.96, then H1 is accepted or the model is proven to be statistically significant. The model that is proven significant indicates that there is an impact between latent variables in the model. On the contrary, if the t-statistic value is less than 1.96 then H1 is rejected, which means that there is no impact between latent variables.

From the results of t-statistical values obtained using SmartPLS software, it proves that IC has a significant impact toward financial performance of manufacturing companies in Indonesia and it can be concluded that H1 is accepted. This result is concluded after seeing the t-stat value in Table 2 which shows that the t-statistic value of the Inner Model ≥ 1.96. The result of this study support research conducted by previous researchers, such as (Chen, Cheng and Hwang, 2005; Lu *et al.*, 2010; Nimtrakoon, 2015; Ulum, Kharismawati and Syam, 2017).

Table 2. PLS Result of H1

Model Summary	Weights	T-Stat	Adj R^2
IntellectualCapital_2015 ❼Financial Performance_2015	0,763	11,288	0,65
IntellectualCapital_2016 ❼Financial Performance_2016	0,869	13,646	0,766
IntellectualCapital_2017 ❼Financial Performance_2017	0,896	13,481	0,781
IntellectualCapital_2018 ❼Financial Performance_2018	0,870	12,049	0,801
IntellectualCapital_2019 ❼Financial Performance_2019	0,895	14,239	0,804

In addition to proving the impact of IC toward company's financial performance, the result of this study shows which indicators are proven to significantly measure the exogenous latent variables of IC which are measured using the M-VAIC components as well as the endogenous latent variables of financial performance measured using ROA and ATO indicators. The results of outer model evaluation show that ROA is the only indicator proofed to be statistically significant in measuring the financial performance of manufacturing companies from 2015 to 2019. This result is concluded after seeing the results of outer model bootstrapping which produces the t-statistic of ROA always greater than the t-table value at the 5% (two-tailed) significant level. These results support the research of Nuryaman (2015) and Ulum et al., (2017).

Different from ROA, the ATO indicator proved to be statistically insignificant for measuring endogenous latent variables because the t-statistic value of ATO does not meet the t-table requirements at the 5% significant level. The insignificance of ATO to measure financial performance supports the research conducted by Firer and William (2003). The research shows that there is no evidence of a significant impact of IC components on financial performance proxied by ATO.

In the indicator for measuring the exogenous latent variable intellectual capital, the CEE indicator or capital employed efficiency is an indicator that proven to be statistically significant to measure the exogenous latent variable of IC. This result is concluded based on the results of the of the outer model evaluation where the CEE indicator has t-statistic ≥ 1.96 during the study period of 2015 to 2019. Not only the CEE indicator, the SCE indicator or structural capital efficiency is also proven statistically significant for measuring the exogenous latent variables IC.

However, in opposition to the CEE indicator which proved to be consistently significant as an indicator for measuring IC during the five years of the study period, SCE indicator is only proven during the three years of research (2016, 2018 and 2019). In 2015 and 2017, SCE proved to be insignificant because it had a t-statistic value < 1.96. The bootstrapping results for the five years of this study period also show that the HCE and RCE indicators are not significant as indicators of IC.

The significance of the CEE indicator shows that the efficiency of physical capital and financial capital still plays an important role in creating value and intellectual capacity for companies to improve their financial performance. Apart from CEE, structural capital efficiency has also proven significant in creating value and intellectual capability for companies. This indicates that manufacturing companies in Indonesia are sufficient to manage and utilize its supporting infrastructure such as database or SOPs to create added value for the company so that the company can improve its financial performance.

The insignificance of the manifest variables HCE and RCE to measure IC latent variables, opens opportunities for companies to improve the efficiency of human capital and relational capital. The HCE indicator that is not significant to the IC variable shows that manufacturing companies in Indonesia are not able to utilize the skills, expertise and knowledge of their employees to create added value for the company.

The condition that the human resource component has not been utilized in manufacturing sector companies must be immediately addressed, because now Indonesia is entering the industrial era 4.0, where the state is committed to revitalizing the manufacturing industry in order to multiply labor productivity, so as to increase global competitiveness and increase the share of the global export market. In preparation for entering the industrial era 4.0, the Indonesian Ministry of Industry formulated 10 national priorities summarized in “Making Indonesia 4.0” to accelerate the development of the manufacturing industry. The implementation of activities or activities in companies that can support 10 national priorities will be urgently needed to achieve the success of the Making Indonesia 4.0 program, where improving the quality of human resources is one of the ten priority programs (Kementrian Perindustrian, 2019).

Besides increasing the human resource efficiency, increasing relational capital efficiency also need to be done. In the Making Indonesia 4.0 program, several programs are aimed at increasing the efficiency of relational capital, such as accommodating and promoting a conducive environment, in terms of regulations, taxes and subsidies to attract investment. In addition, building digital-based infrastructure to encourage and accommodate collaboration between industry players and harmonize rules and policies to increase industrial competitiveness.

The second hypothesis test is carried out to find out whether the size of the company is able to moderate the relation of IC toward company's financial performance. Table 3 is the summary of the t-statistic value of the inner model.

Table 3. PLS Results of H2

Model Summary	Weights	T-Stat	Adj R^2
FS*IC_2015 ❼ Financial Performance_2015	0,104	1,106	0,65
FS*IC_2016 ❼ Financial Performance_2016	0,090	0,815	0,766
FS*IC_2017 ❼ Financial Performance_2017	0,028	0,247	0,781
FS*IC_2018 ❼ Financial Performance_2018	0,157	1,09	0,801
FS*IC_2019 ❼ Financial Performance_2019	-0,110	0,736	0,804

From Table 3, it can be seen that the t-statistical value of FS*IC ❼ Financial Performance, which shows the function of the moderating variable in PLS model, shows value below the 5% significant level. In fact, all the t-statistical values from the bootstrapping results show values that do not meet the significant level limits either 10% or 1%. Based on these results, it can be concluded that H2 is rejected, which means that firm size does not positively moderate the relation between IC and financial performance of manufacturing companies during the study period of 2015 until 2019. The results of this study are contrary to the research conducted by Rosaria (2014) and Mohammad and Bujang (2019) which shows that firm size positively moderates the relation of IC and company's financial performance.

6. CONCLUSION

Drawing upon 77 manufacturing companies listed in Indonesia Stock Exchange during 2015-2019 research period as sample, this research study has studied the relation between IC and company’s financial performance and the impact company’s size as moderating variable. The result of this study which analyzed using the PLS shows that IC is consistently and statistically proven to have a significant positive impact toward financial performance of manufacturing companies during the study period of 2015 until 2019. The CEE and SCE are indicators that have proven significant in measuring the intellectual capital variable, while the ROA indicator is the only indicator that is proven to be significant in measuring the company's financial performance. This study provides an input to the current literature that firm size is proven to not positively moderate the relationship between intellectual capital and company financial performance.

This study is not without its limitations. This study is limited to companies listed on the IDX in the manufacturing sector, further research can conduct research on companies in other sectors such as financial sector and service sector. In addition, conducting analysis by comparing IC performance between sectors can also be carried out in the future. The continuous development of the IC measurement model opens opportunities to measure IC from a different model or perspective or even comparison between the existing and new model. In summary, the results of this study provide additional evidence regarding the impact of IC toward manufacturing company's financial performance and firm size as moderator variable in the relation of IC and financial performance.

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REFERENCES

Ab. Aziz, M. R. and Meor Hashim, A. A. (2017) 'Intellectual Capital (IC) Determinants: Impact on Productivity of Islamic Banks', *Binus Business Review*, 8(3), p. 189.

Amin, M. Al (2011) 'Pengaruh Firm Size terhadap hubungan Intellectual Capital dengan Kinerja Perusahaan (Studi Empiris pada Perusahaan yang Terdaftar di BEI 2001-2010)', *Jurnal Ekonomi dan Pembangunan*, 1(2), p. 123.

Brien, E. O., Clifford, S. and Southern, M. (2011) 'Knowledge Management for Process , Organizational and Marketing Innovation: Tools and Methods', in *Knowledge Management for Process, Organizational and Marketing Innovation: Tools and Methods*. Hershey, New York: Information Science Reference, p. 287.

Chen, M. C., Cheng, S. J. and Hwang, Y. (2005) 'An empirical investigation of the relationship between intellectual capital and firms' market value and financial performance', *Journal of Intellectual Capital*, 6(2), pp. 159–176.

Ermawati, Y. *et al.* (2017) 'Reconstruction of Financial Performance to Manage Gap between Value Added Intellectual Coefficient (VAICTM) and Value of Company in Banking Company Listed in Indonesia Stock Exchange', *International Journal of Economics and Financial Issues*, 7(4), pp. 537–549.

Firer, S. and Mitchell Williams, S. (2003) 'Intellectual capital and traditional measures of corporate performance', *Journal of Intellectual Capital*, 4(3), pp. 348–360.

Gho, P. C. (2005) 'Intellectual capital performance of commercial banks in Malaysia', *Journal of Intellectual Capital*, 6(3), pp. 385–396.

Gunarta, I. K. (2020) *Finance for Engineer, Institut Teknologi Sepuluh Nopember*. Available at: https://www.financeforengineer.net/analisis-laporan-keuangan.

Hair, J. F. *et al.* (2017) *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. Second. Los Angeles, USA: SAGE Publications, Inc.

Herdyanto, I. *et al.* (2013) 'Pengaruh Intellectual Capital pada Financial Performance Perusahaan

(Studi Empiris pada Perusahaan Infrastruktur, Utilitas, dan Transportasi yang Terdaftar di Bursa Efek Indonesia Tahun 2009-2011)', 2(3), pp. 405–414.

Kartikasari, D. and Merianti, M. (2016) 'The effect of leverage and firm size to profitability of public manufacturing companies in Indonesia', *International Journal of Economics and Financial Issues*, 6(2), pp. 409–413.

Kementrian Perindustrian, I. (2019) *Making Indonesia 4.0, Kementrian Perindustrian Indonesia*.

Kianto, A., Andreeva, T. and Pavlov, Y. (2013) 'The impact of intellectual capital management on company competitiveness and financial performance', *Knowledge Management Research and Practice*. Nature Publishing Group, 11(2), pp. 112–122.

Lee, C. S. and Wong, K. Y. (2019) 'Advances in intellectual capital performance measurement: a state-of-the-art review', *The Bottom Line*, 32(2), pp. 118–134.

Lu, W. M. *et al.* (2010) 'Capability and efficiency of intellectual capital: The case of fabless companies in Taiwan', *Expert Systems with Applications*. Elsevier Ltd, 37(1), pp. 546–555.

Mehri, M. *et al.* (2013) 'Intellectual capital and firm performance of high intangible intensive industries: Malaysia evidence', *Asian Social Science*, 9(9), pp. 146–155.

Mohammad, H. S. and Bujang, I. (2019a) 'Firms' Size as a Contingency Approach in the Relationships of Intellectual Capital, Capital Structure and Financial Performance', *International Journal of Academic Research in Business and Social Sciences*, 9(3), pp. 268–277.

Mohammad, H. S. and Bujang, I. (2019b) 'Performance of Malaysian financial firms: An intellectual capital perspective using MVAIC model', *Asian Economic and Financial Review*, 9(7), pp. 752–765.

Nimtrakoon, S. (2015) 'The relationship between intellectual capital, firm's market value and financial performance - Empirical evidence from the ASEAN', *Journal of Intellectual Capital*, 16(3), pp. 587–619.

Nuryaman (2015) 'The Influence of Intellectual Capital on The Firm's Value with The Financial Performance as Intervening Variable', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., 211(September), pp. 292–298.

Ozkan, N., Cakan, S. and Kayacan, M. (2017) 'Intellectual capital and financial performance: A study of the Turkish Banking Sector', *Borsa Istanbul Review*. Elsevier Ltd, 17(3), pp. 190–198.

Prasetio, F. (2015) 'Pengaruh Intellectual Capital terhadap kinerja keuangan (Studi Empiris Pada Perusahaan Perbankan Dan Asuransi Yang Terdaftar Di Bursa Efek Indonesia Tahun 2011-2013)', *Fakultas Ekonomika Dan Bisnis Universitas Diponegoro*, pp. 1–31.

Rosaria, E. S. (STIE P. S. (2014) 'Pengaruh Modal Intelektual terhadap Kinerja Keuangan Perusahaan ManufaKtur yang terdaftar di Bursa Efek Indonesia dengan Ukuran Perusahaan sebagai variabel Moderating', *STIE Perbanas*, 39(1), pp. 1–24.

Sabrina, S. (2015) 'Analysis of Intellectual Capital Effect Toward Financial Performance and Growth', *Binus Business Review*, 6(3), p. 449.

Sarno and Gunarta, I. K. (2017) *Evaluasi Kinerja dengan Metode AHP dan TOPSIS pada Perusahaan Sektor Pertambangan yang tercatat pada Bursa Efek Indonesia Periode 2012-2015*. Institut Teknologi Sepuluh Nopember Surabaya.

Suherman, R. (2017) 'The Impact of Intellectual Capital toward Firm ' s Profitability and Market Value of Retail Companies Listed in Indonesia Stock Exchange (IDX) from 2013-2016', *iBuss Management*, 5(1), pp. 98–112.

Talebnia, G. and Aliari Erdi, M. (2018) 'Investigating the Relationship between Intellectual Capitals in Improving Financial Performance Companies Listed in TSE', *SSRN Electronic*

Journal, pp. 1–14.

Tan, H. P., Plowman, D. and Hancock, P. (2007) ‘Intellectual capital and financial returns of companies’, *Journal of Intellectual Capital*, 8(1), pp. 76–95.

Ulum, I., Ghozali, I. and Chariri, A. (2008) ‘Intellectual Capital Dan Kinerja Keuangan Perusahaan; Suatu Analisis Dengan Pendekatan Partial Least Squares’, *Simposium Nasional Akuntansi XI*, 19(19), pp. 23–24.

Ulum, I., Kharismawati, N. and Syam, D. (2017) ‘Modified value-added intellectual coefficient (MVAIC) and traditional financial performance of Indonesian biggest companies’, *International Journal of Learning and Intellectual Capital*, 14(3), pp. 207–219.

Wang, W. K. *et al.* (2014) ‘Does intellectual capital matter? Assessing the performance of CPA firms based on additive efficiency decomposition DEA’, *Knowledge-Based Systems*. Elsevier B.V., 65(April), pp. 38–49.

ALTERNATIVE CHOICES OF INVESTMENT IN KALITELU TULUNGAGUNG WITH THE HIGHEST AND BEST USE METHOD

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ABSTRACT

According to the Badan Pusat Statistik (BPS), the economic growth of Kabupaten Tulungagung has increased as shown in the calculation of Gross Regional Domestic Product (GRDP) data. The GRDP of Kabupaten Tulungagung from 2017-2019 has increased by 5.21% in 2018 and 5.32% in 2019. Such growth can be seen as a supportive condition for investment. Therefore, this study aims to determine the alternative options on a 13.988 m² on Jalan Kalitelu, Kabupaten Tulungagung. This study discusses alternative land investment options in the area by using the basic principles of assessment with the Highest and Best Use method. The method is used as an entry point for investment to see the value of land use that has maximum productivity. The alternative options are formulated from the trend in the business sector that is growing positively in the area and then determined by using a questionnaire to be analyzed. This study identified five alternatives, namely housing, food court, mix of hotel (30%) and food court (70%), mix of hotel (50%) and food court (50%), and mix of hotel (80%) and food court (20%). The analysis of this study found that the highest land productivity value is land development with a mixed-use building function of hotels (80%) and food court (20%) with the land value of Rp. 268,566,109,515,- / m² or an increase of Rp. 12000,70%.

Keywords: Highest and Best Use, Land Development, Kabupaten Tulungagung, Investment.

1. INTRODUCTION

The economic growth in Kabupaten Tulungagung continues to increase in at least five years, namely 2014-2018[1]. Furthermore, the Gross Regional Domestic Product (GRDP) that is used to determine the added value created from regional activities has experienced an increase from 33,74 trillion Rupiah in 2017 to 36,62 trillion Rupiah in 2018 (Dinas Komunikasi dan Informatika Kabupaten Tulungagung, 2019). From the business sector's perspective, the main aspect that has the most significant role in the manufacturing industry by 21,64%, followed by wholesale and retail trades; car and motorbikes repair shops by 20,82%, and agriculture, forestry, and fisheries by 19,64% (Dinas Komunikasi dan Informatika Kabupaten Tulungagung, 2019). Based on the growth rate in 2016-2018, the highest growth rate was in the electricity and gas procurement, transportation, and accommodation sector, and then followed by the real estate industry.

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[1] [1] Based on the Economic Data and Statistics of Kabupaten Tulungagung in 2019, the GRDP of Kabupaten Tulungagung in 2014 was 25,78 trillion Rupiah, increasing to 36,2 trillion Rupiah in 2018 (Dinas Komunikasi dan Informatika Kabupaten Tulungagung, 2019).

The high economic growth shows that Kabupaten Tulungagung has a positive economic atmosphere for investment. It is also supported by the geographical location of Tulungagung that shares its border with four other regions, namely Kabupaten Blitar, Kediri, Ponorogo, and Trenggalek. Jalan Kalitelu is the only provincial route that interlinks Kabupaten Tulungagung and Trenggalek, so it is very vital and usually packed with vehicles. This study uses the land in the zero kilometers of the provincial route between Tulungagung and Trenggalek, which included in the Kecamatan Gondang, Tulungagung as the research object.

Moreover, the land itself belongs to Rahayu Diesel. Rahayu Diesel is a business entity that operates in equipment rental and heavy spare parts sales. The land is located in the industrial and commercial areas and surrounded by industrial and trade routes between districts. The land surrounding the area develops along with the economic development of Kabupaten Tulungagung. Several economic activities can be found in the area, such as agricultural land which still dominates, buildings like welding workshops for factory machines, stone processing industry stockpiles or stone crushers, retail shops for local residents, and busy gas stations filled with various types of vehicles such as trucks, private vehicles, or public transportation like inter-provincial busses.

Currently, the land on Jalan Kalitelu KM 165 is used only for farming, so the land use is still not maximized. Therefore, it is necessary to conduct an appraisal study of the land to determine land use that has maximum productivity of the area so that land use is right on target. In this study, we use the Highest and Best Use method to analyze the area. This approach tries to see the use of property which at certain times are considered able to produce maximum net returns in the future (Brett and Schmitz, 2009). The highest and best use of property is physically possible to build, permitted by applicable legal regulations, and financially feasible and can produce maximum value (Harjanto and Hidayati, 2014). Highest and Best Use analysis is one of the approaches commonly used by agencies in charge of assessing a property object, including land. The Ministry of Finance of the Republic of Indonesia and the Masyarakat Profesi Penilai Indonesia (MAPPI) use this method in accordance with the Highest and Best Use Concepts and General Principles of Assessment as the most possible and best use of an unutilized land or whose property is already built (Willyana and Utomo, 2014).

The Highest and Best Use method's goal is to estimate what alternative uses of the property that will potentially produce the highest value of future benefits so that it can help the property owner maximize the use of the land. From the results, we will obtain the best usage and time management based on market demand, the highest potential consumers along with the types whether they are investors, developers, or users (Fanning, Wright, and Muenks, 2018). The limitations that should be considered regarding the legal aspect are the use, zoning, building codes, regulations related to cultural heritage, and environmental regulations that must be obeyed (Harjanto and Hidayati, 2014). Other regulations that also need to be considered are regulations that binds the research land and the provisions for building construction, such as Peraturan Bupati Tulungagung No. 23 concerning Technical Guidelines for Building Designation. While the physical aspects that will be reviewed are the size, shape of the land, area, height, and contour of the land that affect the uses of the property development above it (Harjanto and Hidayati, 2014).

According to Harjanto and Hidayati (2014), what needs to be considered in the financial aspect is the financial feasibility of the income that will be received or expected, investment costs, operating costs, and the rate of return on the invested capital. The Discounted Cash Flow (DCF) analysis is also used in the Highest and Best Use analysis, which refers to short-term cash flow that is higher than long-term cash flow where there is a difference according to the required rate of return (Miles, Netherton, and Schmitz, 2015). DCF is widely known to be the best conceptual approach for making capital budgeting decisions (Weygandt, Kimmel, and Kieso, 2014).

The DCF technique considers estimating the total net cash flow from an investment and the time value of money. The total of expected net cash flow consists of the sum of annual net cash flows added with the estimated asset liquidation when the asset is sold at the end of its functional period. Essentially, the DCF analysis uses two methods, namely Net Present Value (NPV) and Internal Rate of Return (IRR) (Weygandt, Kimmel, and Kieso, 2014). Net Present Value involves net cash flow that has been discounted to present value, which is then compared with the present value with the investment's capital. The difference between the two results is known as the NPV. Meanwhile, the IRR refers to the interest rate that will cause the present value of the proposed capital expenditure to be equal to the present value of the expected net annual cash flows (Weygandt, Kimmel, and Kieso, 2014). Based on the Highest and Best Use method, in order to achieve the maximum productivity on land, it is crucial to make sure that investment is legally permissible, physically possible, and fulfilling financial aspects (Fanning S.F., 2008).

Theoretically, the Highest and Best Use (HBU) analysis should be interpreted in the context of the most likely or most appropriate use, consistent with the definition of time (Vandell and Carter, 2000). In his writing that reviews Graaskamps's thoughts on HBU, it is explained that Graaskamp prefers Most Fitting Use (MFU) and Most Probable Use (MPU) to HBU. According to him, the term HBU has a limited meaning and is incompatible with the real estate development process's overall scheme. Graaskamp further explained that HBU only describes a one-person assessment and is limited to one dimensional development concept and involves various hidden interests in cash flows that are influenced by certain land-use decisions (Vandell and Carter, 2000). Thus, Graaskamp uses the MFU concept, which refers to the best use that is obtained only after considering and weighing all alternative programs and its consequences. MFU is a use which is "the optimal reconciliation of consumer demand, production costs, infrastructure service costs, and fiscal and environmental impacts on third parties" (Graaskamp, 1981a, p.11 in Vandell and Carter, 2000). In another article about Graaskamp called Highest and Best Use: The Evolving Paradigm (1990) in the Journal of Real Estate Research, it is explained that there are two different views regarding HBU. The first one talks about site-specific analysis, which typically emphasizes physical and legal attributes (Ricardo), while the second view focuses more on the general areas or the whole urban structure and location (Von Thunen). Literature that focuses on site-specific analysis and individual wealth maximization rarely mentions about macro location parameters and the interests of the communities. In contrast, in literatures that use urban land economy perspective, there are many discussions regarding the land use in the structural context of urban areas (Dotzour, Grissom, Liu, and Pearson, 1990).

This study will provide alternatives to land use by doing field observations and spreading questionnaires to stakeholders. The data then will be analyzed with the Highest and Best Use method based on legal aspects, physical aspects, financial aspects, and maximum productivity. This paper aims to identify which alternative gives the highest productivity in the Kalitelu area based on the Highest and Best Use analysis.

2. METHODOLOGY

This study is a modeling of the highest and best method. This study resolves the issue of possible alternative use options that can be applied in the Kalitelu area, Kecamatan Gondang, Tulungagung by using the Highest and Best Use assessment principles to produce the highest value and best application of the land. Data collection in this research was carried out in several stages in order to determine the Highest and Best Use (HBU) of the land by doing field observation and distributing questionnaires to interviewees, especially stakeholders and published documents. The questionnaires were distributed by conducting a questionnaire survey with several selected respondents, especially those interested in investing in the area or those who know about land investment and the development condition in the area. Those respondents consisted of landowners, district government, and regional banks, as well as local communities in the surrounding area. Finally, the data were processed and analyzed to determine alternative land development by using the Highest and Best Use method.

2.1 Preparation and Identification Stage

The first stage in this research is the preparation and identification stage, which includes making a research plan scheme, determining objectives, collecting data, and recapitulating the data needed in identifying the variables of land development alternatives. Some of those activities are as follows:

1. Preparing the research's background, problem formulation, and research objectives.
2. Designing a questionnaire format that will be distributed to stakeholders.
3. Conducting a literature review of the analytical approaches and methods used by reviewing previous studies.
4. Distributing questionnaires to stakeholders by conducting a questionnaire survey with selected respondents interested in the area and those who know about land investment and the development condition in the area.
5. Collecting and calculating secondary data related to legal and financial aspects.

Doing direct observation around the research area, focusing on the research area's physical aspects, including the mapping of facilities and accessibility. The goal is to check the condition of the research area.

2.2 Analysis Stage

The data collected from the previous stage is processed and analyzed to determine alternative land development by using the highest and best use method. The activities are as mentioned below:

1. Assessing the results of the questionnaire and listing the alternatives for land development
2. Analyzing the data results regarding the legal aspects in the research area and regulations related to each land development alternative. The results will be used as a reference for further analysis on the physical aspects.
3. Analyzing the data results on the physical aspects of the research area based on the results from the previous activity.
4. Analyzing each alternative design with financial analysis to obtain the DCF, NPV and IRR for each alternative and obtain the land value after development.
5. Calculating the maximum productivity value of the land from the financial analysis to further interpret the research results in accordance with the initial objectives of the study.

3. RESULTS

By the look of the economic development in the area, several aspects are always grow positively and can potentially be developed, namely the provision of accommodation, provision of food and drink, and real estate. Therefore, the questionnaire proposed land uses alternatives either with a single-use or mixed-use function, which includes housing, food courts, shops, and hotels. The questionnaire scoring later determined five alternative land uses consisting of two alternatives with the highest score for single-use function and three alternatives with the highest score for mixed-use function. The results are as follows:

1. Alternative 1: Housing (single use)
2. Alternative 2: Food court (single use)
3. Alternative 3: 70% food court 30% hotel
4. Alternative 4: 50% food court 50% hotel
5. Alternative 5: 80% hotel 20% food court

Based on the scoring results of the questionnaire, the five alternatives can be further analyzed using the highest and best use method.

3.1 Legal Aspect Analysis

Table 1. Legal Aspect Data Results Based on Data from the Regulation of the Public Works Office for Spatial Planning and Settlements of Kabupaten Tulungagung

Column Heading 1	Column Heading 2	Column Heading 3	Column heading 4
1	24	12	11
2	25	12	11
3	22	14	10
4	23	15	12

As housing is one of the alternatives suggested in the questionnaire, it is necessary to review the applicable regulations regarding housing and settlement development. The reference to the legal aspects of housing development in this research refers to the Government Regulation of the Republic of Indonesia No. 14 of 2016 concerning the Implementation of Housing and Settlement Areas. The relevant points found in the law include:

1. The house's design must be following the detailed spatial plan or regional spatial plan and zoning regulations.
2. The linkage between the development of rural residential environments and the development of rural areas.

The next relevant legal aspect concerns the provisions of the parking area. In this case, according to the Director-General of Land Transportation from the Ministry of Transportation on Guidelines for Planning and Operation of Parking Facilities, factors that are included in the parking needs are shown in the following table:

Table 2. Parking Unit Determination

No	Vehicle Type	Parking Space Unit (m^2)
1.a	Passenger car for group I	2,30 x 5,00
1.b	Passenger car for group II	2,50 x 5,00
1.c	Passenger car for group III	3,00 x 5,00
2.	Bus/truck	3,40 x 12,50
3.	Motorcycle	0,75 x 2,00

Source: (Departemen Perhubungan Direktur Jenderal Perhubungan Darat, 1998)

Therefore, the analysis of the legal aspects suggested that the maximum ground floor area is 11,667 m², the total buildable floor area of the building is 50,353.20 m², the building height must not exceed 4 floors. The minimum green area is 1,398.7 m². Meanwhile, the result of legal analysis regarding housing development regulations is that the design of the houses must be consistent with the provisions of detailed spatial plans or regional spatial plans and regional zoning regulations of the research area. The land location should also fulfill the requirements for residential development in rural areas according to the zoning system in the area. Lastly, the result of the legal aspect analysis regarding the provisions of parking units is that for hotel parking, 1 hotel room in the alternative development design should have 1 SRP (Parking Space Unit). The results from the legal aspect analysis can be used as the basis of reference for determining the building's alternative design.

3.2 Physical Aspects

Regarding the physical aspect, the variables used in this research are land location, land shape, utility, and accessibility. In the land location variable, the main focus consists of several aspects, namely environmental, commercial, and industrial facilities in the surrounding area. In the variable of land shape, utility, and accessibility, the main focus is land functions and public transportation availability.

Figure 1. The view of the research area right in the northern part of the Kabupaten Tulungagung gate

The area is measured 13,987 m² and divided into 2 parts separated by a river. The land on the south side of the river measures 11,025 m² in the shape of a triangle, and the land in the northern part of the river measures 2,962 m² in the shape of a rectangle. With such a wide area, the land has the potential to develop mixed use buildings that can accommodate food courts, hotels, housing and shops. The field observation showed that the research area has sufficient utilities such as electricity, telephone and internet networks, clean water lines, and drainage channels when it comes to the facilities provided. All of these utilities are crucial for the development in the research area.

From the observation, this study suggested that the area's land accessibility is easily accessible because the land is located on a 10 meters wide provincial road, which interlinks the land with other regions. In addition, there is a bridge that connects the road to the research area so that it is easily accessible to large vehicles. Other than that, the means of transportation to the research area's location is also quite good. Because it is a provincial road, it is common for public transportations like inter-city and inter-provincial buses, microbuses, and minibusses to pass through.

3.3 Alternative Building Designs

Planning an alternative building design requires the results of physical and legal analysis. Apart from having to fulfill the requirements related to legal aspects and the parking area calculation, the design planning should also be adaptable to comparable properties around Kabupaten Tulungagung as shown in the following table:

Table 3. Parking Unit Determinatio

Property Type	Comparison
Hotel	Hotel Panorama 2
Food Court	Teras Kota Tulungagung
Housing	Griya Arsalan and Griya Kepuh Permai

The type of hotel development that is considered suitable in this area is the non-star hotel type. Regarding the standard of hotel rooms, based on the Government Regulations Kep-22/U/VI/78 issued by the Department of Tourism, Mail, and Telecommunication, non-star hotels should be built according to the minimum standard requirements for room area, namely 20 m². Housing construction and the types of constructions are based on the prevailing regulations and housing construction trend in the resident area in Kabupaten Tulungagung. The types are shown in the following table:

Table 4. Housing Types

Type	Number of Floors	Land Dimension (m²)
60/72	2 floors	6x12
50/84	1 floor	7x12

Food court stands range from 2 m² to 10,5 m². Therefore, the food court's alternative design is in accordance with the trend of the food stand area in Tulungagung, which is 2 m² to 10,5 m². The comparison is shown in the table below:

Table 5. Food Court Comparasions in Tulungagung

Name	Land Area (m²)	Dimension	Stand Area (m²)
Teras Kota Tulungagung	2400	40 x 60	3,5 - 10,5
Pasar Sore Lama Foodcourt	1000	20 x 50	7,5 - 10
De'Green Foodcourt	840	12 x 70	3,5 - 8
Pujasera Pinka	318	6 x 53	2

3.4 Alternative Design Planning

Alternative design planning according to the results of the questionnaire and the results of the analysis of legal aspects and physical aspects is shown in Table 6.

	Alternative 1	**Alternative 2**	**Alternative 3**		**Alternative 4**		**Alternative 5**	
Allocation	Housing	Food Court	Food Court 70% - Hotel 30%		Food Court 50% - Hotel 50%		Food Court 20% - Hotel 80%	
Groung Building Area (m²)	7.728	5.712	6.838	2.930	4.884	4.884	1.954	7.814
Ground Floor Area (m²)	5.680	11.424	13.672	5.860	9.768	9.768	3.908	15.628
Number of Floors	1 & 2	1	2	2	2	2	2	2
Number of Units	101	168	113	46	125	78	62	108
Area of the Unit Types (m²)	60/72	10,5	10,5	22	10,5	22	10,5	22
	50/84	7,5	7,5		7,5		7,5	
		3,75	3,75		3,75		3,75	
		2	2		2		2	
Jumlah Satuan Ruang Parkir (m²)		340	519	245	343	357	265	495

3.5 Financial Aspect Analysis

The next analysis step after legal aspect, physical aspect, and alternative designs is the financial aspect analysis. What needs to be reviewed in this stage are investment costs, income, expenses, and cash flow. The cash flow in each alternative is analyzed in order to calculate the rate of return of the capital. The investment cost consists of standard construction costs, non-standard costs, and land costs. Estimated income includes calculations of the sales and rental income according to the sale scheme of each alternative. In the alternative 1, the alternative housing development sales are projected for four years, while for the alternative 2-5, the estimated rental income and expenditure are projected for 20 years.

Expenditure planning is the cost required for each alternative's operation and maintenance, namely housing, food court, and hote. The operational cost for housing consists of electricity cost, employee salaries, marketing cost, and maintenance cost. While the operational cost for food courts and hotels is calculated from the electricity costs, water costs, employee salaries, taxes, and insurance. The impact of the Covid-19 pandemic on the property sector is also considered in this study so that it affects the overall income for several years in all alternatives. The methods used in this study's cash flow analysis are Net Present Value (NPV), Internal Rate of Return (IRR), and Discounted Payback Period. The sum of the financial analysis can be seen in Table 6. It is shown that alternative 1, alternative 3, alternative 4, and alternative 5 meet all of the financial criteria required.

Table 7. Financial Analysis Data

Alternatives	Income	Expenditure Planning	Investment Cost (Rp)	NPV (Rp)	IRR (%)	Discounted Payback Period (tahun)	Analysis Results
Alternative 1	48.244.525.741	4.326.660.919	37.535.884.625	8.535.138.714	46,79	2,2	Fulfilled
Alternative 2	37.351.010.740	3.705.752.195	28.628.302.487	(6.335.833.776)	2,53	9,98	Unfulfilled
Alternative 3	46.694.606.960	4.346.397.118	56.141.602.076	4.028.850.040	8,79	16,43	Fulfilled
Alternative 4	64.786.665.360	6.469.334.132	59.755.749.230	19.282.324.368	13,48	11,5	Fulfilled
Alternative 5	78.176.289.602	7.823.688.182	62.939.052.056	28.685.686.338	15,55	9,01	Fulfilled

3.5 Maximum Productivity Analysis

Maximum productivity analysis is used to determine the highest land value among several investment alternatives in the research area. Calculating the land value per square meter is the next stage after analyzing the legal, physical and financial aspects. The land value is obtained from the calculation of the property value minus the building value. The property value can be obtained from the terminal value because the terminal value is greater than the NPV or investment value. Maximum productivity can be seen from the escalation of the highest land value due to the construction of a building. The results can be seen in the following table:

Table 8. Maximum Productivity Data

Alternatives	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Property value	70.888.919.802	175.113.060.867	97.751.983.606	241.705.234.085	333.743.081.571
Building value	37.535.884.625	28.628.302.487	56.141.602.076	59.755.749.230	65.176.972.056
Land value	33.353.035.177	146.484.758.380	41.610.381.530	181.949.484.855	268.566.109.515
Land value/m^2	2.384.574	10.472.922	2.974.933	13.008.471	19.201.123
Initial land value/m^2	160.000	160.000	160.000	160.000	160.000
Productivity	1490,36%	6545,58%	1859,33%	8130,29%	12000,70%

Table 7 suggested that if alternative 4 is established, then a land value of Rp. 13,008,471,-/ m2 will be obtained from the initial value of Rp. 160,000,-/ m2, so it will provide land productivity of 8130,29%. Meanwhile, if alternative 5 is established, an additional land value of Rp. 19,201,108/ m2 will be obtained so that it will provide land productivity of 12000,70%. Therefore, based on the table, alternative 5 is the highest and best use of the land.

4. CONCLUSION

From the results of the analysis and research that has been carried out in this study, there are several things that can be concluded. First, based on the GRDP report of Kabupaten Tulungagung in 2015-2019, the business sectors that has positive growth are the provision of accommodation by 37,25%, provision of food and drink by 33,60%, and real estate of 26,56%. The analysis based on the field observation in the area found that micro and small and medium enterprises dominate the area. Therefore, the direction of land development in Kabupaten Tulungagung revolves around single-use and mixed-use building systems.

Second, there are five results of the stakeholder questionnaire scoring showed that the most recommended designations. The first alternative is housing for single use, the second alternative is food court for single use, the third alternative consists of 70% food court and 30% hotel, the fourth alternative consists of 50% food court and 50% hotel, and the fifth alternative consists of 80% hotel and 20% food court. Lastly, by using the highest and best use method, along with maximum productivity, it is known that alternative 5, which has the composition of 80% hotel and 20% food court has the highest maximum productivity compared to other alternatives. Alternative 5 has a value of Rp. 19,201,123,-/ m2 or an increase of 12000,70% compared to the condition before the development.

However, this research still has several limitations and shortcomings, so it is recommended that further research be conducted by paying attention to several aspects. First, there needs to be a further empirical research on market demand and business operating costs in Kabupaten

Tulungagung in order to adjust income and expenditure on an empirical basis. This is crucial because the assessment of the assumptions used can change over time as it is affected by time, economic and political conditions, and so on. The authors should double-check the data in the upcoming years because the land value increases every year. Second, there needs to be a further research that focuses on the impact of Covid-19 especially regarding the economic condition in Kabupaten Tulungagung..

6. REFERENCES

Brett, D. L., and Schmitz, A. (2009). *Real Estate Market Analysis Methods and Case Studies* (2nd ed.). Washington, D.C: Urban Land Institute.

Departemen Perhubungan Direktur Jenderal Perhubungan Darat. (1998). *Pedoman Perencanaan dan Pengoperasian Fasilitas Parkir. Diambil kembali dari Direktorat Jenderal Perhubungan Darat Kementrian Perhubungan Republik Indonesia*: http://hubdat.dephub.go.id/spesial- konten/pustaka/literatur/transport-umum/514-pedoman-perencanaan-dan-pengoperasian-fasilitas- parkir.

Dinas Komunikasi dan Informatika Kabupaten Tulungagung. (2019). *Data dan Statistik Ekonomi Kabupaten Tulungagung Tahun 2019*. Tulungagung: Dinas Komunikasi dan Informatika Kabupaten Tulungagung.

Dotzour, M. G., Grissom, T. V., Liu, C. H., and Pearson, T. (1990). Highest and Best Use: The Evolving Paradigm. *The Journal of Real Estate Research*, Vol. 5(No. 1), 17-32.

Fanning, S. F. (2008). *Highest & Best Use: Basic Concepts. in S. F. Fanning*, Appraisal Institute Market Analysis Book. Chicago: Appraisal Institute.

Fanning, S. F., Wright, L. T., and Muenks, R. J. (2018). Highest and Best Use and Property Rights - Does It Make a Difference? *The Appraissal Journal*, 171-191.

Harjanto, B., and Hidayati, W. (2014). *Konsep dasar Penilaian Properti* (Kedua ed.). Yogyakarta: BPFE- Yogyakarta.

Miles, M. E., Netherton, L. M., and Schmitz, A. (2015). *Real Estate Development Principles and Process*. Washington D.C.: Urban Land Institute.

Weygandt, J., Kimmel, P., and Kieso, D. (2014). *Accounting Principles*. Wiley.

Willyana, C., and Utomo, C. (2014). Analisa Alih Fungsi Pemanfaatan Tertinggi dan Terbaik Pada Lahan di Jalan Lowanu Kota Yogyakarta. *Seminar Nasional Manajemen Teknologi XX* (hal. B-11-1 - B- 11-11). Surabaya: Program Studi MMT-ITS.

Vandell, K. D., & Carter, C. C. (2000). Graaskamp's Comcept of Highest and Best Use. *Essays in honor of James A Graaskamp:ten years after*/edited by James R. DeLisle, Elaine, 307-319.

FORECASTING INDONESIAN RUPIAH OUTFLOW USING HYBRID MODELLING : A STUDY CASE IN JAKARTA REGION

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ABSTRACT

As a region with rapid economic growth in Indonesia, Jakarta, cash-basis transactions are still favored to this day. To ensure continuity of cash-basis transactions and to keep the inflation stable, the amount of cash circulated in public must be maintained properly. This is achieved by ensuring the efficient supply of cash to the public, which should neither be under-supply nor over-supply. Statistical forecasting technique yielding high accuracy (MAPE <10%) for a longer period is needed to achieve the objective. This paper proposes a hybrid model forecasting to predict the amount of circulated banknotes. The results show , using the outflow data of Rp.100.000 denomination in Jakarta (from 1999-2019), that the hybrid modelling ARIMA & FFNN provides higher accuracy (MAPE = 8,96%) in comparison to individual model such as ARIMA (MAPE = 10.06%) or FFNN (MAPE = 9,16%), in forecasting outflow for 9 months periods. This model will help the central bank as a basis for issuing banknotes to the public, along with the consideration of other factors.

Keywords: DKI Jakarta, cash-in-circulation, forecasting, hybrid.

1. INTRODUCTION

In Indonesia, demand for cash is continuing to rise in parallel with an increase of non-cash transactions, amidst the global shift from cash basis transactions to non-cash basis transactions (Yulianti et al., 2019). Farmers and retailers are two market segments still favoring cash-basis transactions to non-cash basis transactions (Sigalingging et al., 2004). In Indonesia, one of the factors which significantly influences the demand of cash is holiday related to religious observance (Prawoto, 2010).

According to Law Number 7 Year 2011 on The Currency in Chapter IV : Management Rupiah, there are 6 phases on managing banknotes, i.e : 1) Planning, 2) Printing, 3) Issuing, 4) Distributing, 5) Revocation and Extraction, and 6) Extermination. The goal of managing banknotes is to supply cash to the public with the right amount (and denominations), right timing and in good condition. Undersupplying banknotes to public will lead to market stagnation, while oversupplying banknotes to public leads to inflation.

In the planning phase, the central bank and government (Indonesia's Ministry of Finance) determine numbers of notes and denominations according to the demand on certain periods. Planning phase takes into account macroeconomic factors such as : inflation assumption, economic growth assumption, GDP and interest rate. Other factors to consider i.e : inflow and outflow of money (historical data), exterminated money, cash vault position, and regional economic situation. Inflow of money is defined as the number of money stored by the public to the central bank, while outflow of money is defined as the number of money distributed to the public. Inflow and outflow of money may differ from one region to another. According to Sigalingging et al (2004), several things which influence inflow and outflow of money, such as: economic growth; inflation rate which force people to use cash more than before to purchase the same goods in same quantity; loan disbursed, which increase job supply to market, thus affecting flow of money; number of ATM and bank branches; local autonomy & decentralization policy and; seasonal factor such as : religious observances, holidays, academic recess, great harvest period and regional observance. Banknote printing is performed by Indonesia's state-owned banknotes printing ("Perum Peruri"), then distributed by the central bank to regional offices across Indonesia. Each regional office accepts inflow and outflow transactions from the public.

Minimum stock of banknotes in each regional office must be kept safe. For head office (located in Jakarta) minimum stock is for 2 days from average monthly outflow, 1 week worth of monthly outflow for regional offices in Java, 2 weeks worth of monthly outflow for regional offices outside Java. National iron stock to keep is 15% worth of currency in circulation. With that in mind, it is necessary to have a forecast on the outflow and inflow on each region, especially for highly demanded banknotes (Rp100.000), in the area which banknotes move quickly and in great amounts such as Jakarta. Because failing to plan the banknotes stock in Jakarta (and failing to supply the demand), will likely lead to systemic economic halts in Indonesia.

There are numerous forecasting technique adopted by forecasters, which can be classified into two categories : statistical models (often referred as linear model) such as Autoregressive Integrated Moving Average (ARIMA), exponential smoothing (ES) or Generalized Autoregressive Conditional Heteroskedasticity (GARCH), which assuming the future values are linear function of past values; and artificial intelligence (AI) or non-linear model which employs artificial neural network (ANN) (Wang et al., 2012). Beside that, there is a hybrid technique which combines statistical models and AI. Combining forecasting models tends to yield higher accuracy than only using individual models (Bates & Granger, 1969; Clemen, 1989; Hajirahimi & Khashei, 2019; Hyndman, 2020; Zhang, 2003).

Several countries and organization such as : Sri Lanka, Pakistan, Germany and European Union have been conducting research in forecasting the flow of money, to help countries controlling liquidity (Bartzsch et al., 2011; Cabrero et al., 2009; Dheerasinghe, 2009; Riazuddin & Khan, 2005). In this paper we will be discussing forecasting outflow of rupiah in Jakarta using hybrid modelling, combination of ARIMA-based and ANN-based modelling.

This paper aims to find the best model in forecasting outflow of Rp.100.000 banknotes in the Jakarta region. Result of this paper can be adopted by policy makers to help planning banknotes stock, thus controlling inflation in the region.

2. LITERATURE REVIEW

2.1 Autoregressive Integrated Moving Average (ARIMA)

Model ARIMA consists of components, i.e : autoregressive (AR) and moving average (MA). Integrated (I) is the degree of differencing needed to achieve unchanging statistical properties which do not depend on the time (stationarity). With AR component in-hand, ARIMA model consists of "self-regression" performed on its lagged value of stationarized response y on period t . Moving average is defined by lags of forecast error on which forecasting is performed by AR component. Autoregressive integrated moving average model is also capable of modelling time-series data which pattern is affected by seasonal factors such as the time of the year or the day of the week (Hyndman & Athanasopoulos, 2018). Autoregressive integrated moving average model with seasonal model can be written as $ARIMA(p, d, q)(P, D, Q)[m]$. First in-bracketed p, d, q represents the non-seasonal components, while P , D, Q represents seasonal components P / p represents number of AR component in seasonal / non-seasonal part of model, D / d represents number of differencing needed in seasonal/non-seasonal components, while Q / q represents the number of MA components in the seasonal / non-seasonal part of the model. m represents the period of seasonality.

To amplify readability of model specification on AR, I and MA component, in a more compact form, an autoregressive integrated moving average model can also be written in backshift (B) notation. By applying B, means to shift the data one period (Eq.(2)). Two application of B,resulting in shifting the data two periods (Eq.(3)), while d -th order difference can be written as shown in Eq.(4) (Hyndman & Athanasopoulos, 2018).

$$By_t = y_{t-1} \quad (2)$$

$$B(By_t) = B^2 y_t = y_{t-2} \quad (3)$$

$$(1 - B)^d y_t \quad (4)$$

Putting all together, the general form of seasonal $ARIMA(p, d, q)(P, D, Q)[m]$ written in backshift notation is as shown in Eq.(5)

$$\psi_p(B)\Psi_P(B^m)(1 - B)^d(1 - B^m)^D y_t = \varphi_q(B)\Phi_Q(B^m)\varepsilon_t \quad (5)$$

With y_t is the nonstationary time series on time t , $\psi_p(B) = 1 - \psi_1 B - \psi_1 B^2 - ... - \psi_p B^p$ is a non-seasonal AR component. $\Psi_P(B^m) = 1 - \Psi_1 B^m - \Psi_1 B^{2m} - ... - \Psi_p B^{pm}$ is a seasonal AR component. $(1 - B)^d$ is differencing on non-seasonal part, while $(1 - B^m)^D$ is a differencing process on the seasonal part. $\varphi_q(B) = 1 + \varphi_1 B + \varphi_2 B^2 + ... + \varphi_q B^q$ is a non-seasonal MA component, while $\Phi_Q(B^m) = 1 + \Phi_1 B + \Phi_2 B^2 + ... + \Phi_3 B^q$ is a seasonal MA component, and ε_t is the error on forecast (from MA) on time t.

2.2 Artificial Neural Network (ANN)

The drawback of ARIMA modelling is that the data generating process is assumed to be linear. In reality, such a phenomenon rarely occurred. Therefore, a more robust, yet more data-driven modelling technique that is capable of capturing the non-linearity of data is needed.

Inspired by human-brain, ANN are able to learn the patterns exhibited by data, without any prior assumption required. The idea of forecasting data using ANN, dated back in 1964. Since then, many research has been conducted on forecasting using ANN, in parallel with research on improving the learning algorithm of ANN. One of the models of ANN is multilayer perceptron (MLP). An MLP consists of several layers of nodes, namely: the input layer, hidden layer, and output layer. In forecasting, the input layer of MLP maps the lagged data, thus this is equivalent to a nonlinear autoregressive model for time series forecasting problems (Zhang et al., 1998).

Training of networks occurs by gradually shifting the lagged data one step until all training data is completely trained into the networks.

In designing MLP for forecasting, forecasters must determine: 1) the number of input nodes, which lags are important in the training process; 2) the number of hidden layers and hidden nodes on each layer; 3) the number of output nodes (Zhang et al., 1998). One of many ways in determining input nodes is to consider lags from the autoregressive component from the ARIMA model (Lachtermacher & Fuller, 1995). Forecasters can employ grid search technique to determine the best number of hidden layers and hidden nodes (Gorr et al., 1994).

2.3 Hybrid Modelling for Forecasting

In this paper, a time series data can be considered of having a linear autocorrelation structure and a non-linear component (Zhang, 2003). As summarised from Hajirahimi & Khashei (2019), structure of hybridization technique can be divided into three, i.e : paralel, series and parallel-series. Parallel structure can further be divided based on its combination and weighting method. Series structure can be classified into the arrangement of models. In parallel structure, models are capturing the data separately, then combined using a weighting function to produce fitted value and forecast value. In series structure, the first model will do the modeling of the data, followed by the second model to model the residual from the first model. Adding fitted value from the first and second model will generate overall fitted value, while adding forecast value from first and second model will generate overall forecast value. Classification of hybridization technique is as shown on Figure 1. Readers are encouraged to refer to Hajirahimi & Khashei (2019), for details on structure, weighting function and combination.

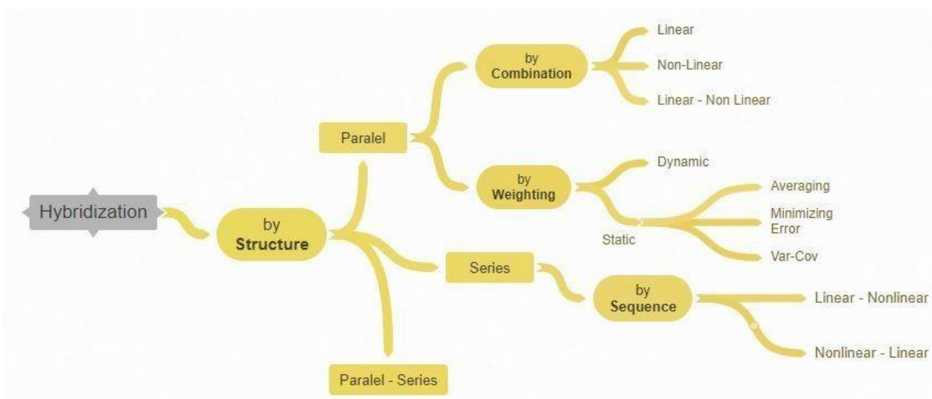

Figure 1. Classification of Hybridization Technique

2.4 Stationarity Test

In order to check whether time series follow stationarity assumption, a statistical test is required. One of the tests is the Augmented Dickey-Fuller (ADF) test. Null hypothesis (H_0) of the test is that time series contain unit-root, thus non-stationarity is assumed. Alternative hypothesis (H_1) of this test is that the time series is already stationary, thus no differencing is required.

3. METHODOLOGY

Methodology on finding the best model to forecast outflow of Rp.100.000 in Jakarta is as follows :

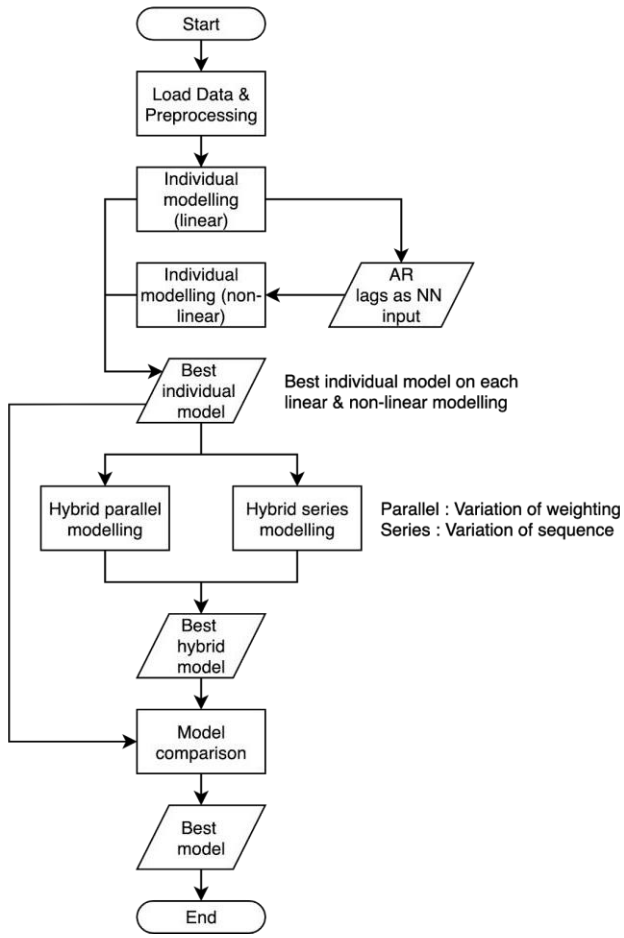

Figure 2. Research Methodology

3.1 Load Data & Preprocessing

Monthly outflow data, ranging from November 1999 to June 2019, is first loaded in R and stored into time-series compliant format. Preprocessing is performed to stationarize data (on both seasonal and non-seasonal part) and add exogenous regressor (dummy) such as : month, calendar variation due to Eid-ul Fitr and effect of Eid-ul Fitr on previous month (Dana, 2018; Prayoga et al., 2017). Data is then splitted into : training data and testing data, with ratio of 80:20 (Macek,2008).

3.2 Individual Modelling

Training data will be modeled using seasonal ARIMA (SARIMA) and seasonal ARIMAX (SARIMAX) technique. Value of p, d, q, P , D, Q is obtained by performing a search method as proposed by Hyndman & Khandakar (2008). In this phase, Corrected Akkaike Information Criterion (AICc) is used as a metric to compare between model parameters.

Statistically significant lags on AR component on each model, SARIMA and SARIMAX, will be used as input lags in non-linear modelling. Lags in AR component on SARIMA will be used in feed forward neural network (FFNN) and deep learning neural network (DLNN), while AR component in SARIMAX will be used in FFNNX and DLNNX modelling. Hidden layers are varied from 1-2 layers with 1-20 nodes each layer. Grid search is performed to obtain the best neural network topology by comparing out-of-sample RMSE for each topology setting.

In order to compare forecasting performance between model (i.e : SARIMA - SARIMAX, FFNN - FFNNX - DLNN - DLNNX or between individual model from different class), model that can forecast longer forecast horizon with out-of-sample Mean Average Precentage Error (MAPE) <10% is considered to be better than the other.

3.3 Hybrid Modelling

Best in-class model on each linear and non-linear model is then combined in this phase. Parallel modelling varies the weighting method, using : simple averaging (SA), genetic algorithm (GA) and ordinary least square (OLS) method, while series hybrid modelling varies the sequence, by : linear - nonlinear and nonlinear - linear modelling.

3.4 Model Comparison

Individual and hybrid models are compared by considering the length of forecast horizon with out-of-sample MAPE <10%.

4. RESULT & DISCUSSION

Time series decomposition plot of Rp.100.000 outflow data in Jakarta is displayed in Figure 3.

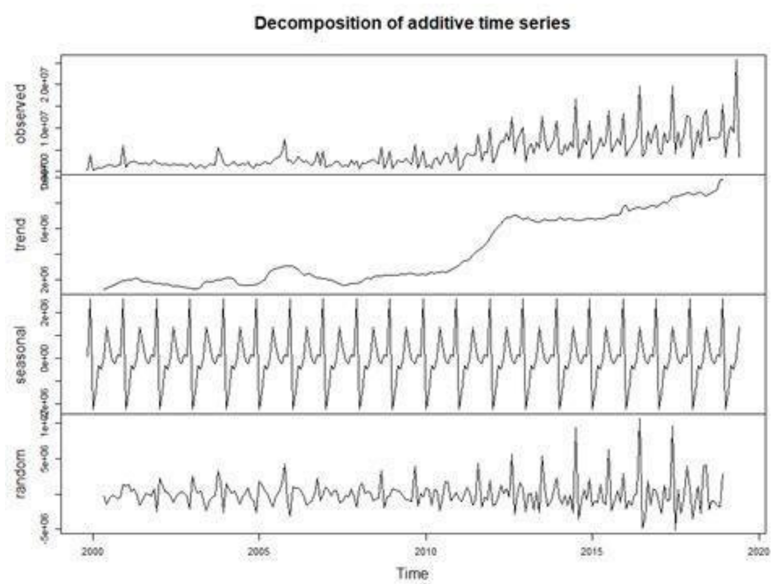

Figure 3. Decomposition Plot of Rp.100.000 Outflow Jakarta

As shown in Figure 3, outflow tends to increase from time to time. The notable increase is found from 2011-2013. The P-value of the ADF test is 0.219, therefore differencing is required to stationarize the data.

4.1 Individual Modelling

4.1.1 Linear Modelling

From the grid search performed to obtain number of AR, I and MA components, best ARIMA model is ARIMA(0,1,2)(1,1,1)[12], and ARIMAX model is ARIMAX (5,0,0)(0,0,2)[12]. Model specification of ARIMA and ARIMAX model is written in Eq(6) and Eq(7) respectively.

$$(1 - B - 1.539B^{12} + 1.539B^{13} + 0.539B^{24} - 0.539B^{25})y_t = (1 - 0.988B - 0.249B^2 + 0.828B^{12} - 0.818B^{13} - 0.206B^{14})\varepsilon_t \quad (6)$$

$$(1 - 264.79B - 1931.4B^2 - 1260.5B^3 - 1787.4B^4 - 1660.2B^5)y_t - 81884.34F_{1,t} + 1195614F_{2,t} + 2291506.1F_{3,t} + 4209254.9F_{4,t} + 3205822F_{1,t-1} + 950609.1F_{2,t-1} + 396555.7F_{3,t-1} + 1007187.4F_{4,t-1} - 3745039.1M_{1,t} - 2991971M_{2,t} - 2247295.2M_{3,t} - 1982587.5M_{4,t} - 2046407.1M_{5,t} - 2039776.5M_{6,t} - 973705.9M_{7,t} - 2212223.9M_{8,t} - 2482055.9M_{9,t} - 2085939M_{10,t} - 2560558.2M_{11,t} + 32400.6t = 2116851.7 + (1 + 4462.1B^{12} + 2414.3B^{24})\varepsilon_t \quad (7)$$

With $F_{w,t}$ is the dummy variable on explaining Eid-Ul Fitr, w denotes the week of month (w = 1, 2, 3, 4). $F_{w,t-1}$ denotes effect of outflow on previous month. $M_{m,t}$ denotes dummy variable of month of year, with m = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12. t denotes timestamp of data from 1 to 236 (length of time series). AR lags which composing ARIMA model are : 1,12,13,24, and 25, and lag 1,2,3,4,5 are what compose AR component in ARIMAX. Those lags is used as input node specification for non-linear modelling.

4.1.2 Non-Linear Modelling

By constructing MLP for autoregressive, best topology that yields highest accuracy for out-sample data, for each MLP combination is as shown in **Table 1**.

Table 1. Best Topology for each MLP Combination

MLP Combination	Topology (input node - layer 1 - layer 2 [if DLNN] - output node)
FFNN	5-2-1
FFNNX	25-11-1
DLNN	5-7-10-1
DLNNX	25-17-20-1

4.1.3 Best In-Class Model

Each model will be forecasting data for 1-24 steps ahead. Model that can forecast accurately (MAPE <10%), with the longest forecast horizon is considered to be the best model. Figure 4 shows the comparison of MAPE for each model combination

From Figure 4, ARIMA is considered to be the best model in linear modelling and overall individual modelling. This model is able to forecast accurately with a maximum forecast horizon of 10 steps ahead. Non-linear modelling DLNN is considered to be the best model in non-linear modelling category. This model is able to forecast 9 step ahead with high accuracy. These model specification is then combined in hybrid modeling.

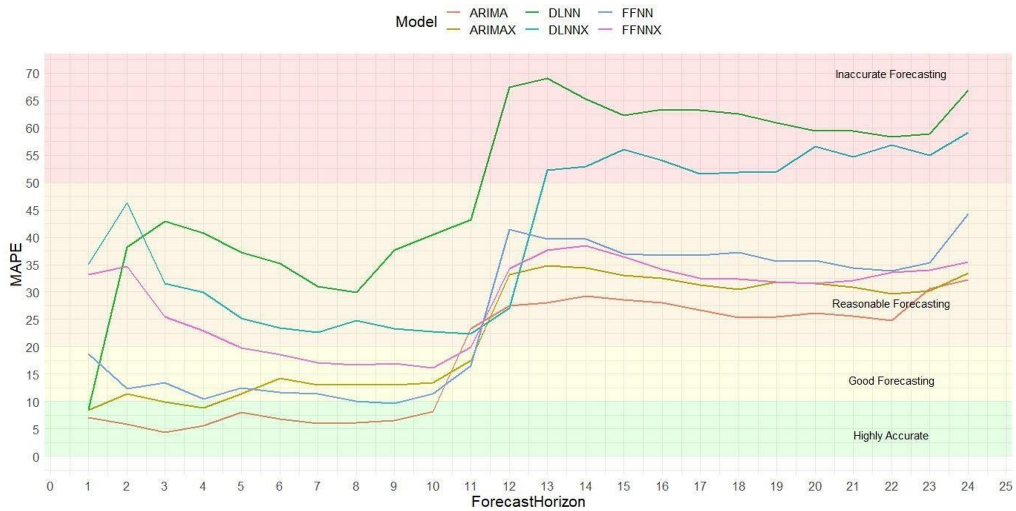

Figure 4. MAPE Comparison for each individual model

4.2 Hybrid Modelling

4.2.1 Parallel Hybrid Modelling

In this phase, model candidates from individual modelling are combined in parallel structure by varying the weighting function, i.e : 1) simple averaging, both models are weighted equally 0.5; 2) genetic algorithm, weight for each models are optimized using genetic algorithm (may vary on each run, therefore it requires to set number used to generate a sequence of random numbers); and 3) ordinary least square, fitted value from each model is used as predictors and in-sample data as response. Each model is tested to forecast 1-24 steps ahead data. Mean Average Percentage Error (MAPE) for different forecast horizon length is as shown on **Figure 5.**

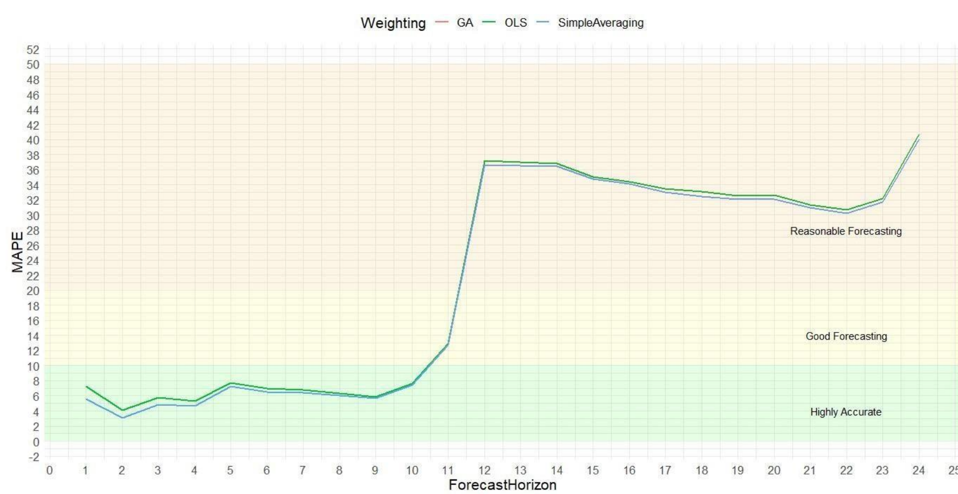

Figure 5. MAPE Comparison for each weighting method

From Figure 5, the best weighting function for ARIMA and FFNN is using simple averaging, thus weighting for each model is equal to 0.5. Note that there's no significant difference in accuracy performance between genetic algorithm and ordinary least square method.

4.2.2 Series Hybrid Modelling

Two best models from individual modelling are combined into series structure, by varying sequence, i.e : 1) ARIMA - FFNN; 2) FFNN - ARIMA. The result is shown in **Figure 6.**

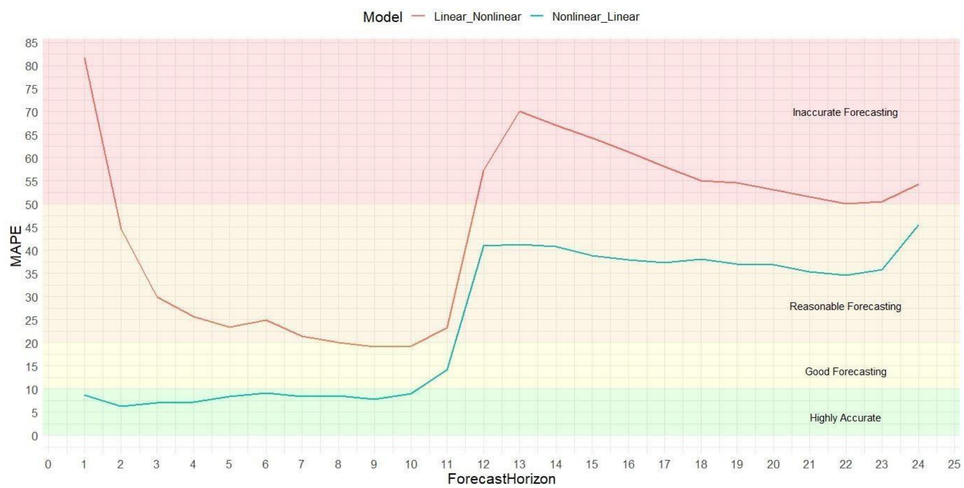

Figure 6. MAPE Comparison for each sequence

From Figure 6, the best sequence in series structure that yields best forecasting accuracy, is achieved by sequencing FFNN as first model and ARIMA as second model.

4.2.3 Final Model Selection

From the experiment conducted, comparison of MAPE between individual and hybrid models are shown in Figure 7.

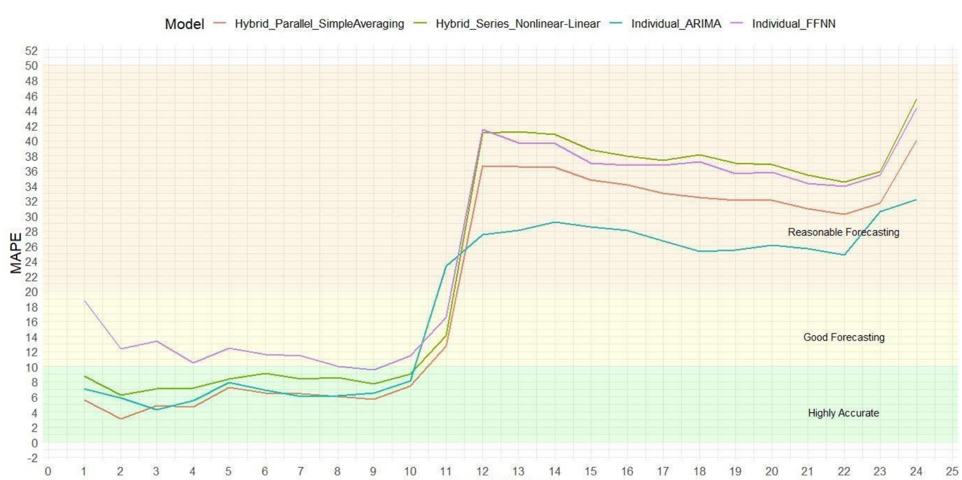

Figure 7. MAPE Comparison for overall model combination

From Figure 7, it is shown that hybrid modelling in parallel structure outperforms hybrid modelling series structure and individual models. Hybrid modelling in parallel structure has a MAPE score of 7.40% for forecast horizon up to 10 steps ahead. With the same forecast horizon length, MAPE score for hybrid modelling series structure is 9.02%, for ARIMA is 8.13% and 11.39% for FFNN. This gives the conclusion that the best model to forecast outflow of denomination Rp.100.000 in Jakarta region is ARIMA(0,1,2)(1,1,1)[12] and FFNN(5-2-1). Weighting for each model is equal to 0.5.

5. CONCLUSION

As a basis for government and policy-makers to plan banknotes to distribute to public, especially for fast-moving banknotes such as Rp.100.000 and in a region where economic largely expanding such as Jakarta --thus availability of cash in the region must be maintained well; to ensure continuity of transaction--, forecasting of outflow is required along with consideration of other factors. Forecasting using individual models tends to yield lower accuracy, therefore hybridization is needed. In forecasting outflow of Rp.100.000 denomination, from the research conducted, ARIMA(0,1,2)(1,1,1)[12] and FFNN(5-2-1) in parallel structure with each weight of 0.5, is considered the best forecasting specification model. Calendar variation doesn't influence the model, and the outflow tends to increase over time. Next step to do for the government and policy-makers is to create a dashboard using the model to get an outlook of outflow on Rp100.000 denomination.

6. REFERENCES

Dana, I. M. G. M. D. (2018). MODEL HYBRID GSTARX-ANN UNTUK PERAMALAN DATA SPACE-TIME DENGAN EFEK VARIASI KALENDER (Studi Kasus: Data Inflow dan Outflow Uang Kartal di Bank Indonesia Wilayah Jawa Timur). Institut Teknologi Sepuluh Nopember Surabaya.

Gorr, W. L., Nagin, D., & Szczypula, J. (1994). Comparative study of artificial neural network and statistical models for predicting student grade point averages. International Journal of Forecasting, 10(1), 17–34. https://doi.org/10.1016/0169-2070(94)90046-9

Hajirahimi, Z., & Khashei, M. (2019). Hybrid structures in time series modeling and forecasting: A review. Engineering Applications of Artificial Intelligence, 86, 83–106. https://doi.org/10.1016/j.engappai.2019.08.018 Hyndman, R. J., & Khandakar, Y. (2008). Automatic Time Series Forecasting: The forecast Package for R. Journal of Statistical Software, 27(3). https://doi.org/10.18637/jss.v027.i03

Lachtermacher, G., & Fuller, J. D. (1995). Back propagation in time-series forecasting. Journal of Forecasting, 14(4), 381–393. https://doi.org/10.1002/for.3980140405

Macek, K. (2008). The Pareto Principle in Datamining: An Above-Average Fencing Algorithm. Acta Polytechnica, 48(6), 5.

Prawoto, N. (2010). Money Demand: A Study On The Indonesian Influential Factors. Economic Journal of Emerging Markets, 2(3), 223–236.

Prayoga, I. G. S. A., Suhartono, & Rahayu, S. P. (2017). Forecasting currency circulation data of Bank Indonesia by using hybrid ARIMAX-ANN model. AIP Conference Proceedings, 1842(1). https://doi.org/10.1063/1.4982867

Sigalingging, H., Setiawan, E., & Sihaloho, H. D. (2004). Kebijakan Pengedaran Uang Di Indonesia. Pusat Pendidikan dan Studi Kebanksentralan (PPSK) BI.

Yulianti, M. M. F., Nurcahyo, R., & Farizal. (2019). Cash and Non-Cash Payment Data Analysis in Indonesia. 2019 IEEE 6th International Conference on Engineering Technologies and Applied Sciences (ICETAS), 1–5. https://doi.org/10.1109/ICETAS48360.2019.9117219

Zhang, G. P. (2003). Time series forecasting using a hybrid ARIMA and neural network model. Neurocomputing, 50, 159–175. https://doi.org/10.1016/S0925-2312(01)00702-0

Zhang, G. P., Eddy Patuwo, B., & Y. Hu, M. (1998). Forecasting with artificial neural networks: International Journalof Forecasting, 14(1), 35–62. https://doi.org/10.1016/S0169-2070(97)00044-7

CASH CONVERSION CYCLE (CCC) MEASURING ON STATE-OWNED ENTERPRISE (SOE) GROUP OF SURVEY SERVICES AND ITS EFFECT ON COMPANY PROFITABILITY

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ABSTRACT

Cash Conversion Cycle (CCC) is one of the tools used to measure Working Capital Management. Companies with shorter CCC time lag are considered to be more efficient due to more sales and profit from the working capital used. Conversely, the longer the CCC period, the greater the working capital needed by the company. The availability of sufficient working capital enables a company to carry out its activities and ease the companies to handle difficulties or obstacles in its implementation. However, excessive working capital could indicate unproductive funds, and this would result in losses since the available funds are not used effectively for company activities. On the contrary, the lack of working capital is the main cause of the company's failure in carrying out its activities. The purpose of this study is to determine the effect of accounts receivable and accounts payable on profitability in State-Owned Enterprise (SOE) group of survey services. This study uses a quantitative approach with explanatory research methods. The data used in this study is secondary data, in the form of financial reports sourced from the company's website. Sampling was carried out using a non-probability sampling technique with a purposive sampling method so that it was assigned to the SOE group of survey services. The data analysis used is multiple linear regression, classical assumption test, and descriptive statistics. The result of this research explains/shows that CCC has a significant positive effect and the Days Payable Outstanding (DPO) has a significant negative effect on profitability. Days Sales Outstanding (DSO) does not have a significant effect on profitability. One of the reason for this phenomenon is that the service industry is not similar with the manufacturing industry.

Keywords: Cash Conversion Cycle, Days Sales Outstanding, Days Payable Outstanding, Profitability.

1. INTRODUCTION

Every company must be able to manage working capital effectively in order to ensure the availability of sufficient cash flow for the company to pay short-term debts that are due time and also finance the company's operational activities. Chang (2017) said that working capital management has a close relationship with company performance. One of the tools that can be used to measure working capital management is the Cash Conversion Cycle (CCC). Companies which have a shorter CCC time lag are considered more efficient because they could generate more sales and profits from the working capital used. Conversely, if the company has a longer CCC time lag, it means that the working capital owned by the company is insufficient.

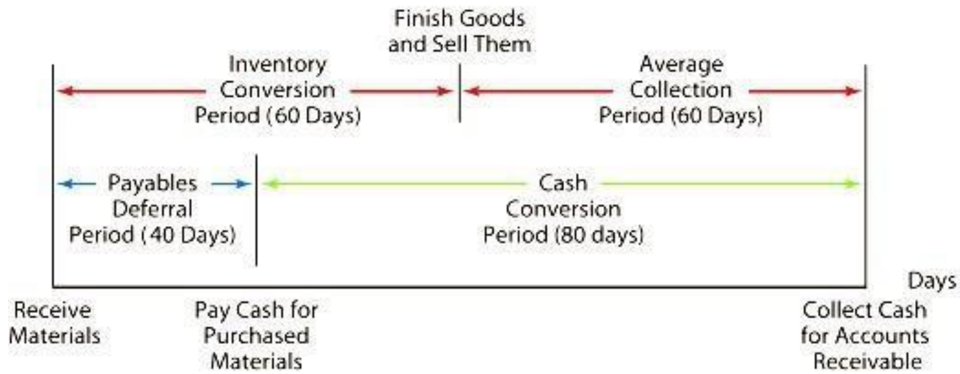

Figure 1. Cash Conversion Cycle Illustration

The ideal liquidity ratio of each company varies; it depends on the type of business. If the liquidity owned by the company is lacking, it will be considered less good because the amount of current assets is insufficient to cover its short-term liabilities. This creates an illiquid condition. However, if the current assets owned by the company are too large, it will create idle funds and would affect the company's operational activities. Therefore, a good working capital management is needed so that the company's activity processes run smoothly and are able to achieve the expected benefits.

The subject in this research/study were State-Owned Enterprise (SOE) group of survey services. Recently, SOE group of survey services have experienced cash flow changes due to non-current collection of account receivables or a long period of time for collection, thus causing retention of cash receipts on sales / receivables. Accounts receivable turnover period will show the effectiveness of working capital embedded in receivables. Therefore, SOE group of survey services also need to take CCC measurements to evaluate the company's performance in managing working capital. The main components of CCC measurement and this research/study are the period of collection of accounts receivable and period of payment of debts.

Working Capital is the amount of money that companies have to run their daily operational activities. Management Working capital is defined as a measure of available liquidity assets to meet contingencies and uncertainties around the company's cash balances and outflows Sugathadasa (2018). According to Gitman (2012) Cash Conversion Cycle is the time required by a company to convert cash invested in its operations into cash receipts as a result of its business activities. The main components in CCC are:

1. Inventory Conversion Period (ICP).
   The purpose of inventory management is to manage inventory turnover as quickly as possible without risking a shortage of inventory which will lead to lost sales Gitman (2012).
2. Account Receivable Conversion Period (RCP).
   Account receivables are receivables that arise as a result of a sale on credit/installment. Companies must be able to collect receivables as quickly as possible. And to find out how effective a company is in collecting its receivables, you can use the average collection period. The average collection period is the time period required to convert the company's receivables into cash, which is the period from the sale to the collection realization. The average collection period represents the average number of days it takes a company to collect payments from customers Gitman (2012).

3. Payable Conversion Period (PCP).
   Payable Conversion Period (PCP). Account payable debts that arise because companies buy raw materials on credit/installment Gitman (2012). Brigham and Houston (2009) stated that profitability is used to measure a company in generating profits. Profitability provides information about how a company operates and is a necessary tool for growth and maintaining the survival of the company. In this research/ study, the measurement of profitability ratios uses Net Profit Margin (NPM).

The NPM ratio refers to the ability of sales to generate gross profit. High ratio refers to high selling prices and low production costs. A high selling price refers to a company's products that have a competitive advantage. If a product has a competitive advantage in either cost or quality, then this will help the company to increase profitability Robinson et al (2015).

2. METHOD

This research uses a quantitative approach. This research is included in the type of explanatory research, which implies that changes in one variable cause or lead to changes in other variables. In this study, the sampling used a non-probability sampling method with purposive sampling technique. The data analysis technique in this study used multiple linear regression analysis.

The process/stage of this research is carried out in several stages ranging from the identification problem to conclusions and suggestions. The following are detailed stages that will be implemented, among others:

1. Conducting the identification process to the problems faced today by SOE group of survey services related to financial problems.
2. After the problem identification process is completed, the researchers make some research questions and research objectives as the basis in the development of research models and research methods.
3. Explore or study theories relevant to research questions and collect previous research journals as a reference in creating research models.
4. Designing the right research method in order to answer research questions, in this stage including determining research samples, observation periods/ years, types and data sources to be used, variable measurement, and statistical data/model analysis to be used.
5. Furthermore, data collection and data recapitulation in accordance with the provisions set out in the research method section.
6. After the data is collected, and measured according to the operational definition of variables, then a pre-repression test is carried out in this case a classic assumption test as the basis for seeing if the research data is qualified for regression test or hypothesis test.
7. Conduct multiple linear regression tests to prove each hypothesis that has been proposed in the conceptual framework.
8. Analyze data and conduct discussions related to theoretical and managerial implications.
9. Draw conclusions and make suggestions for the company and future research.

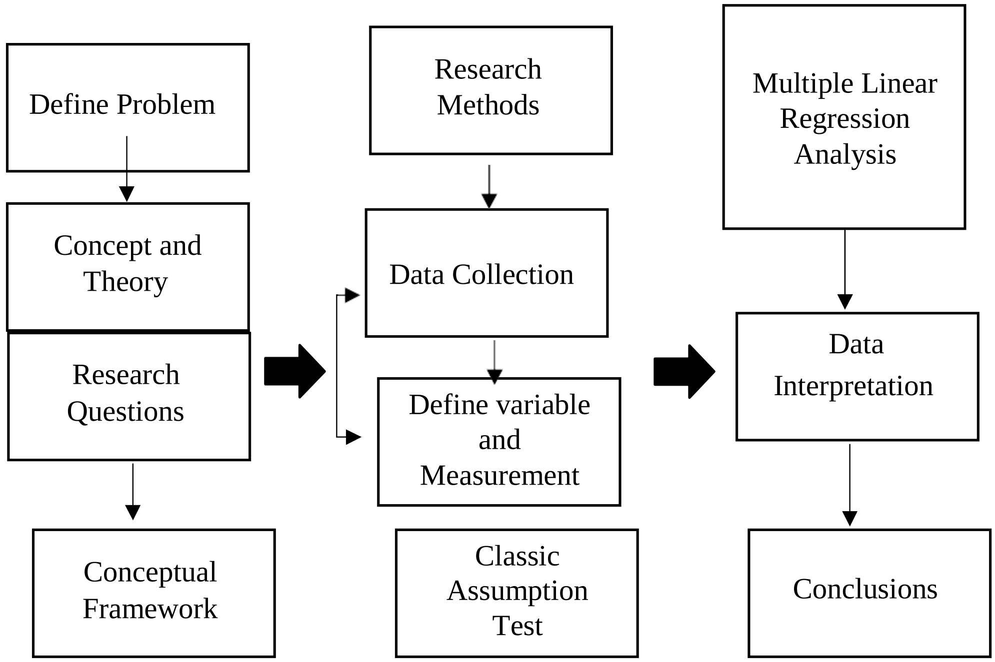

Figure 2. Research Stages

3. RESULT AND DISCUSSION

As a result, based on data compiled, it is discovered that the average value of the turnover rate of accounts receivable from SOE group of survey services in Indonesia for the period 2009 to 2019 is 82 days. This shows that the performance of the accounts receivable collection has not been maximally applied in SOE group of survey services. While the average value of the debt turnover rate of the SOE group of survey services in Indonesia for the period 2009 to 2019 is 18 days. In other words that the performance of SOE group of survey services is getting better because they can delay payment of debt longer, and these funds can be used for other more priority costs.

In addition, the average cash conversion cycle (CCC) value of the SOE group of survey services in Indonesia for the period 2009 to 2019 is 63 days. Judging from the average CCC value per year, the cash turnover rate has fluctuated, it shows that the performance of the accounts receivable collection and operations division has not been maximally applied in SOE group of survey services.

The results of regression testing shows:

1. Variable rate of Days Sales Outstanding (DSO) turnover obtained a beta value of 0.000 with a t-statistic value of 1.443 <t-table value of 2.045 (df = 33; alpha = 0.05) and a significant value of 0.159> 0.05. Thus, it can be concluded that the rate of DSO turnover does not have a significant effect on profitability (NPM) in SOE group of survey services in Indonesia.
2. Days Payable Outstanding (DPO) turnover rate obtained a beta value of -0.001 with a t-statistic value of -2.188> a t-table value of 2.045 (df = 33; alpha = 0.05) and a significant value of 0.036 <0.05. It can be concluded that the level of DPO turnover has a significant effect on profitability (NPM) in SOE group of survey services in Indonesia.
3. Cash Conversion Cycle variable (CCC) obtained a beta value of 0.001 with a t-statistic value of 2.573> a t-table value of 2.045 (df = 33; alpha =0.05) and a significant value of 0.015 <0.05.

Thus it can be concluded that the cash conversion cycle (CCC) has a significant effect on profitability (NPM) at the SOE group of survey services in Indonesia.

The results of the determinant coefficient test can be explained as follows:

1. Variable rate of receivable turnover (DSO) to profitability (NPM) obtained R-Square value of 0.063 or 6.30%.
2. Variable debt turnover rate (DPO) to profitability (NPM) obtained R-Square value of 0.134 or 13.4%.
3. Variable cash conversion cycle (CCC) to profitability (NPM) obtained R-Square value of 0.176 or 17.6%.

Effect of Receivable Turnover Rate (DSO) on Profitability (NPM):

The first hypothesis indicates that the turnover rate of receivables (DSO) affects profitability (NPM). Based on the test results showed that the hypothesis was rejected. This is because based on partial testing (t-test) obtained a beta value of 0.000 with a statistical t-value of 1,443 < a t-table value of 2,045 (df=33; alpha=0.05) and a significant value of 0.159 > 0.05. Thus, it is concluded that the level of receivable turnover (DSO) has no significant effect on profitability (NPM) in SOE group of survey services in Indonesia.

Effect of Debt Turnover Rate (DPO) on Profitability (NPM):

The second hypothesis suggests that the level of debt turnover (DPO) affects profitability (NPM). Based on the test results showed that the hypothesis was accepted. This is because based on partial testing (t-test) obtained a beta value of -0.001 with a statistical t-value of -2.188 > t-table value of 2.045 (df=33; alpha=0.05) and a significant value of 0.036 < 0.05. Thus it is concluded that the level of debt turnover (DPO) has a significant effect on profitability (NPM) in SOE group of survey services in Indonesia.

Effect of Cash Conversion Cycle (CCC) on Profitability (NPM):

The third hypothesis suggests that the cash conversion cycle (CCC) affects profitability (NPM). Based on the test results showed that the hypothesis was accepted. This is because based on partial testing (t-test) obtained a beta value of 0.001 with a statistical t-value of 2,573 > a t-table value of 2,045 (df=33; alpha=0.05) and a significant value of 0.015 < 0.05. Thus it is concluded that the cash conversion cycle (CCC) has a significant effect on profitability (NPM) in SOE group of survey services in. he company's profitability.

Cash conversion cycle or CCC is a powerful measuring tool to measure how well the company manages its working capital (Nobanee et al. 2011), working capital management is an important part of financial management decisions in all companies including Survey service companies. The company's ability to operate in the long term depends on the proper trade-off between long-term and short-term investment management (working capital). The Company can achieve optimal working capital management by forming a trade-off between profitability and liquidity.

The results of this study showed a positive relationship between Cash Conversion Cycle and the profitability of the company. Positive results indicate the longer the cash conversion cycle, the profitability will increase. This may be due to several things. Characteristics of Survey service companies, namely the sale of service products that take a long time to complete their work in every single sales transaction. Where for the life of receivables survey service companies are generally much longer compared to manufacturing products or telecommunications services. This is what makes Survey service companies have a longer CCC rate and have a positive impact on the profitability of the company.

4. CONCLUSIONS

The conclusions of this study/ research are:

1. Accounts receivable turnover (DSO) does not have a significant effect on profitability at SOE group of survey services.
2. The level of debt turnover (DPO) has a negative and significant effect on the profitability of SOE group of survey services.
3. The cash conversion cycle (CCC) has a positive and significant effect on profitability in SOE group of survey services.

Based on the results and conclusions from this research/ study, researcher suggest to the companies to accelerate the outstanding debt, because the delay of the outstanding debts payment would give negative perception of the creditors and would give negative impacts on the company's profitability performance as well. It is also suggested the companies should also accelerate the accounts receivable turnover rate so that the company will be able to be more productive to increase profitability. The most important thing that companies should do is to tighten policies regarding receivable accounts. It has to be done to fasten the working capital turnover period.

For further research, researcher recommends choosing state-owned companies with wider scope service sectors such as construction services. In addition, further research could add more variables that have the same effect or are still unknown, for instance, company size and cash turnover, so that it will result more model variations. The researcher hopes that the next research will result a longer period in order to make it more accurate.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Brigham, Eugene F., Houston, Joel F., (2009). *Fundamental of Financial Management*, 12th Edition, Cengage Learning.

Chang, Chong Chuo. (2017). Cash Conversion Cycle and Corporate Performance: Global Evidence, *International Review of Economics and Finance*.

Gitman, Lawrance., (2012). *Principle of Managerial Finance*, 12th Edition, Prentice Hall.

Nobanee, H., Abdullatif, M., Al Hajjar, M., (2011). Cash conversion cycle and firm's performance of Japanese firms. *Asian Review of Accounting*, 19 (2), 147-156.

Robinson, T., Henry, E., Pirie, W., Broihahn, M. (2015). *International Financial Statement Analysis,* 3rd Edition, John Wiley, New Jersey.

Sugathadasa, D. D. K. (2018). The Relationship between Cash Conversion Cycle and Firm Profitability: Special Reference to Manufacturing Companies in Colombo Stock Exchange, *Journal of Economics and Finance*, Vol. 9, No. (6), 38–47.

MARGINAL GAS WELL FOR NATIONAL ENERGY RESISTANCE: MONETIZATION PROSPECT AND CHALLENGES

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ABSTRACT

Indonesia's natural gas reserves currently reach five times Indonesia's petroleum reserves. Marginal gas wells that are quite widely spread in the island of Sumatra, Java and Kalimantan from the many marginal gas wells are still widely untapped to the maximum this is because in its development required a considerable investment cost. Monetization and utilization of natural gas is one of the key drivers of the economy, both for the industrial sector and households. CNG offers opportunities because it is effective for short-haul transportation. PT. X in this case national private companies engaged in EPC and investment get the opportunity to explore investment opportunities for the construction of CNG *Mother Station* capacity of 3.5 MMSCFD with build, operate and owned (BOO) scheme for 10 years offered by PT. Pertamina Gas. In these conditions, a comprehensive technical and financial review is needed to determine whether or not this investment is feasible. This research uses quantitative case study research analysis to evaluate the investment plan of CNG Mother Station development in Central Java. The results showed that with a loan ratio of 70% and equity of 30% The result obtained from financial modeling is *Net Present Value* (NPV) is $ 3,184,715.32, the Period of Return (PP) in 2.6 years and the *Internal Rate of Return* (IRR) is 33.12%. Based on sensitivity analysis on the decrease in capacitors and the selling price of CNG ± 10%, the IRR value is still above the interest of 12% and the NPV value > 0

Keywords: Capital Structure, Monetization, Natural Gas, CNG Mother Station.

1. INTRODUCTION

Natural gas is often also referred to as Natural gas or swamp gas, is a fossil fuel in the form of gas consisting mainly of CH4 methane. Indonesia's natural gas reserves currently reach five times Indonesia's petroleum reserves, (Director General of Oil and Gas, 2014). Marginal gas wells that are quite widely spread in the island of Sumatra, Java and Kalimantan from the many marginal gas wells are still widely untapped to the maximum this is because in its development required a considerable investment cost. CNG *Compressed Natural Gas* is an alternative fuel other than gasoline or diesel. In Indonesia, CNG is known as BBG (gas fuel). This fuel is considered cleaner when compared to oil fuel because of its environmentally friendly exhaust emissions. CNG is made by performing methane compression (CH4) extracted from natural gas.

The current energy system is heavily dependent on fossil fuels, with coal, oil and gas occupying about 80% of the world's main energy demand (Bhattacharyya, 2012). Fossil energy are still the most important energy source in the world (Gunarta and Hervianto, 2017). The dominance of oil, coal and gas occurs in asia pacific including Indonesia which still relies on these resources (Gunarta and Putri, 2017).

Utilization of natural gas is one of the key drivers of the economy, both for the industrial sector and households. In addition to being an efficient and environmentally friendly source of energy, domestic natural gas production is abundant. No wonder, energy from natural gas is increasingly in demand. This dependence clearly encourages gasification as a way of increasing fuel diversification and supply security, as well as reducing exposure to high oil product prices. His rationale for gasification becomes stronger if the gas is supplied by marginal gas fields. This is also in line with the Indonesian government's program to encourage the utilization of natural gas at the mouth of gas wells than to move them to other locations (Permen ESDM No. 45/2017). And in order to optimize the production of Petroleum in a working area in which there is an Old Well and to improve the welfare of the community around the old well site, it is necessary to do petroleum mining in the old well by including the participation of the surrounding community. (Permen ESDM No.1/2008).

PT. X in this case national private companies engaged in EPC and investment get the opportunity to explore investment opportunities for CNG *Mother Station* development with *Build, Operate and Owned* (BOO) scheme offered by PT. Pertamina Gas thats manages marginal gas wells in Central Java. From the information above, a study is needed that can provide inputs and solutions for the company in terms of determining how much the investment cost needs and socializing the *feasibility of building the Compressed Natural Gas* (CNG) production facility by utilizing these marginal gas wells.

2. DEFINITION AND TERMINOLOGY

Natural gas (*Natural gas)* is a gas obtained from underground natural reservoirs both as free gas and together with crude oil. Natural gas is a major resource for global energy supply and raw materials for the production of essential base materials and can be monetized or utilized through many alternative routes (Al-Mohannadi et al., 2017). This gas has a composition of carbon and hydrogen nuclei with varied atomic bonds that are generally in the form of methane (CH4) and other hydrocarbons with small amounts. These gases generally contain impurities (substances that cause impureness) such as H2S, N2 and CO2. According to Soemardan et al. (2013) Natural gas can be measured in a variety of ways, as it can be measured through volume at normal temperatures and pressures, expressed in cubic feet (CF), commonly used in thousands of cubic feet (MCF), millions of cubic feet (MMCF) or trillion cubic feet (TCF). Natural gas is also often measured and asked in the British Thermal Unit (BTU).

Alternative gas monetization such as CNG, LNG, GTL (gas to liquid) and GTW (gas to wire) are used to address the challenges of natural gas transportation. Of these, lng and CNG use is dominant (Khalilpour and Karimi, 2012). The first world-scale LNG project resulted in lng sales from Indonesia to Japan in the 1970s. The LNG project is characterized by a high level of government involvement and long-term gas receipt contracts based on sales and purchase agreements specific to specific buyers (Griffin, 2006). On the other hand, the CNG utilization process consists of three different stages: compression, transportation and decompression of natural gas. At the compression stage, natural gas is cooled to a lower temperature, which makes it easier to compress. At the stage of transportation, natural gas is transported using specially designed containers, which are stacked vertically or horizontally. Finally, at the decompression stage, natural gas is heated to the desired temperature and compressed gas is released into the delivery terminal.

Several utilization options, and uncertainty in energy prices make the planning decisions of upstream natural gas investors a complex problem. Various thermodynamic scenarios for the compression and cooling of gas fuels and studies their impact on the economies of the entire value chain (Deshpande and Economides, 2005). As well as the transportation of natural gas in the form of LNG, the transportation of natural gas in the form of CNG also requires shipping and receiving facilities. Until now, CNG transport was carried out using only trailers. The process of natural gas transportation in the form of CNG requires 3 types of facilities, namely delivery facilities *(mother station),* transportation facilities and reception facilities (*daughter station).* (Ministry of Energy and Mineral Resources, 2020).

Figure 2.1 *CNG Mother Station* Jakabaring (Gas and Fuel Division of PT. PLN Persero, 2013)

Gas coming from gas wells will be processed first at the gathering station. The gas with agreed specifications is then distributed through pipes from the gathering station (PLNGG, 2019). In general, the Main Process of CNG *Mother Station* can be seen in **Figure 2.2**

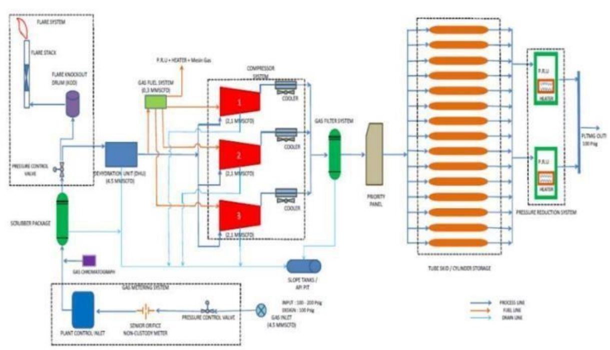

Figure 2.2 Process Flow Diagram Main Process *CNG Mother Station* (Source: PT. PLN Gas & Geothermal)

2.1 Capital

Capital is an important factor for the company to carry out its operational activities, business development and investment. According to Munawir (2004) capital is a right or part owned by the owner of the company indicated in the capital post (share capital), surplus and retained profit, or excess value of assets owned by the company against all its debts. Basically, the sense of capital is everything owned and controlled by the company, be it money or goods.

2.2 Capital Structure

Capital structure is *a* long-term comparison or balance indicated by the comparison of long-term debt to own capital (Martono, 2008). Capital structure (*capital structure)* related to the determination of the mix long-term expenditure of the company. Capital structures are part of the financial structure. Financial structure is a combination or mix of all posts included in the right side of the company's balance sheet, while the capital structure is a mix of all long-term spending sources used by the company (Warsono, 2003). Based on this opinion, the capital structure is basically a permanent expenditure in which it reflects the balance between long-term debt and own capital.

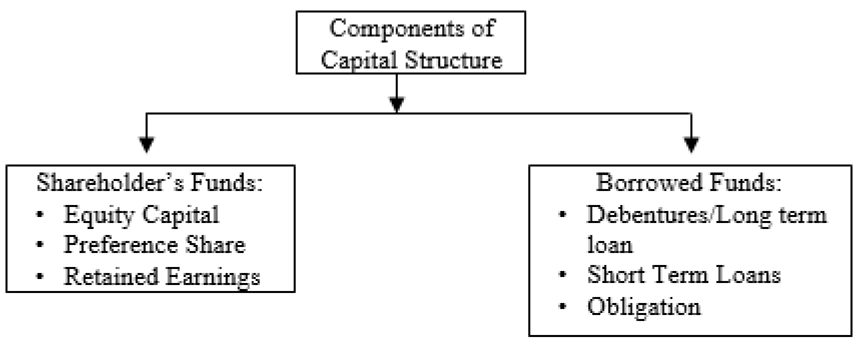

Figure 2.3 Components of the Capital Structure

In **Figure 2.3** it can be seen that in theory, the capital structure is a composition of funds sources that generally consist of own funds and loans in the form of ordinary and preferred shares, profit balances, long-term debt, short-term debt and bonds. In determining the capital structure, the company must involve many parties, both internal and external.

In general, capital expenditure (CAPEX) for mother station facility construction projects and CNG regasification consists of equipment, materials, prefabricated, construction, project design and management, insurance and certification and contingency costs. Typical capex cost distribution can be seen in **Table 2.1**

Table 2.1: Distribution of CAPEX components

CAPEX Components	%
Equipment	33%
Material	16%
Prefabrication	2%
Construction	14%
Design and Project Management	14%

CAPEX Components	%
Insurance and Certification	1%
Contingency	20%
Total	**100%**

Source: Chimale, 2009

2.3 Feasibility Analysis

Feasibility analysis in this research is very important and must be done in the development of new businesses or businesses including the utilization of these marginal gas wells. In this research required theories that support the research process. This is done to see if an investment is financially profitable or detrimental to the company. Feasibility analysis is the determining factor for investors to invest their business capital for the company

To assess the feasibility of investment proposals, an indicator is needed that can bridge the difference between the value of future investment money and the current one called the Profitability Indicator, using the technical economic method.

2.4 Economic Feasibility Analysis Methods

The data analysis method used to determine the economic feasibility of residual gas utilization is through an approach analysis:

1. *Net Present Value* (NPV),
2. *Internal Rate of Return* (IRR),
3. *Pay Back Period* (PBP),

In the method of economic feasibility analysis of investment, of course, must pay attention to the following factors explanation of the approach taken.

1. NPV *(Net Present Value) method,* where the investment feasibility requirement if NPV > 0
2. IRR *(internal Rate of Return) method or* interest rate that provides NPV = 0 with eligibility conditions when IRR > the most attractive loan interest rate.
3. *Pay Back Period Method*, with the condition that the sooner the capital returns the better

2.5 Time Value of Money

Time value of money is a thought based on the understanding that the value of money does not have the same value certainty in the future. This is due to inflation, namely the decreasing purchasing power of money. In doing the comparison should be used value for money at the same time. Pujawan (2012) suggested to do the equivalence of the value of money must be known about the amount of money borrowed or invested, the period of investment or borrowing time, and the interest rate charged.

3. RESEARCH METHODOLOGY

3.1 Investment Variables Analysis

Investment variables need to be estimated or calculated first before conducting analysis or other analysis. Variable in investment concerns initial investment costs, operational costs, Income, Investment Period, Interest rate, and Terminal value.

3.2 Analysis of Revenue

In the analysis of alternative income, income is released by calculating the selling price of gas per MMBTU per year during the investment period of 10 years.

3.3 Investment Feasibility Analysis

Investment variables are analyzed and then the variable variables are assessed feasibility, to determine the feasibility of the project. There are several methods used in analyzing investment feasibility, among others:

1. Net Present Value (NPV) is an analysis of the difference between receipts and expenses that have been multiplied by the discount rate or presented. By knowing the value of the NPV, we can determine the feasibility of the project, if the NPV value is greater than zero, then this project is worth doing and vice versa if the NPV is less than zero, then this project is not worth doing.
2. Internal Rate of Return (IRR), in this analysis if the interest rate is greater than the specified interest rate, then the investment is profitable or not. The IRR value should also not be less than the Minimum Rate of Return, if the IRR value is less than MARR then the investment becomes unworthy.

3.4. Sensitivity Analysis

Sensitivity analysis is performed on the cash flow of each alternative income system. Sensitivity analysis is obtained from the assessment of changes in investment variables such as changes in sales value and Plant capacity assumed changes occurred 10%. After that, a simulation of NPV and IRR investment variable's calculation is carried out to find out the extent of the change in the value of both.

4. DATA COLLECTION AND PROCESSING

In this chapter will be explained about the objects discussed in this research, calculation of investment costs, preparation of financial models, optimization modeling of capital structure and optimization results.

4.1 Research Locations

This research was conducted in a national private company engaged in EPC and Investment that will conduct business development in the construction, operation and maintenance of CNG Mother Station and its supporting facilities in Blora Regency, Central Java Province in one of the working areas of state-owned Oil and Gas companies. Cooperation scheme offered *Build, Operate and Owned* (BOO) scheme with *throughput fee* per MMBTU for 10 years starting from the completion of the construction period. The land provided by the employer for the construction of CNG *Mother Station* covers an area of ± 1.2 ha with an operating capacity of 3.5 MMSCFD.

4.2 CNG *Mother Station Investment Plan*

The large amount of gas content in Indonesia and the increasing domestic needs, especially the use of CNG in Indonesia, has encouraged people to use CNG as an alternative to cheap and environmentally friendly energy. This of course creates opportunities for companies that produce gas products where the research object wants to utilize marginal gas wells that are processed into *Compressed Natural Gas* (CNG) products. With the utilization of marginal gas wells, it is expected to also help contribute to the government in meeting domestic needs, especially fuels derived from natural gas.

The technology that will be developed here is the construction of *a* new CNG Mother Station to compress the gas into CNG products. *Mother Station* capacity to be made here ranges from 3.5 MMSCFD to process gas from marginal gas fields that still have economic content.

4.3 CNG *Mother Station Investment Cost Planning*

Natural development of *CNG* Mother *Station* is needed a large fund to be able to utilize gas from marginal wells as fuel that can be of economic value. Information about the cost of each component is needed to be able to conduct economic analysis on plant *development* into valuable gas. From knowing the process of exporting CNG products, the next is to take into account the tools as well as supporting components as one of the initial investments in the construction of this *plant.* Assumptions will be application as follows **Table 4.1**:

Table 4.1 Assumption Data

Assumption	Remarks
Investment Time (year)	10
Construction Time (Mo)	6
Construction Age Plan (Year)	20
Plant Capacity (MMSCFD)	3,5
MMSCFD/MMBtu	1.040
Throughput fee ($/MMBTU)	1.8
Hour/Day	24
Day/Year	365
Rate USD to Rp	14.500
Inflation (%)	5
Tax (%)	30
Interest Rate (%)	12

Tabel 4.2 *Investment Cost CNG Mother Station*

Investment Calculation	Plant 3.5 MMSCFD
Base Unit	
Engineering Works	$120.748
Plant Construction	$4.077.589
Total Investment	**$4.198.338**
CNG Production, MMBTU/day	3.640
CNG Price US$/MMBTU	$1,8

5. ANALYSIS AND RESULTS

In this chapter will be explained about the results and discussion consisting of investment costs of both plants, financial projections, environmental aspects, technical and sensitivity analysis.

5.1 Environmental and Technical Aspects Analysis

Marginal gas wells with large amounts and potential reserves that have, if managed properly, can have the opportunity to be able to increase national oil and gas production while improving its welfare for local communities. Technically, the construction of CNG *Mother Station* can be said to be safe to project considering that the products produced are considered more 'clean' when compared to two fuel oils due to their environmentally friendly exhaust emissions. so that the production of a new CNG product and plant can be a plus for the company.

5.2 Plant Financial Feasibility Analysis

The results of the calculation of CNG *Mother Station* that has been done using the capacity of the plan 3.5 MMSCFD. The results can be found in **Table 5.1**

Table 5.1. *CNG Mother Station* Feasibility

No	Feasibility Financial	CNG Plant Capacity 3,5 MMSCFD
1	IRR	33,12 > 1
2	NPV	$3.184.715,32 (NPV > 0)
3	Average/Year	$129.308
4	PBP	2.6 Years, < N

For *CNG Mother Station* with a capacity of 3.5 MMSCFD obtained the results of calculations, namely:

1. NPV = $3,184,715,32 obtained from the calculation using excel formula with a 12% interest rate and the value of the investment in the 1st year, so that the amount of profit obtained for 10 years in accordance with the existing cash flow. (NPV>0) this project can be run.
2. IRR = 33,12% obtained from the cash flow value where the value of expenditure (investment) in the 1st year amounted to $ 4,198,338 with profit according to cash flow. IRR with a value of 33. 12%can be said to be feasible because (IRR>i) or greater than the set interest rate of 12%.
3. PBP = PBP value obtained from the investment amount is 2.6 years which means the return is faster than N (10 years). This project can be said to be feasible because of the data adjusted to the provisions of PBP <N.

NPV is a measure of the present value of the revenue stream generated from a resource usage activity. The formal criterion of NPV use is that if NPV is positive value, then economic activities are feasible, on the contrary if NPV is negative value, then economic activities are not feasible to do or continue.

Based on the results of economic analysis, the results of the calculations stated in **Table** 5.1 show that the development of CNG industry shows a fairly good performance. This can be seen from the Positive NPV value and IRR value that is greater than the bank interest rate during the 10-year analysis on the discount factor (nominal interest rate) of 8%. This condition indicates that based on calculations based on current value, future net cash receipts will be greater than the investment value, so that the company earns profit.

From the calculation of plant capacity of both have the same advantages and worth running. This feasibility is seen from indicators such as NPV, PBP and IRR.

5.3 Sensitivity Analysis

Sensitivity analysis here is done by changing the dominant variables to the project so that it can see the extent to which the project will be affected by such changes such as CNG price and *plant capacity*. The sensitivity analysis aims to see how far the project is affected by those changes.

In the graph of the analysis of the impact on the project IRR, it appears that changes in CNG gas prices resulted in changes in IRR. It is seen that at the gas sales price of CNG US$1.62, US$1.8 and US$1.98 per MMBTU resulting in IRR 28.09%, 33.12%, 37.95% for further charts shown in **Figure 5.1.**

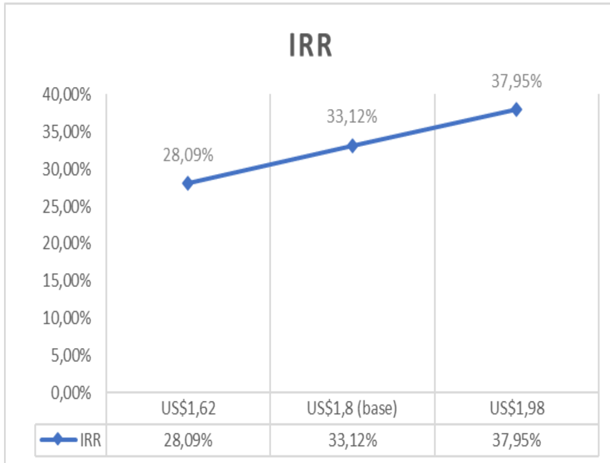

Figure 5.1 Effect of CNG price on IRR

The feasibility of the project is not only seen from the IRR side but also from the NPV side that the company wants. Successively the influence on NPV amounted to, US$ 2,351,759, US$ 3,184,715, US$ 4,017,671 as shown below.

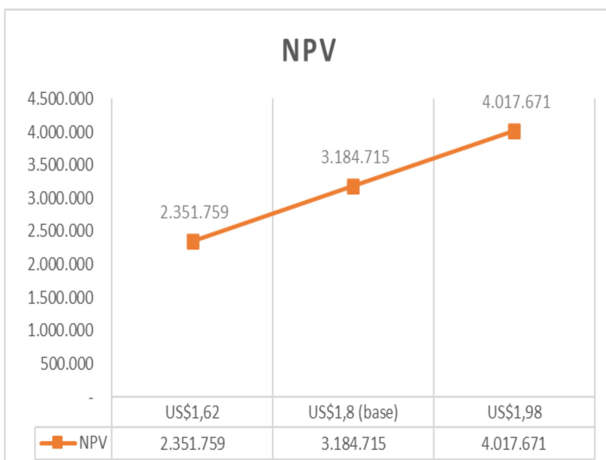

Figure 5.2 Effect of CNG price on NPV

From the description of the two charts above shows that in the condition of decreasing to 10% both the selling price of CNG products and the decrease in plant capacity of IRR value is still above the interest of 12% and the value of NPV > 0 with this company can make a decision if necessary correction to the selling value of CNG products. Figure 5.3 shows the change in the selling price capacity of CNG products ±10% showing changes in IRR and NPV values of 23.32%, 33.12% and 43.08% and $1,602,099, $3,184,715 and $4,933,923 respectively.

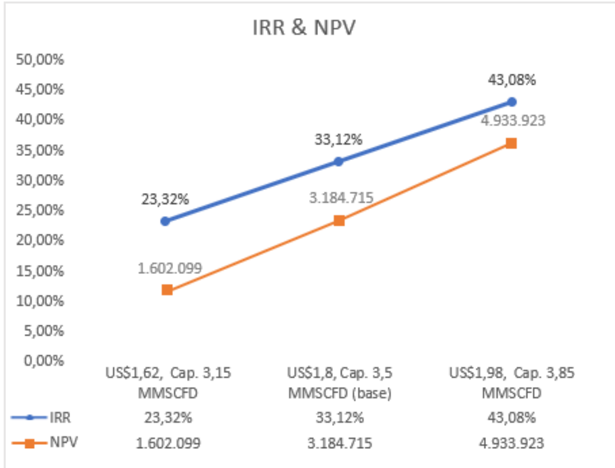

Figure 5.3 The Effect of CNG Capacity and Price on IRR & NPV

6. CONCLUSION

From this research, the results of the feasibility study of CNG *Mother Station* development with the utilization of marginal gas wells owned by the government Oil and Gas company in this case PT. Pertamina Gas in Blora Regency, Central Java, based on the following financial approach:

1. NPV value of CNG *Mother Station* development with a capacity of 3.5 MMSCFD of \$3,184,715.32 (NPV > 0), this investment is worth implementing.
2. The IRR value of CNG *Mother Station* development with a capacity of 3.5 MMSCFD of 33.12% is said to be feasible because IRR > i (12%)
3. Payback value of 2.6 years of this investment plan meets the feasibility because PBP < N (10 years).

From the explanation above, it can be seen that the investment prospect of utilization of marginal gas wells in Indonesia is quite attractive to investors.

7. REFERENCES

Al-Mohannadi, D. M., Abdulaziz, K., Alnouri, S. Y., & Linke, P. (2017). On the synthesis of carbon constrained natural gas monetization networks. *Journal of Cleaner Production*, 168, 735–745.

Bhattacharyya, S.C. (2012), Energy Economics: Concepts, Issues, Markets and Governance. London: Springer.

Chimale, Noelia Denisse dan Gustavo Fabián Acosta. (2009). LNG in argentina a regasification *plant* feasibility study. *University of Buenos Aires* (UBA), Argentina.

Economides, M. J., Sun, K., & Subero, G. (2006, May 1). *Compressed Natural Gas* (CNG): An Alternative to Liquefied Natural Gas (LNG). *Society of Petroleum Engineers*. doi:10.2118/92047-PA

Elbashir, N. O., El-Halwagi, M. M., Economou, I. G., & Hall, K. R. (2018). *Natural Gas Processing from Midstream to Downstream*, John Wiley and Sons Ltd., UK.

Griffin, P. (2006), Liquefied Natural Gas: The Law and Business of LNG. 3rd ed. London, UK: Globe Law and Business

Gunarta, IK, Hervianto BC. (2017), Technical and Financial Feasibility Analysis for Gas *Plant* Operating Scenario Selection by using *Discounted Cash Flow* (DCF) Method, ISCRBM 2017, Surabaya

Gunarta, IK., Putri FA. (2017), Valuating Indonesian Upstream Oil Management Scenario through System Dynamics Modelling. JURNAL TEKNIK ITS Vol. 6, No. 2 (2017), 2337-3520

Hakam, Dzikri Firmansyah, Asekomeh, Ayodele O., (2018), Gas monetisation intricacies: evidence from Indonesia, *International journal of energy economics and policy*.174-181

Kementrian ESDM RI (2017). Peraturan Menteri ESDM No. 45 Tahun 2017 Tentang Pemanfaatan Gas Bumi Untuk Pembangkit Tenaga Listrik.

Kementrian ESDM RI (2008). Pedoman pengusahaan Pertambangan Minyak Bumi pada Sumur Tua. Khalilpour, R., Karimi, IA. (2012), Evaluation of utilization alternatives for stranded natural gas.

Energy, 40(1), 317-28

Pujawan, I., N., (2012). Ekonomi Teknik, Edisi ke-2. Guna Widya. Surabaya.

Soemardan, S, Purwanto, W., (2013), Production Optimization for Plan of Gas Field Development Using Marginal Cost Analysis. Makara Journal of Technology, 17(2), 94-102.

Warsono. 2003. Manajemen Keuangan Perusahaan, Malang: Penerbit Bayu Media.

Wicaksono, MW., (2012) *Studi Kelayakan Pembangunan Plant dalam pemanfaatan Gas Sisa dengan pendekatan finansial*. Master Tesis. Universitas Indonesia.

Wood, D., S. Mokhatab, and M.J. Economides, 2008. Technology oftions for securing markets for remote gas. Proceeding of the 87th Annual Convention, GPA

Wood, David & Nwaoha, Chikezie & Towler, Brian. (2012). Gas-to-liquids (GTL): A review of an industry offering several routes for monetizing natural gas. *Journal of Natural Gas Science and Engineering*. 9. 196–208.

COVID-19 IMPACT ANALYSIS TOWARDS STOCK MARKET: CASE STUDY OF JAKARTA COMPOSITE INDEX

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ABSTRACT

Pandemic COVID-19 has a significant negative impact to the global economy as many countries need to implement the lockdown policy to push down the number of new cases. Stock market as one of economy indicator also impacted by the COVID-19 issues in respective country. This study examines the impact of COVID-19 issues in Indonesia towards the movement of Jakarta Composite Index (JCI). Three different methods are utilized to get a better understanding of what happen to JCI after first COVID-19 case reported in Indonesia. The methods being used are structural change analysis, intervention analysis, and outlier analysis. Instead of comparing the result of those three methods, collaborating them can provide a richer information to get more confirmed analysis of the data, as each method has its own strengths and weaknesses. Eventually, in general, those methods provide the same information related to the first time COVID-19 impact captured in JCI data, which is on March 9th, 2020 or 5 working days after the first COVID-19 case is reported in Indonesia. The impact is last for 12-13 working days in the stock market before the recovery phase is begin. The impact of COVID-19 itself towards stock market is well estimated by outlier detection and intervention analysis.

Keywords: COVID-19, stock market, structural change, intervention analysis, outlier analysis.

1. INTRODUCTION

In the capital market, stock price fluctuations are affected by a variety of economic-related events or events that have a sufficiently large effect on a country. Event variables not only impacting to the level of performance of the company, but it may also have a global impact. An example of this is the 2008 economic crisis, which led to a decline in the composite stock price index in Indonesia and many other developing and industrialized countries. The effect of the COVID-19 pandemic on the economic development of the affected countries, which has also resulted in a fall in the global stock price index, is another factor that has occurred recently.

An overview of the effect of the COVID-19 case on JCI data movement is carried out in this analysis. In several previous studies, analysis regarding the impact of the number of COVID-19 cases on the stock price index in a country has been carried out, including the following:

- Topcu & Gulal (2020) examined the impact of COVID-19 on stock markets in developing countries during the period March 10th – April 30th, 2020. The findings showed that there was a substantial negative impact of the COVID-19 pandemic on stock index movements in developing countries. This negative effect, however, decreased only gradually until it became negligible in April 2020.
- The effect of COVID-19 on capital markets in sixteen countries was examined by Khan, et.all (2020), which shows that the rise in the number of new cases in a country would predict negative stock return movements. It was also mentioned in his study that investors in the capital market only showed negative reactions when the transition from one person to another in the country was verified.
- A study of the effects of the COVID-19 pandemic on many sectoral indices in the stock market in China was carried out by He, P. et.all (2020). The findings of this study show that there have been negative impacts from the COVID-19 pandemic on the transport, mining, energy & heating, and environmental sectors. On the other hand, COVID-19 did not impact the manufacturing, information technology, educational and health industries.
- The impact of the number of new cases and the number of deaths from COVID-19 on the stock market index was examined by Ashraf, B.N (2020) with case studies in 64 countries. The findings of this analysis suggest that the movement of return data from the stock market is inversely proportional to the growth in the number of cases of COVID-19. The study also shows that the COVID-19 pandemic had a strong negative effect on the financial markets during the early days of the country's reporting of active cases and 40-60 days after the first case.

The COVID-19 variable is treated as an event in this study, unlike the previous studies described above where analysis was carried out using a variable number of active cases or the number of deaths due to COVID-19. The starting point for the events in this study is the date when the first active cases were reported in Indonesia, which is on March 2nd, 2020. This judgement is based on the findings of previous studies, which notes that the rise in the number of active cases is more important than the number of deaths.

An overview of the effect of COVID-19 on the sectoral index of the IHSG is also carried out in this study in order to understand more thoroughly the conditions of each industrial sector on the Indonesia stock exchange. The initial assumption from the study of the impact of COVID-19 on the sectoral index is that the impact of COVID-19 encountered by each industrial sector varies in terms of quantity. The JCI movement's concern in making business decisions would be deeper by recognizing the effect of COVID-19 in each sectoral industry so that it keeps away from the risk of decision-making mistakes.

The purpose if this study is to examine the impact of COVID-19 towards JCI daily closing price data, including analyzing the pattern of JCI data after 1st COVID-19 case reported in Indonesia, and the amount of the impact. The impact of the COVID-19 is also analyzed deeper into the sectoral stock indices in Indonesia Stock Exchange, to understand the condition of each sectors after affected by the pandemic.

2. METHOD

2.1 Structural Changes Analysis

Changes in time series data movement due to an occurrence are not always observed visually. A test is important to confirm whether there is a systemic shift in the data or not. The method of analysis of structural changes can be used to identify a change in the data structure due to an occurrence from a time series data with the following equation:

$$y_i = \mu_i + e_i, \qquad i = 1, \ldots, T$$

where μ_i is a deterministic signal and e_i is a residual with mean 0 and variance σ^2. The initial hypothesis (H_0) in this test is $\mu_i = \mu_0$ for all i, or it can be interpreted that there is no significant difference between the observed values of one another. The alternative hypothesis of this test is that there are differences in the observed values at a certain period, thus indicating a structural change in the time series data. In the initial hypothesis, the natural estimate for μ_0 is a recursive estimate of $\hat{\mu}_k = k^{-1} \sum_{i=1}^{k} y_1$, for k = 1, …, T. Thus, the corresponding recursive residuals are $\tilde{e}_i = y_i - \hat{\mu}_{i-1}$, $i = 2, \ldots, T$. The basic concept of structural change analysis is to study the fluctuation of the partial and cumulative totals (CUSUMs) of the recursive residuals. The initial hypothesis will be rejected if excessive fluctuation is found in the recursive residual data (Kleiber, 2016).

2.2 Intervention Analysis

Changes in the movement of data are also triggered by an occurrence in a time series of data that cannot be quantified. An intervention analysis approach is used, which is by looking at the trends generated from the residual time series models, to be able to determine the impact of an event on time series data.

It is assumed in the intervention analysis that an intervention event happens at a certain time that is denoted by T in data from a time series. The general equation of the intervention model is as follows (Box & Jenkins, 1994),

$$Y_t = \frac{\omega(B)B^b}{\delta(B)}\xi_t + N_t$$

where N_t is the initial model equation from the time series data used, regardless of the effect of the intervention on the data. While the intervention effect is represented by an equation $Y_t = \delta^{-1}(B)\omega(B)B^b\xi_t$, where (Wei, 2006),

$$\omega(B) = (\omega_0 - \omega_1 B - \omega_2 B^2 - \ldots - \omega_s B^s)$$
$$\delta(B) = (1 - \delta_1 B - \delta_2 B^2 - \ldots - \delta_r B^r)$$

and ξ_t is a deterministic input variable that describes the intervention event.

2.3 Outlier Analysis

Outlier is an observational data that in its sequence is anomalous or contradictory. If the effect that occurs is very extreme, the effect of an event on time series data will generate outlier data. There are 4 (four) forms of outliers in general, including the following.

1. Innovation Outlier (IO)
   is an anomaly that in the next cycle results in major changes in the observed value (Popova, et.all, 2018). The effect of innovation outliers normally follows the Autoregressive Moving Average (ARMA) process in a pattern.
2. Additive Outlier (AO)
   is an anomaly in observational data that occurs only in one observation data period and does not affect observational data in the subsequent observation data period.
3. Level Shift (LS)
   is a data phenomenon in 1 observational data cycle, but it has a lasting effect on the data in many observational data periods or all the data afterwards.

4. Temporary Change (TC)
   is an anomaly that temporarily affects the observational data in the next cycle, with the magnitude of the anomaly's impact value decreasing slowly until it is not significant (Wei, 2006).

3. RESULTS AND DISCUSSION

3.1 COVID-19 Impact Analysis to Jakarta Composite Index

The most fundamental thing that needs to be done in evaluating the effect of COVID-19 on the JCI is to demonstrate that there is indeed a change in data trends that occurred during the pandemic era of COVID-19. For this reason, with the initial hypothesis that there were no structural changes in the JCI data, a Chow test was performed. The Chow Test p-value on the JCI data is 0.000. With a tolerance level of alpha = 0.05, this test's initial hypothesis was successfully rejected. In other words, the Chow Test results of the JCI data succeeded in validating that during the period January 2019 to July 2020, there was indeed a major change in the structure of the data pattern in the JCI daily closing data. The optimal number of partitions is 3 partitions, so the JCI data for the period January 2019 - July 2020 is divided into 4 parts, as shown in Figure 1 below, with the aid of orders from the 'strucchange' package in R software.

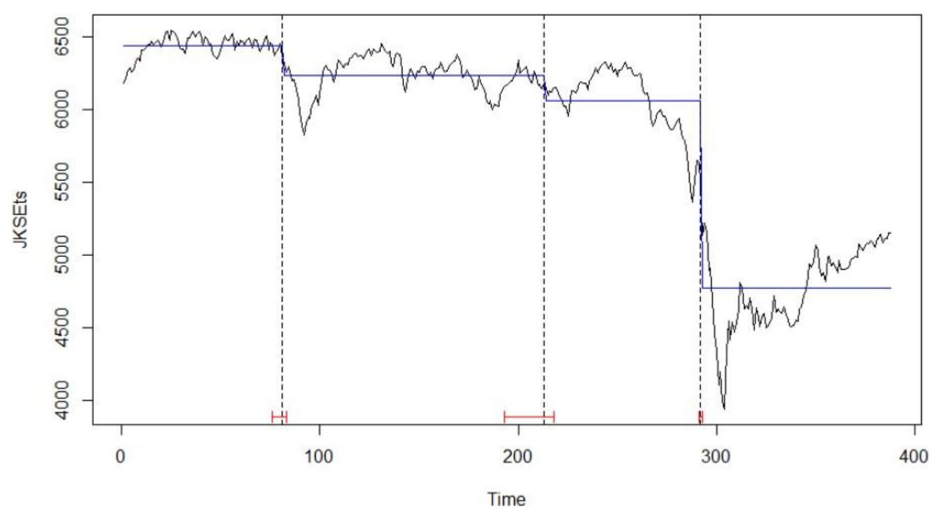

Figure 1. Segmentation of JCI data based on structural changes analysis

The partition point from the results of structural changes in date notation is as follows,

Table 1. Partition point of JCI's segmentation

Partition	Observation Number	Date
1	82	3-May-19
2	214	13-Nov-19
3	293	9-Mar-20

Considering that the first case of patients with COVID-19 recorded in Indonesia occurred on 2nd of March 2020, hence, one of the structural changes in the JCI data caused by the COVID-

19 pandemic is the 3rd partition, which occurred on 9 March 2020. It is also visually evident in Figure 1 that the 3rd partition has the most significant structural shifts relative to the other 2 partitions.

Then an intervention analysis is carried out to get a more comprehensive picture of the effect of COVID-19 on the JCI, with the concept of identifying the response to an event after the intervention occurs through the residual value of the model. The first step in intervention analysis is to define the required ARIMA modeling for data prior to the occurrence of the intervention event. The ARIMA model that is appropriate for the JCI data before the intervention event is obtained is ARIMA (0,1,1) with the aid of the "forecast" package in R program. Figure 2 below shows the results of the forecasting of JCI data for the post-intervention period for the COVID-19 case, which is period of March-July 2020, based on ARIMA (0,1,1).

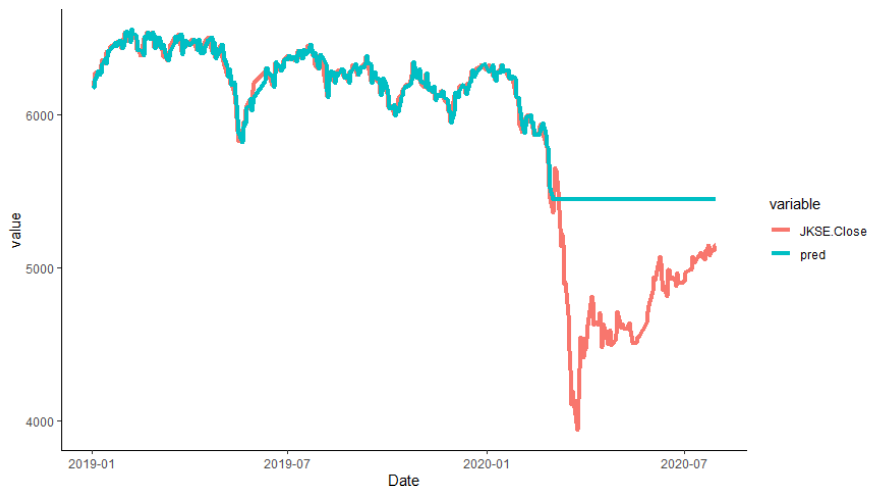

Figure 2. Forecast result of ARIMA(0,1,1) model after intervention period

A large difference between the forecast results from the ARIMA model (0,1,1) in the intervention period and the actual observation data is shown in the graph in Figure 2 above. This shows that the COVID-19 pandemic has a major effect on JCI data movement. Residual data from the JCI forecast results will be used to identify the effect of the intervention of the COVID-19 pandemic on the JCI. The pattern of residual data with the ARIMA (0,1,1) from the JCI forecasting results can be seen in Figure 3 below.

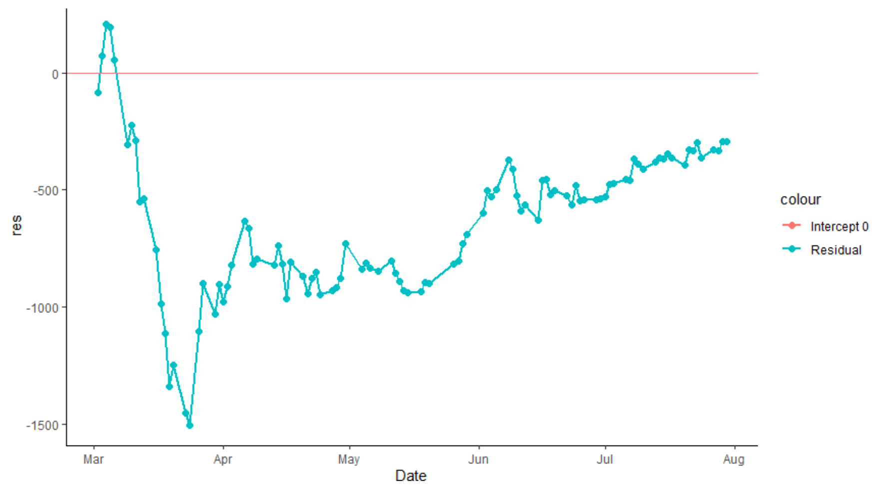

Figure 3. Residual plot of ARIMA(0,1,1) model during intervention period

Based on the residual plot shown in Figure 3 above, it is known that the impact of the COVID-19 pandemic was not immediately reacted by Indonesia Stock Exchange investors, but that it took 5 working days after the first COVID-19 case was reported in Indonesia to show a decreasing trend. Therefore, the effect of the COVID-19 pandemic on JCI data is appeared starting from March 9th, 2020. The market players' negative reaction continued for 12 working days until the JCI eventually entered the recovery phase on 26 March 2020.

It is possible to measure the magnitude of the effect of the COVID-19 pandemic on the JCI from the deviation between the initial model forecast results and the actual data during the affected period. The effect of the COVID-19 pandemic on the JCI during the period 9-26 March 2020 was -15.8% based on this approach. The effect of the COVID-19 intervention is significant, referring to the significant gap that is happened between the data prior intervention occurred compared to after intervention. The movement of data that is extremely far from the movement of standard observational data is often referred to as outlier data, so it can also be analyzed using the outlier detection method.

Assuming that the market reaction to the COVID issue is a market shock which results an anomaly in the JCI movement, so that the anomaly will be captured as outlier data in the outlier detection analysis. With the help of the 'tsoutlier' package in the R software, outlier detection results were obtained on the JCI data for the period January 2019 - July 2020 which is visualized in Figure 4 below.

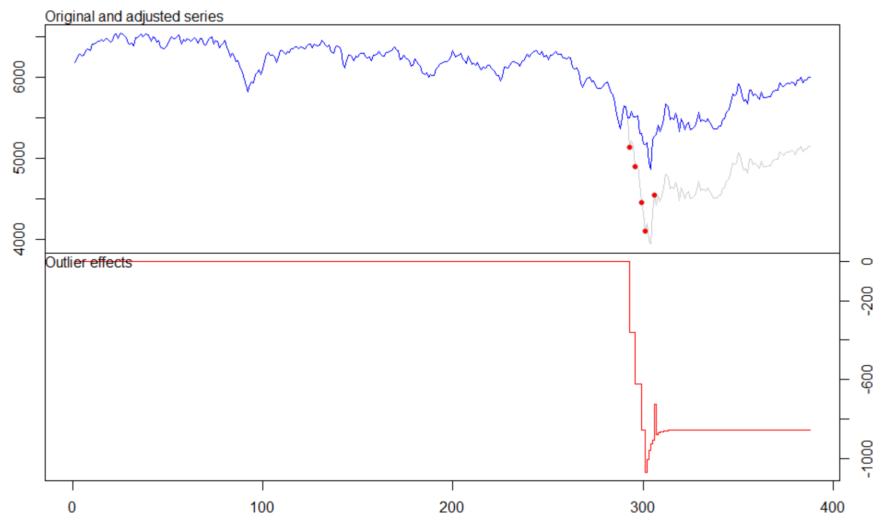

Figure 4. Outlier detection in JCI data

The results of outlier detection in the plot above show that there are at least 5 JCI price observation data which are outlier data. As explained in Chapter 2, where in general there are 4 types of outliers, the JCI data itself found 3 different types of outliers. A detailed explanation of each outlier is shown in Table 2 below.

Table 2. Outlier detection in JCI data

Tipe	Observation Number	Date	Coefficient Estimation
Level Shift	293	9-Mar-20	-361.7
Level Shift	296	12-Mar-20	-258.4
Level Shift	299	17-Mar-20	-233.9
Temporary Change	301	19-Mar-20	-215.0
Additive Outlier	306	27-Mar-20	166.5

There were 3 level shift outliers found in the JCI data on March 9^{th}, 12^{th}, and 17^{th}, based on the outlier analysis, which indicating that the effect of the COVID-19 issue on the JCI occurred during those dates. Outliers with a negative temporary shift were identified on March 19^{th}, indicating that the JCI recovery process began after March 19^{th}, and reaffirmed by the positive additive outliers on March 27^{th}, showing the capital market players' optimism about the JCI reversal phase. The impact of the COVID-19 problem on the JCI was -902 index point, which occurred in stages up to 4 times a substantial decrease, based on the coefficient estimation results.

Overall, the analysis of structural changes, intervention, and outlier detection can complement each other and confirm in providing an overview regarding the movement of JCI data after the COVID-19 event occurs. The results of the analysis of the three methods provide similar information regarding the visible impact of the COVID-19 issue on the JCI, which is in 5 working days after the first COVID-19 case was reported in Indonesia. The outlier analysis also confirmed the intervention analysis that visually depicted the impact of the COVID-19 issue on the JCI that lasted for 12 to 13 working days before finally stabilizing and recovering slowly.

3.2 COVID-19 Impact Analysis to Sectoral Indices in Indonesia Stock Exchange

A study of the effects of COVID-19 on sectoral indices on the Indonesia Stock Exchange is also carried out to get a more in-depth image of the impact of the COVID-19 pandemic on the JCI. In general, 709 companies listed on the Indonesia Stock Exchange are divided into 9 sectors of business, according to each company's industrial sector. Company stock performance in 9 industrial sectors is represented in the sectoral index for each sector.

For the 9 sectoral indices, the results of structural change tests with the Chow Test produce a p-value < 2.2e-16. The p-value, which is smaller than the alpha 0.05 tolerance value, indicates that in each sectoral index there is a significant pattern shift. In addition, an intervention analysis for each sectoral index was performed to further understand the impact of the COVID-19 pandemic on the JCI sectoral index data. Table 3 shows the results of the analysis of the residual data pattern from the initial model forecast, in the form of the date on which the JCI decline began to enter the recovery phase as the impact of COVID-19.

Table 3. Intervention analysis in JCI data

Sectoral	Period of the Impact		Date of the Impact	
	Appeared *(working days after 1st case)*	**Lasted** *(working days after appeared)*	**Started**	**Ended**
Trade, Service, and Investment	5	12	3/9/2020	3/26/2020
Property and Real Estate	5	12	3/9/2020	3/26/2020
Consumer Goods Industry	10	7	3/16/2020	3/26/2020
Mininng	5	12	3/9/2020	3/26/2020
Basic Industry and Chemistry	5	12	3/9/2020	3/26/2020
Agriculture	5	12	3/9/2020	3/26/2020
Infrastructure and Transportation	5	11	3/9/2020	3/24/2020
Finance	5	12	3/9/2020	3/26/2020
Miscellaneous	5	12	3/9/2020	3/26/2020

Based on the results of the analysis of residual data patterns, it is known that most of the sectoral indices have similar data pattern to the JCI pattern after the COVID-19 pandemic. The impact of the COVID-19 pandemic appears in 5 working days after the first COVID-19 patient was reported in Indonesia, and the impact last for up to 12 working days before finally establishing a stable movement pattern. However, the Consumer Goods Industry sector shows a different data pattern, where the COVID-19 pandemic has only impacted the Consumer Goods Industry index after 10 working days from the day COVID-19 patients were first reported in Indonesia. The period of the impact of COVID-19 on the Consumer Goods Industry index is also shorter than other indices, which is only 7 working days.

The calculation of the impact value of the COVID-19 pandemic was carried out for 2 time periods, namely the affected period by COVID-19, or so called the early COVID-19 period, where the start and end dates of the period are based on the analysis results from Table 3. The second is for all periods after the COVID-19 pandemic, that is, in the case of this study it was started based on the date of the analysis in Table 3 that refer to the beginning of the affected period, until July 31, 2020. The results of the calculation of the impact of the COVID-19 pandemic on the JCI sectoral index are summarized in Table 4 below.

Table 4. COVID-19 impact towards sectoral indices

Sectoral	COVID-19 Impact	
	Early Period	Overall Period
Trade, Service, and Investment	-10.2%	-3.3%
Property and Real Estate	-18.2%	-23.9%
Consumer Goods Industry	-14.7%	9.9%
Mininng	-14.4%	-5.3%
Basic Industry and Chemistry	-20.7%	-7.6%
Agriculture	-18.4%	-12.7%
Infrastructure and Transportation	-15.7%	-9.6%
Finance	-20.6%	-23.7%
Miscellaneous	-22.7%	-20.5%

All industrial sectors experienced significant negative impacts during the early period of the COVID-19 pandemic in Indonesia. The deepest decline was experienced by the index of miscellaneous industry, which is -22.7%. One of the reasons of this deep decline in miscellaneous index is contributed by PT Astra International, which has a large market capitalization in Indonesia Stock Exchange and is a holding of several big automotive companies in Indonesia. In accordance with the analysis from Sparrow, Dartanto, & Hartwig (2020) which states that there is a decline in the transportation equipment production sector along with a decline in the transportation sector in Indonesia's GDP, this is also shown by the performance of PT Astra International companies which experienced a significant decrease in the number of vehicle sales.

Table 4 shows that most of the impacts that occurred in the overall period after the onset of the pandemic show a lower negative value than the impact at the early period of the pandemic. The consumer goods industry index even shows a positive value on the impact of the overall period. This is an indication of a pattern of improvement that is higher than the value of the initial model forecast. Meanwhile, the property and real estate index and financial index have not indicated a recovery phase towards the value of the initial forecasting results.

4. CONCLUSION

The movement pattern of JCI data after the reporting of the first COVID-19 patient in Indonesia showed a significant decline within 5 working days after the reporting of the first patient in Indonesia. The pattern of decline in the JCI is lasted for 12 working days, before finally entering the recovery phase. Based on the results of intervention analysis and outlier detection, it is known that the impact of the COVID-19 pandemic on the JCI in the early period of COVID-19 in Indonesia was -15.8% to -16.4% or a decrease of 859-902 index points over 12 working days.

The COVID-19 pandemic also had a significant impact on the JCI sectoral index, as confirmed by the results of the structural changes Chow Test which showed that there was a shift in data movement in 9 sectoral indices around the period of the COVID-19 pandemic in Indonesia. The pattern of sectoral index data that was occurred after being affected by the COVID-19 pandemic mostly has a similar pattern to the JCI, which is a decline after 5 working days from the day the first COVID-19 case was reported in Indonesia and continues to decline for 12 consecutive working days. However, the magnitude of the impact of the COVID-19 pandemic on the decline in the sectoral index is quite diverse. The decline is in the range of 10% to 22% during the early period of COVID-19 in Indonesia.

5. REFERENCES

Alamsjah (2017). Pengaruh Faktor Makro Ekonomi terhadap Harga Saham Industri Makanan yang Tercatat di Bursa Efek Jakarta. *Jurnal Economix* Volume 5 Nomor 1.

Ashraf, B.N. (2020). Stock Market Reaction to COVID-19: Cases or Fatalities? *Research in International Business and Finance.*

Badshah, W., Alvi, M. S. I., dan Sayilir, O. (2016). Macro-Economic Variables and Their Impact on Stock Exchange: A Study of Pakistan (KSE 100 Index. *Journal of Research in Business, Economics and Management*, vol.5-5.

Box, G. E. P. dan Jenkins, G. M. (1970). *Time Series Analysis, Forecasting, and Control*. San Fransisco: Holden Day.

Budiarti, L., Tarno, dan Warsito, B. (2013). Analisis Intervensi dan Deteksi Outlier pada Data Wisatawan Domestik (Studi Kasus Daerah Istimewa Yogyakarta). *Jurnal Gaussian*, Volume 2, No.1:39-48.

Camilleri, S. J., Scicluna, N., Bai, Y. (2018). Do Stock Markets Lead or Lag Macroeconomic Variables? Evidence from Select European Countries. *North American Journal of Economics & Finance.*

Cominicioli, B. (1996). The Stock Market as A Leading Indicator: An Application of Granger Causality. *University Avenue Undergraduate Journal of Economics.*

Fama, E. F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance, Vol. 25, No. 2, Papers and Proceedings of the Twenty-Eighth Annual Meeting of the American Finance Association* New York, N.Y. December, 28-30, pp. 383-417.

Hartono, J. (2018). *Studi Perstiwa: Menguji Reaksi Pasar Modal Akibat Suatu Peristiwa*. BPFE Yogyakarta.

Hasbullah, J. (2013). *Tangguh dengan Statistik: Akurat dalam Membaca Realita Dunia.* Nuansa Cendekia, Bandung.

He, P., Sun, Y., Zhang, Y., dan Li, T. (2020). COVID–19's Impact on Stock Prices Across Different Sectors—An Event Study Based on the Chinese Stock Market. *Emerging Markets Finance and Trade*, 56:10, 2198-2212.

Khan, K., Zhao, H., Zhang, H., Yang, H., Shah, M.H., dan Jahanger, A. (2020). The Impact of COVID-19 Pandemic on Stock Markets: An Empirical Analysis of World Major Stock Indices. *Journal of Asian Finance, Economics and Business* Vol 7 No 7 (2020) 463 – 474.

Kleiber, C. (2016). Structural Change in (Economic) Time Series. *Center of Business and Economics (WWZ)*, University of Basel.

Martono dan Hardjito, A. D. (2002). *Manajemen Keuangan*, *Edisi Pertama*, Ekonisia, Yogyakarta.

Nordin, S. dan Nordin N. (2016). The Impact of Capital Market on Economic Growth: A Malaysian Outlook. *International Journal of Economics and Financial Issues* 6(S7) 259-265.

Rowter, K. (2016). Indonesian Capital Market Development and Challenges. *Nomura Journal of Asian Capital Market* Vol.1 No. 1.

Samsul, Muhamad. (2006). *Pasar Modal Dan Manajemen Portofolio*. Penerbit Erlangga, Surabaya.

Sparrow, R., Dartanto, T., dan Hartwig, R. (2020). Indonesia Under the New Normal: Challenges and the Way Ahead. *Bulletin of Indonesian Economic Studies*, 56:3, 269-299.

Topcu, M. dan Gulal, O.S. (2020). The Impact of COVID-19 on Emerging Stock Market. *Finance Research Letters.*

Tsay, R.S. (2014). *Multivariate Time Series Analysis with R and Financial Applications*. John Wiley & Sons, Inc., Hoboken, New Jersey.

Wei, W. W. (2006). *Time Series Analysis Univariate and Multivariate Methods (2nd edition)*. Canada: Addison Wesley Publishing Company.

Yunanto, M. dan Medyawati, H. (2013). Macroeconomic Structural Change in Indonesia: in The Period of 1990 to 2011. *International Journal of Trade, Economics and Finance,* Vol. 4, No. 3.

Zeileis, A., Kleiber, C., Kramer, W., dan Hornik, K. (2003). Testing and Dating of Structural Changes in Practice. *Computational Statistics & Data Analysis* 44 (2003) 109 – 123.

POWER PLANTS PROJECT INVESTMENT ANALYSIS WITH BALANCED SCORECARD AND HYBRID MULTI CRITERIA DECISION MAKING

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ABSTRACT

Ministerial Energy and Mineral Resources (ESDM) Regulation 70/2017 allows private power plants to contribute to the electricity supply in Indonesia. The regulation, on the other hand, is resulting in a reduction in the role and contribution of state-owned power plants. PT. XYZ is one of the state-owned power plants which is facing this condition by developing new power plants following the National Strategic Project. An investment in power plants with 2000 MW total capacity is a large-scale investment that requires commitment and cooperation with financial institutions, due to large costs with long payback periods. The main goal of this study is to determine the factors that underlie financial institution considerations in providing funding for the construction of power plants. The next research objective is to determine the most appropriate financial institution to finance a power plant construction project. This study uses the Balanced Scorecard (BSC) to determine the investment criteria based on the expert opinion approach. Hybrid multi-criteria decision making with the IT2 DEMATEL and QUALIFLEX approaches are also used to provide the most affected criteria and select the most suitable financial institutions. Finally, this study found that 'investment cost' and 'length of time of return on investment' are the most influential criteria in the power generation investment decision. In addition, this study found that the Export Credit Institution (ECA) is the most appropriate financial institution to invest in the PT XYZ project.

Keywords: Power Plant Project Finance, Balanced Scorecard, Multi-Criteria Decision Making, IT2 DEMATEL, QUALIFLEX.

1. INTRODUCTION

PT. XYZ is a is engaged in the production and maintenance of power plants. In 2008, PT. XYZ supplies around 48% of electric power to Java and Bali. However, over time, regulations that offer private parties the opportunity to play a role in the area of production, have led to PT's contribution. PT. XYZ's proportion is decreasing. Recorded in 2014, PT. XYZ contributed about 26%, this value is very far from 2008. In its entirety, Table 1.1 provides data on the electricity supply of the Jawa-Bali system in 2014-2018. The table shows the contribution of power generation companies in Indonesia. PT. XYZ is the biggest contributor, but its contribution continues to decline over the years, this can be seen clearly in the graph of the evolution of the PT. XYZ contribution in Table 1.

Table 1.1 Jawa-Bali Electric Power Supply System

Companies	Electric Supply Capacity (MW)				
	2014	2015	2016	2017	2018
PT. XYZ	8.167,27 (26,10%)	8230,08 (25,99%)	8.155,06 (24,61%)	7.790,32 (23,32%)	7.948,82 (23,04%)
PT. ABC	6.484,00 (20,72%)	6374,85 (20,13%)	6.370,39 (19,22%)	6.370,40 (19,07%)	6.376,36 (18,49%)
UB Tanjung Jati B	2.643,80 (8,45%)	2643,80 (8,35%)	2.643,80 (7,98%)	2.643,80 (7,91%)	2.643,80 (7,66%)
IPP	5.840,85 (18,66%)	6253,85 (19,75%)	6.869,29 (20,73%)	7.505,68 (22,47%)	7.531,06 (21,83%)
UPJB	8.161,00 (26,08%)	8161,00 (25,77%)			
Unit O&M managed by XYZ			4.954,00 (14,95%)	4.954,00 (14,83%)	5.848,10 (16,95%)
Unit O&M managed by ABC			4.145,00 (12,51%)	4.145,00 (12,41%)	4.145,00 (12,02%)
Jawa Bali System	31.296,92 (100%)	31.663,58 (100%)	33.137,54 (100%)	33.409,20 (100%)	34.493,14 (100%)

Figure 1.1 shows that the evolution of the contribution of electricity supply by PT. XYZ in the Jawa Bali system has experienced a significant decline. After calculation, the decline index reaches 0.785% per year. If it follows the trend of the line, the projection for 2034, PT. XYZ will be just history.

The reduced contribution of PT. XYZ in power supply in Jawa Bali, besides being caused by regulation in the area of generation, is also due to the reduced performance of existing power plants. This is because the age of the plant and the system used are less relevant to current conditions. In order to survive in the power generation sector, PT. XYZ is developing one of its businesses, namely the construction of new power stations that are more efficient, more reliable and more respectful of the environment.

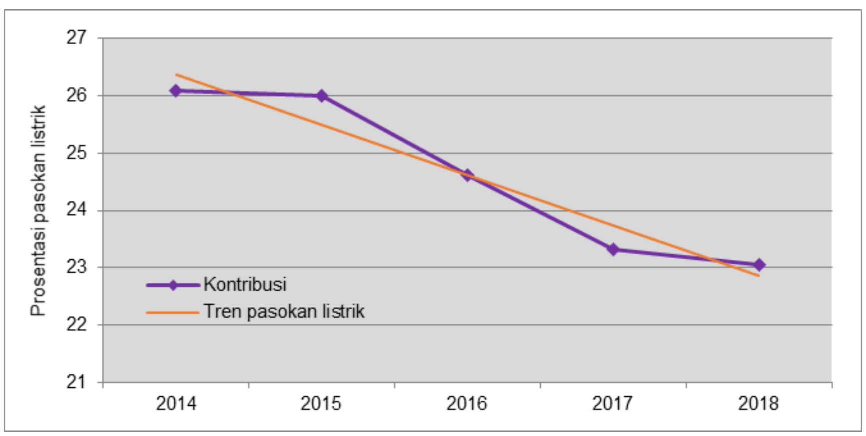

Figure 1.1 Trend of Contribution of PT. XYZ for Jawa Bali Electricity Supply from 2014-2018

The energy sector, especially power generation, has become a sector that attracts domestic and foreign investors. It is also a priority for a country in the area of investment finance strategy. Therefore, the financing of energy projects is essential for the development of a country. In addition to the urgent need for new generators, a project finance plan is needed as the process requires a lot of funds. PT. XYZ needs cooperation with financial institutions to finance the projects undertaken. High funding and a long repayment period can cause financial institutions to be very concerned about granting investment loans. The main reason is that they have a high risk of default due to several critical factors. This leads financial institutions to simultaneously consider many factors when making financing decisions for power generation projects (He, et al., 2019).

2. METHOD

2.1 LARGE-SCALE PROJECT FUNDING

A few examinations have recommended that the main factor in financing enormous scope projects is the expense of the venture. One of these was done by Mora, et al (2019) who expressed that if the venture cost is too high, monetary foundations are encouraged to put resources into different zones. In view of this, Dell et al (2017) additionally led research on the elements that fundamentally impact the financing of huge scope power projects and presumed that the expense of a venture is the primary concern a monetary establishment intends to contribute. Furthermore, Srivastava (2017) directed similar investigation in India. His exploration presumed that organizations that have a ton of costs can make a task fall flat, so this ought to likewise be considered. Ogino (2016) and Oinarov, et al (2019) led research zeroed in on South Asia and Kazakhstan utilizing the relapse strategy for their exploration and found that the higher the expense of an undertaking, the more the disappointment rate is high.

Cruz and Sarmento (2018) express that organizations with huge obligations will encounter challenges simultaneously, regardless of whether the venture is beneficial. This will make the venture fall flat. In another examination, Thierie and De Moor (2019) led research in Australia, the United States and Europe, reasoning that organizations that can't deal with their resources won't keep going long. Subsequently, the achievement of any significant task will be amazingly troublesome. Alongside comparable examination, Cooper and Nyborg (2018) guarantee that organizations with high liquidity danger will improve the probability of undertaking disappointment.

2.2 BALANCED SCORECARD

In the financial aspect of the BSC approach, issues such as the level of the company's profit, the level of income and effective cost management are taken into account. In addition, the customer dimension includes factors that can increase customer satisfaction, such as meeting customer expectations and handling customer complaints. On the other hand, factors such as the efficiency of communication between departments and the company's technological infrastructure are dealt with in the internal dimension of the BSC. Finally, the dimensions considered important are learning and growth. Included in this dimension are training and development linked to the quality of the company's staff and the training received, as well as the innovation dimension which is now considered more and more important to consider.

The BSC method is a very popular approach in the literature on strategic management. This method has been considered by many researchers in various sectors. For example, Dimitropoulos et al (2017) used this method to assess government effectiveness. Likewise, Ge (2016) focuses on how to improve the performance of local authorities using the BSC method. Ćwiklicki (2017) conducted this research for a non-profit organization. On the other hand, Elkhouty et al (2015) used the BSC method approach to assess the performance of banks. In addition, Dong et al (2016) conducted a BSC approach to analyze energy companies.

2.3 MULTI CRITERIA DECISION MAKING

The multi-models dynamic strategy is a technique utilized essentially for settling on choices when there are numerous rules and options. In the writing, this methodology likewise thinks about fluffy rationale to accomplish an answer in complex conditions. It is conceivable to order this methodology into two particular classes. The main classification concerns the methodology utilized for various weighting measures. For instance, Chou et al (2019) utilize the AHP fluffy strategy for various purposes, for example, dissecting the productivity of HR and wellbeing administrations divisions. Also, Alilou et al (2019) plan to utilize the Fuzzy ANP strategy to perform examines on human turn of events and natural issues. Hence, the interior reliance between the models can be defeated in this investigation. Then again, Lo, et al (2019) plan to utilize the fluffy DEMATEL strategy to gauge re-association models, internet business execution and measure ecological supportability. With the assistance of the DEMATEL fluffy methodology, a relationship sway guide can be made. Dinçer et al (2020) express that the fluffy DEMATEL approach can be executed with a kind 2 fluffy span rationale.

The second evenhanded of this multi-measures dynamic model is to arrange various other options. In this specific situation, a few weighted models are considered. For instance, Chou (2019) and Mohsin (2019) utilize the TOPSIS fluffy technique for various purposes, like estimating mechanical execution and breaking down energy effectiveness. Also, Liang, et al (2019), and Gul, et al (2019) essentially with the point of evaluating the nature of Internet banking sites, the determination of coordinations accomplices and the thought of dangers in the mining business. Then again, Arabsheybani, et al (2018) and Gürbüz and Erdinç (2018) center around choosing economical providers, distinguishing the ideal blend for unadulterated titanium, and deciding the best lodging utilizing the fluffy MOORA . With the assistance of this methodology, both positive and negative standards can be considered in this investigation. Truth be told, Demirel, et al (2019), Dong, et al (2018), and Liang, et al (2019) directed an examination positioning different options utilizing QUALIFLEX fluffy rationale. Positioning few options as per the degree of significance isn't simple utilizing the multi-models fluffy dynamic strategy. In any case, such an examination is conceivable utilizing the QUALIFLEX fluffy technique. This methodology additionally utilizes the sort 2 fluffy span rationale approach, however the quantity of studies is exceptionally restricted.

In light of the current writing, research on the financing of enormous scope power plant projects utilizing fluffy rationale has never been directed. In this exploration, the DEMATEL fluffy IT2 and QUALIFLEX fluffy IT2 strategies are utilized to decide the dynamic of enormous scope power plant projects. Along these lines, this investigation will supplement the writing on the financing of huge scope projects.

2.3.1 IT2 FUZZY DEMATEL

A decision method is mainly used for a significant level case. In addition, it is possible to visualize the impact relationship map using this method. It is therefore very useful to understand the causal relationship between different elements. The DEMATEL approach can be deepened by using IT2 fuzzy logic. The decision-making assessment is provided in the first aspect. After that, they are converted to fuzzy sets. The DEMATEL technique has the following advantages: DEMATEL efficiently analyzes the interplay (both direct and indirect) between different factors and understands the complex cause and effect relationships in decision making problems. It is able to visualize the relationship between the factors and allows decision makers to clearly understand which factors are influencing each other. DEMATEL can be used not only to rank alternatives, but also to determine critical endpoints and measure the weight of endpoints.

2.3.2 IT2 FUZZY QUALIFLEX

QUALIFLEX is a type of multi-criteria decision-making method which, in this study, aims to determine the ranking of several different financial institutions. The main advantage of this approach is that it provides flexibility with the correct handling of cardinal and ordinal information. Another advantage is that this method is good to use even if the selected objects are few. Compared to other MCDM approaches, such as the Ideal Solution Similarity Order Preference Techniques (TOPSIS), the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) and 'Weighted Total Sum Product Assessment (WASPAS). Wang et al (2017) stated that the real advantages of the QUALIFLEX approach can be summarized as follows: (1) The calculation process is very simple and easy to use and implement; (2) Can effectively process title and ordinal information according to different criteria in MCDM problems; and (3) It is suitable for dealing with MCDM problems that involve a reduced number of criteria and alternatives.

3. RESULTS AND DISCUSSION

3.1 Balanced Scorecards

Table 3.1 Focus Group Discussion “Dematel” Result

NO	PERSEPECTIVE	DIMENSION	CRITERIAS
1	Finance	Project Performance	Investment Cost
			Return on Investment
2	Customer	Corporate Reputation	Financial Reputation
			Market Reputation
3	Internal Business Process	Operational Effectiveness	Technical and Organizational Effectiveness
			Financial Effectiveness
4	Learning and Growth	Competitive Structure	Growth Potectial
			Market Risks

From focus group discussion with the senior leader results is eight citerias from four dimension.

3.2 DEMATEL

The main technique of data collection is to use the forum group discussion method with the directors of PT. XYZ who have experience in the field of power generation for over fifteen years.

Table 3.2 Focus Group Discussion “Dematel” Result

	C1					C2					C3					C4				
	DM1	DM2	DM3	DM4	DM5	DM1	DM2	DM3	DM4	DM5	DM1	DM2	DM3	DM4	DM5	DM1	DM2	DM3	DM4	DM5
C1	-	-	-	-	-	AT	AT	ST	AT	ST	ST	M	ST	AT	AT	ST	ST	ST	ST	ST
C2	AT	AT	ST	ST	ST	-	-	-	-	-	ST	M	ST	T	T	T	ST	T	ST	ST
C3	T	R	T	R	R	ST	ST	ST	ST	ST	-	-	-	-	-	T	ST	T	ST	ST
C4	T	T	T	T	T	T	ST	ST	ST	ST	MR	ST	T	ST	ST	-	-	-	-	-
C5	ST	ST	T	T	ST	MR	MR	MR	MR	MR	T	MR	MR	MR	MR	R	MR	R	MR	MR
C6	ST	AT	T	T	ST	T	ST	T	ST	ST	R	T	T	T	T	R	MR	R	MR	MR
C7	R	MR	MR	R	MR	SR	R	R	R	R	MR	R	R	R	R	MR	R	R	R	R
C8	M	R	M	R	MR	SR	SR	SR	SR	SR	MR	R	R	R	R	MR	R	R	R	R

	C5					C6					C7					C8				
	DM1	DM2	DM3	DM4	DM5	DM1	DM2	DM3	DM4	DM5	DM1	DM2	DM3	DM4	DM5	DM1	DM2	DM3	DM4	DM5
C1	T	MT	T	MT	MT	ST	ST	ST	ST	ST	MR	R	R	R	R	ST	ST	ST	ST	ST
C2	T	T	T	T	T	ST	ST	ST	ST	ST	MR	MR	MR	MR	MR	ST	ST	ST	ST	ST
C3	MT	MT	MT	MT	MT	ST	ST	ST	ST	ST	MR	MR	MR	MR	MR	MR	R	R	R	R
C4	T	T	T	T	T	MT	T	MT	T	T	MR	MR	MR	MR	MR	MR	R	R	R	R
C5	-	-	-	-	-	MT	T	MT	T	T	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR
C6	T	T	T	T	T	-	-	-	-	-	MR	MR	MR	MR	MR	MR	MT	MR	MT	MT
C7	MR	R	R	R	R	MR	R	R	R	R	-	-	-	-	-	MR	R	R	R	R
C8	MR	R	R	R	R	MR	R	R	R	R	MR	R	R	R	R	-	-	-	-	-

From the results of interviews with sources, a direct relation matrix is determined:

$$\mathbf{X}=\begin{bmatrix} 0 & 8{,}6 & 7{,}8 & 8{,}0 & 6{,}4 & 8 & 4 & 8 \\ 8{,}4 & 0 & 7 & 7{,}6 & 7 & 8 & 4 & 8 \\ 7 & 8 & 0 & 7{,}6 & 6 & 8 & 4 & 4 \\ 7 & 7{,}8 & 7 & 0{,}0 & 7 & 6{,}6 & 4 & 4 \\ 7{,}6 & 4 & 4{,}6 & 4{,}0 & 0 & 6{,}6 & 4 & 4 \\ 7{,}8 & 7{,}6 & 7 & 4{,}0 & 7 & 0 & 2 & 5{,}2 \\ 4 & 2 & 4 & 4{,}0 & 4 & 4 & 0 & 4 \\ 4{,}6 & 2 & 4 & 4{,}0 & 4{,}0 & 4 & 4 & 0 \end{bmatrix}$$

Determine the Y matrix with the formula:

$$Y = k.A$$

Where *k:*

$$k=\frac{1}{\max\left(\sum_{i=1}^{n} a_{ij}\right)}, \text{ where i,j=1,2…n}$$

By adding up all the rows in the Y matrix to get the highest value, k is 50.8. So that the Y matrix is obtained as follows:

$$Y=\begin{bmatrix} 0{,}00000 & 0{,}16929 & 0{,}15354 & 0{,}15748 & 0{,}12598 & 0{,}15748 & 0{,}07874 & 0{,}15748 \\ 0{,}16535 & 0{,}00000 & 0{,}13780 & 0{,}14961 & 0{,}13780 & 0{,}15748 & 0{,}07874 & 0{,}15748 \\ 0{,}13780 & 0{,}15748 & 0{,}00000 & 0{,}14961 & 0{,}11811 & 0{,}15748 & 0{,}07874 & 0{,}07874 \\ 0{,}13780 & 0{,}15354 & 0{,}13780 & 0{,}00000 & 0{,}13780 & 0{,}12992 & 0{,}07874 & 0{,}07874 \\ 0{,}14961 & 0{,}07874 & 0{,}09055 & 0{,}07874 & 0{,}00000 & 0{,}12992 & 0{,}07874 & 0{,}07874 \\ 0{,}15354 & 0{,}14961 & 0{,}13780 & 0{,}07874 & 0{,}13780 & 0{,}00000 & 0{,}07874 & 0{,}10236 \\ 0{,}07874 & 0{,}03937 & 0{,}07874 & 0{,}07874 & 0{,}07874 & 0{,}07874 & 0{,}00000 & 0{,}07874 \\ 0{,}09186 & 0{,}03937 & 0{,}07874 & 0{,}07874 & 0{,}07874 & 0{,}07874 & 0{,}07874 & 0{,}00000 \end{bmatrix}$$

Then reduce the identity matrix with Y, so that we get:

$$I-Y=\begin{bmatrix} 1 & -0{,}169291 & -0{,}153543 & -0{,}15748 & -0{,}125984 & -0{,}15748 & -0{,}07874 & -0{,}15748 \\ -0{,}165354 & 1 & -0{,}137795 & -0{,}149606 & -0{,}137795 & -0{,}15748 & -0{,}07874 & -0{,}15748 \\ -0{,}137795 & -0{,}15748 & 1 & -0{,}149606 & -0{,}11811 & -0{,}15748 & -0{,}07874 & -0{,}07874 \\ -0{,}137795 & -0{,}153543 & -0{,}137795 & 1 & -0{,}137795 & -0{,}129921 & -0{,}07874 & -0{,}07874 \\ -0{,}149606 & -0{,}07874 & -0{,}090551 & -0{,}07874 & 1 & -0{,}129921 & -0{,}07874 & -0{,}07874 \\ -0{,}153543 & -0{,}149606 & -0{,}137795 & -0{,}07874 & -0{,}137795 & 1 & -0{,}07874 & -0{,}102362 \\ -0{,}07874 & -0{,}03937 & -0{,}07874 & -0{,}07874 & -0{,}07874 & -0{,}07874 & 1 & -0{,}07874 \\ -0{,}091864 & -0{,}03937 & -0{,}07874 & -0{,}07874 & -0{,}07874 & -0{,}07874 & -0{,}07874 & 1 \end{bmatrix}$$

Next, do an inverse matrix (I-Y) which is the Total Relation Matrix.

Next, after determine the value of cause and effect, determine the threshold value by looking for the average value of the total relation matrix, so that the threshold value is 0.494405.

Then determine the Total Relationship Matrix by finding the average value of the Y matrix:

	C1	C2	C3	C4	C5	C6	C7	C8	Rata-rata	Peringkat
T-Matriks	0,582382	0,666071	0,659415	0,635432	0,63609	0,705435	0,432854	0,612422	0,616	1
C2	0,71429	0,511298	0,637963	0,620053	0,636034	0,695336	0,426722	0,6044	0,606	2
C3	0,651358	0,612483	0,479259	0,584286	0,583214	0,654947	0,399328	0,505921	0,559	3
C4	0,636332	0,594782	0,586116	0,441269	0,584847	0,619011	0,390237	0,493655	0,543	4
C5	0,545724	0,446035	0,459175	0,429141	0,373956	0,521296	0,32984	0,413647	0,440	6
C6	0,635388	0,578571	0,574002	0,504817	0,57245	0,491348	0,382722	0,503989	0,530	5
C7	0,378425	0,312965	0,349143	0,334419	0,348403	0,371648	0,190308	0,321905	0,326	8
C8	0,397676	0,321068	0,357165	0,342149	0,356141	0,38023	0,268566	0,256363	0,335	7
	0,568	0,505	0,513	0,486	0,511	0,555	0,353	0,464		
Threshold	0,494405									

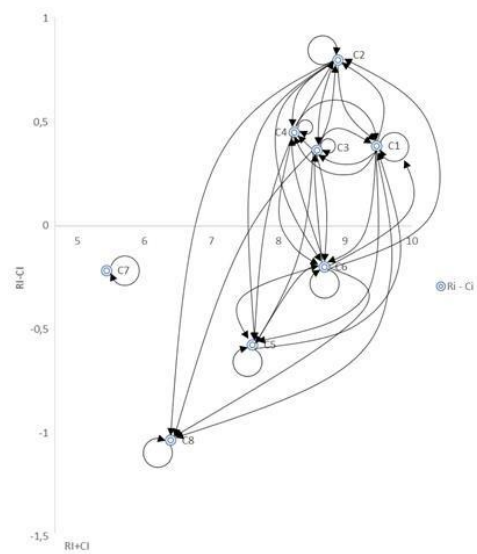

Figure 2. Intercorrelation map

Considering the intercorrelation map in Figure 4.2, as well as the cause and effect values of the attributes, general learning ability (C5) has a higher priority than the other attributes, and the final ranking is as follows:

C1>C2>C3>C4>C6>C5>C8>C7

3.3 QUALIFLEX

Table 3. Focus Group Discussion "Qualiflex" Result

No	Criterias	ECA (Export Credit Agency)			Association of State Owned Banks & foreign private sector			ECA guaranteed foreign private banks		
		DM1	DM2	DM3	DM1	DM2	DM3	DM1	DM2	DM3
1.	Ability to provide funding	AB	SB	B	MB	MB	MB	MB	MB	B
2.	Interest rate	SB	SB	SB	SB	SB	SB	B	B	B
3.	Financial Reputation	SB	SB	SB	AK	AK	AK	MB	AK	MB
4.	Financial Institution Requirements	MB	B	MB	SB	SB	SB	SB	B	SB
5.	Ability to meet the requirements of financial institutions	B	B	B	SB	SB	AB	AB	SB	SB

Make a decision matrix by making the average value of the criteria:

$$\mathbf{X} = \begin{bmatrix} 8 & 6 & 6,3 \\ 8 & 8 & 7 \\ 8 & 5 & 5,67 \\ 6,33 & 8 & 7,67 \\ 7 & 8,33 & 8,3 \end{bmatrix}$$

Determine transpose matrix X, X^T:

$$C_1 = 1$$

Determine *initial ranking* as alternative:

$$X^T = \begin{array}{c} A_1 \\ A_2 \\ A_3 \end{array} \begin{bmatrix} 1 & 1 & 1 & 3 & 2 \\ 3 & 1 & 3 & 1 & 1 \\ 2 & 2 & 2 & 2 & 1 \end{bmatrix}$$

From the results of Permutation 1 to Permutation 6, the permutation values are obtained as follows:

	C1	C2	C3	C4	C5	$\bar{X}$
Per1	1	2	1	-1	-2	**0,2**
Per2	-1	2	-1	1	0	**0,2**
Per3	-1	-2	-1	1	2	-0,2
Per4	-1	-2	-1	1	0	-0,6
Per5	1	-2	1	-1	0	-0,2
Per6	3	0	3	-3	0	**0,6**

From the table of permutation values, Permutation 6 is obtained as the permutation with the largest value.

$$Per_6 = A_1 > A_3 > A_2$$

So the results show that the ECA (Export Credit Agency) is the best financial institution to fund power plant projects.

Since the size of the investment cost of the project is the main factor for financial institutions to consider when granting loans and the payback period as the second factor, the financial aspect is the main factor to consider. for a financial institution in the financing of the big power plant project.

In this study using IT2 DEMATEL and QUALIFLEX in the analysis of decision making, the analysis using other MCDM methods to compare.

The use of the interview method to collect data on sources should be done separately to reduce opinion interference between one source and another.

4. CONCLUSSION

Using the Balanced Scorecard method to determine the factors that influence financial institutions in making a decision to finance a project provides eight criteria, namely investment costs, investment payback time , the project's financial reputation, market reputation, technical and organizational efficiency, financial efficiency, potential development and market risk.

The investment cost is the first factor observed by financial institutions to finance the Java-9 & 10 project. The second factor is the payback period of the investment. The financial reputation of the father of the company, PT XYZ and PT. DEF, are the third factors that influence financial institutions in granting loans. The fourth factor is the commercial reputation of the father of the company. The fifth factor is the financial efficiency of the power plant project. The sixth factor is the technical and organizational efficiency of the Java-9 & 10 project. The seventh factor is the market risk and the last factor is the potential growth of the power plant project.

The best financial institutions to finance the Java 9 & 10 project are the ECA (Export Credit Agency), then the foreign private bank which is guaranteed by the ECA and the last financial institution is a consortium of himbara and foreign private banks.

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6. REFERENCES

Alilou, H. et al., 2019. Evaluation of watershed health using Fuzzy-ANP approach considering geo-environmental and topo-hydrological criteria. *Environment Management,* Volume 232, pp. 22-36.

Arabsheybani, A., Paydar, M. & Safaei, A., 2018. An integrated fuzzy MOORA method and FMEA technique for sustainable supplier selection considering quantity discounts and supplier's risk. *Journal of cleaner production,* Volume 190, pp. 577-591.

Chou, Y., Yen, H., Dang, V. & Sun, C., 2019. Assessing the Human Resource in Science and Technology for Asian Countries: Application of Fuzzy AHP and Fuzzy TOPSIS. *Symmetry,* 11(2), p. 251.

Cooper, I. & Nyborg, K., 2018. Consistent valuation of project finance and LBOs using the flows-to-equity. *Eur. Financ. Manag.,* Volume 24, pp. 34-52.

Cruz, C. O. & Sarmento, J. M., 2018. The price of project finance loans for highways. *Economics,* Volume 70, pp. 161-172.

Ćwiklicki, M., 2017. Applying Balanced Scorecard in Non-Government Organizations. In: *Decision Management: Concepts, Methodologies, Tools, and Applications.* s.l.:IGI Global, pp. 902-923.

Dell, R. W., Hendrickson, S. H., Hadley, S. W. & Chinthavali, S., 2017. The geography of project finance in US electricity generation Electricity. *The Electricity Journal,* 30(7), pp. 8-17.

Demirel, H., Akyuz, E., Celik, E. & Alarcin, F., 2019. An interval type-2 fuzzy QUALIFLEX approach to measure performance effectiveness of ballast water treatment (BWT) system on-board ship. *Ships Offshore Struct.,* Volume 14, pp. 675-683.

Dimitropoulos, P., Kosmas, I. & Douvis, I., 2017. Implementing the balanced scorecard in a local government sport organization. *International Journal of Productivity and Performance Management,* Volume 66, pp. 362-379.

Dinçer, H., Yüksel, S., Canbolat, Z. & Pınarba¸sı, F., 2020. Data Mining-Based Evaluating the Customer Satisfaction for the Mobile Applications: An Analysis on Turkish Banking Sector by Using IT2 Fuzzy DEMATEL. In: *Tools and Techniques for Implementing International E-Trading Tactics for Competitive Advantage.* PA, USA: IGI Global, pp. 320-339.

Dong, J., Chen, Y. & Wan, S., 2018. A cosine similarity based QUALIFLEX approach with hesitant fuzzy linguistic term sets for financial performance evaluation. *Appl. Soft Comput.,* Volume 69, pp. 316-329.

Dong, J., Xue, G. & Li, X., 2016. *Value Evaluation of Integrated Energy Services Based on Balanced Scorecard.* Guangzhou, Atlantis Press.

Elkhouty, S., Ibrahim, M., ElFrargy, M. & Kotb, A., 2015. Measuring the effectiveness of banking risk balanced scorecard in enhancing bank value. *Int. J. Econo. Financ*, Volume 7, pp. 139-152.

Ge, L., 2016. *Exploration of Balanced Scorecard-Based Government Performance Management in China.* Kumming, Atlantis Press.

Gul, M., Ak, M. & Guneri, A., 2019. Pythagorean fuzzy VIKOR-based approach for safety risk assessment in mine industry. *Journal of Safety Research,* Volume 69, pp. 135-153.

Gürbüz, F. & Erdinç, G., 2018. *Selecting The Best Hotel Using The Fuzzy-Moora Method With a New Combined Weight Approach.* Ankara, s.n., pp. 1-8.

He, L. et al., 2019. Green credit, renewable energy investment and green economy development: Empirical analysis based on 150 listed companies of China. *Journal of Cleaner Production,* Volume 208, pp. 363-372.

Liang, D., Zhang, Y., Xu, Z. & Jamaldeen, A., 2019. Pythagorean fuzzy VIKOR approaches based on TODIM for evaluating internet banking website quality of Ghanaian banking industry. *Appl. Soft Comput. ,* Volume 78, pp. 583-594.

Liang, W., Dai, B., Zhao, G. & Wu, H., 2019. Assessing the Performance of Green Mines via a Hesitant Fuzzy ORESTE–QUALIFLEX Method. *Mathematics,* Volume 7, p. 788.

Lo, H., Liou, J. & Tzeng, G., 2019. Comments on “Sustainable recycling partner selection using fuzzy DEMATEL-AEW-FVIKOR: A case study in small-and-medium enterprises. *Journal of cleaner production,* Volume 228, pp. 1011-1012.

Lu, Z. et al., 2015. Social impact project finance: An innovative and sustainable infrastructure financing framework. *Procedia Engineering,* Volume 123, pp. 300-307.

Ma, T., 2016. Basel III and the future of project finance funding. *Mich. Bus. & Entrepreneurial L. Rev.,* 6(109).

Mohsin, M. et al., 2019. Economic assessment and ranking of wind power potential using fuzzy-TOPSIS approach. *Environ. Sci. Pollut. Res,* Volume 26, p. 22494–22511.

Mora, E. B., Spelling, J., Weijde, A. H. v. d. & Pavageau, E.-M., 2019. The effects of mean wind speed uncertainty on project finance debt sizing for offshore wind farms. *Applied Energy,* Volume 252, p. 113419.

Ogino, K., 2016. Conflicts of decision-making processes between Clean Development Mechanism and project financing. *Development in Practice,* 26(8), pp. 1083-1093.

Oinarov, A. R., Eshimova, D. & Adilbekova, B., 2019. Public policy on public-private project financing in Kazakhstan. *Journal of Asian Public Policy,* 12(2), pp. 228-256.

Srivastava, V., 2017. Project finance bank loans and PPP funding in India: A risk management perspective. *Journal of Banking Regulation ,* Volume 18, pp. 14-27.

Thierie, W. & De Moor, L., 2019. Determinants of bank loan spread in project finance. *International Journal of Managing Projects in Business,* 12(1), pp. 161-186.

Thierie, W. & De Moor, L., 2019. Loan tenor in project finance. *International Journal of Managing Projects in Business,* Volume 12.

ANALYSIS OF THE INTERNAL CONTROL SYSTEM IN THE PAYROLL CYCLE AT THE DIRECTORATE GENERAL FOR MULTILATERAL COOPERATION AFFAIRS

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ABSTRACT

The background of this research is data findings from examiners which indicate that there is an error in the employee performance allowance payment system at the Directorate General for Multilateral Cooperation Affairs, which is resulting in an overpayment. To explore this problem, the researcher analyzed the internal control system especially in the control activity component for the payroll cycle with the aim of finding out the weaknesses of the internal control system in the payroll cycle and to analyze the improvement that to be made. This research using a case study approach with a single unit analysis. The data used in this research are secondary data such as standard operating procedures, regulations and internal document. The analysis technique of this research is a literature study where the data analysis is carried out using the COSO framework which has been adopted to the public sector environment in Indonesia. The result of this study indicates that there are weaknesses in the control activity components, such as inadequate standard operating procedures, inadequate document authorization and inaccurate data recording. Based on that, it is expected that the Directorate General for Multilateral Cooperation Affairs can make improvements to the internal control system especially at control activity component, in ways such as to design standard operational procedure for each activity, data validation prior to authorization and record data in a timely manner.

Keywords: COSO, internal control, payroll cycle.

1. INTRODUCTION

In the reform era, the government has issued 3 (three) packages of State Finance Laws, namely Law (UU) No.17 of 2003 concerning State Finance, Law (UU) No. 1 of 2004 concerning State Treasury and Law (UU) No. 15 of 2004 concerning Audit of Management and Accountability of State Finances. The package of the State Finance Law is one of the government's efforts to achieve transparency and accountability in the management of state finances. In accordance with the mandate of the package of the State Finance Law, the government is required to carry out the administration and accountability of the APBN in a transparent and accountable manner through orderly, efficient and effective administration of government activities.

Law No.1 of 2004 states that the management of the APBN should be carried out based on an adequate internal control system with the aim of providing adequate confidence that the management of state finances has been carried out in line with the government's objectives, namely effective and efficient government activities, reliability of financial reporting, security of state assets and regulatory compliance. In order to carry out the mandate of Law No.1 of 2004, the government has issued Government Regulation (PP) No.60 of 2008 concerning Government Internal Control System (SPIP) which states that the minister / head of the institution is obliged to exercise control over the implementation of government activities to achieve financial management which effective, efficient, transparent and accountable.

The internal control system framework in the PP is based on the framework developed by the Committee of Sponsoring Organizations of Treadway Commission (COSO) in 1992, so that the definition of the internal control system stated in Government Regulation No.60 of 2008 is in line with the internal control defined by COSO. Furthermore, Government Regulation No.60 of 2008 defines an internal control system as an integral process of actions and activities carried out continuously by the leadership and all employees to provide adequate confidence in the achievement of organizational goals through effective and efficient activities, reliability of financial reporting, security state assets, and compliance with laws and regulations.

Based on the 1945 Constitution, the Supreme Audit Agency (BPK) is an institution given the mandate to carry out audits of the management and accountability of state finances. In the context of the internal control system, one of the powers of the BPK in accordance with the mandated task is to evaluate the effectiveness of the implementation of the government's internal control system. In accordance with Law No.15 of 2006 concerning the Supreme Audit Agency, the results of the BPK audit consist of the results of audits of financial reports, the results of performance audits and the results of audits with a specific purpose. It is further explained that the results of an examination with a specific objective include an examination of the internal control system and an examination of compliance with laws and regulations. The BPK examination with a specific purpose aims to reveal any indication of state loss or criminal elements.

The Directorate General of Multilateral Cooperation Affairs is one of the working units in the Ministry of Foreign Affairs. In carrying out its duties and functions, the Directorate General of Multilateral Cooperation Affairs is required to not only focus on substance aspects but also administrative aspects related to the management of state finances. One of them is the obligation to prepare financial reports every year which will then be consolidated with the financial statements of the Ministry of Foreign Affairs as a whole. Furthermore, the BPK as an institution in charge of examining the management and responsibility of state finances will audit the Ministry of Foreign Affairs' financial reports and then provide an opinion on the fairness of the presentation of financial statements. In the examination of these financial statements, the BPK will evaluate the internal control system implemented at the Ministry of Foreign Affairs as well as test compliance with laws and regulations.

Based on the results of the BPK examination in 2017, the Directorate General of Multilateral Cooperation Affairs was one of the working units that did not comply with statutory provisions on the main findings of the BPK, namely regarding the payment of performance allowances, and the findings continued to repeat themselves until 2019. From the results of BPK's investigation of evidence accountability for personnel spending at the Directorate General of Multilateral Cooperation Affairs working unit, it is known that there has been an overpayment of performance allowances to employees who have been placed in Indonesian Representatives abroad (the embassy of the Republic of Indonesia) because there is still a weakness in the internal control system over the payment of performance allowances. The results of the examination stated that there were still employees at the Directorate General of Multilateral Cooperation Affairs working unit who had received a portion of the performance allowance in the month concerned had left for the Indonesian Representatives abroad, whereas this was contrary to the provisions of the Regulation of the Minister of Foreign Affairs No.4 of 2013 which stated that the employees who had been on duty Representatives of the Republic of Indonesia cannot receive a performance allowance because when they arrive at the Indonesian Representatives abroad, the employee concerned will receive an Overseas Livelihood Allowance (TPLN).

In accordance with the description above, it is necessary to carry out an analysis of internal control, especially in the control activity component of the payroll system related to the payment of performance allowances at the Directorate General of Multilateral Cooperation Affairs. Analysis of these components needs to be carried out to determine weaknesses in the policies or procedures implemented, considering that the BPK has discovered errors in the payment of performance allowances for 3 (three) consecutive years.

2. METHOD

This research is a research using a case study approach where this method focuses on research by collecting information from an object of research (Sekaran, 2013). This approach was chosen because the authors wanted to see and know more clearly and significantly related to the problem of implementing an internal control system in the payroll cycle, especially in the control activity components. To determine the application of the internal control system, this study uses a single unit analysis, namely the payroll cycle for the payment of performance allowances for employees of the Directorate General of Multilateral Cooperation Affairs.

The data used in this research are only secondary data. Secondary data obtained by the authors include examples of attendance results, detailed list of performance allowances, standard operating procedures, Regulation of the Minister of Foreign Affairs No. 4 of 2013, Regulation of the Minister of Foreign Affairs No.2 of 2016, BPK audit reports, strategic plan documents and risk register documents. In this research, data analysis was carried out using the COSO framework which has been adapted to the public sector environment in Indonesia, as stated in Government Regulation No.60 of 2008 concerning Government Internal Control Systems. Data analysis was performed by evaluating the elements associated with the control activity components. The elements of the control activity components are described in table 1 below:

Table 1. List of Component Elements of Control Activities

No	Principles of Control Activities	Analyzed Element
1.	Government agencies select and develop control activities	1. There is a separation of functions, duties and responsibilities for a transaction. 2. Government agencies have set the terms and conditions for authorization. 3. Accurate recording of the entire transaction cycle.
2.	Government agencies select and develop general control activities over information technology	1. Government agencies have implemented safeguard for information technology system. 2. Government agencies have implemented access restrictions. 3. Government agencies documenting risk assessments of information technology systems.
3.	Government agencies implement policies and procedures for implementing policies	Government agencies documenting policies and procedures for all transactions or activities.

3. RESULTS AND DISCUSSION

3.1 Results

Based on the analysis using the COSO framework, the result obtained that there are still weaknesses in the component of control activities. One thing that needs special attention in this component is the inadequate standard operating procedures because the standard operating procedures implemented at the Directorate General of Multilateral Cooperation Affairs do not currently cover all transactions or activities. For example, there is no standard operating procedure related to the use of information technology systems or the payment of performance allowances.

Related to the payroll cycle, the standard operating procedure used is the payment of salaries, but basically the activities / transactions in this cycle are not only related to salary payments, but there are also performance allowance payments or other employee financial rights, so that the use of these standard operating procedures is not suitable. The absence of standard operating procedures will result in no clear separation of duties and functions and inappropriate authorization. The existence of this condition ultimately causes an error in calculating the employee performance allowance which is the object of the findings of the examiner, which is due to the absence of clear procedures so that the official authorized to authorize payment documents does not make data matching / reconciliation and does not validate existing data.

3.2 Discussion

The component of control activities is the implementation of policies and procedures to help ensure that every risk has been properly handled. The elements of control activities are:

1) Government agencies select and develop control activities

Related to the payroll cycle, according to the standard operating procedure document obtained, the Directorate General of Multilateral Cooperation Affairs has implemented a separation of duties and powers so that there are no concurrent positions or functions. The separation of duties and functions is described as follows:

a. Human Resources Function

These duties and functions are carried out by the general and human resources departments. In the payroll cycle, the general and human resources departments have the duty to determine the level of salary and benefits of each employee, update employee salary data if there is an increase in rank or class, transfer or dismissal of employees.

b. Attendance Record Function

These tasks and functions are carried out by the general and human resources departments using the Attendance Management System (AMS) application. AMS is a presence tool owned by the Ministry of Foreign Affairs and managed by the Bureau of Human Resources (HR), which functions to record evidence of employee attendance (presence) by taking into account the time of arrival and return.

c. Payroll Function

These tasks and functions are carried out by PPABP which is under the finance department. From the results of attendance records carried out by the general and human resources departments, PPABP will then input them into the GPP application, so that it will produce a list of salaries and benefits.

d. Financial Function

These duties and functions are carried out by several employees in the finance department, they are:

i) SAS application operators
After PPABP has made a list of salaries and benefits, the list will then be inputted into the SAS application to make SPP. SPP will be submitted to PPK for authorization. Then when the PPK has approved it, the operator will make an SPM document. The SPM will be authorized by PPSPM and after that it will be sent to KPPN to get approval for disbursement, which is usually marked by the issuance of the SP2D document.

ii) Treasurer
After the SP2D document is available, the treasurer will disburse the salary and allowances by using a check and hand it over to the bank for transfer of funds to each employee of the Directorate General of Multilateral Cooperation Affairs.

e. Accounting Functions
These tasks and functions are carried out by the reporting and accounting department under the finance department. The SP2D document will be recorded by the head of the accounting subdivision as data for preparing financial statements.

From these functions, the payroll cycle activities that have been running at the Directorate General of Multilateral Cooperation Affairs so far are described as follows:

a. Payroll Master Data
This activity is carried out by the general and human resources departments, because the entire personnel administration management of the Directorate General of Multilateral Cooperation Affairs is carried out through the general and human resources departments. In the payroll cycle, if there is a change in employee status, for example an increase in rank or class, the employee master data will be immediately updated by the general and human resources department, in accordance with a decree issued by the HR Bureau, so that if PPABP will compile the salary list for the following month, the data is already is the most recent data.

b. Validate Time and Attendance Data
This activity is also carried out by the general and human resources departments. At the Directorate General of Multilateral Cooperation Affairs, usually the task of validating time and attendance data is the personnel sub-section. Validation of time and attendance data is required in order to pay performance allowances. This is in accordance with the mandate of Regulation of the Minister of Foreign Affairs No.4 of 2013 which states that the amount of the performance allowance is calculated based on employee attendance. Meanwhile, in paying salaries, this activity is not necessary because basically the salaries of civil servants will always be paid in full every month without being influenced by employee attendance data. Employee attendance data is obtained from the AMS application which will then be validated again by the personnel sub-section. Usually in validating attendance data, the personnel sub-section will match the employee's official travel data, because if an employee goes on an official trip, the person will not make attendance at the office, but the performance allowance cannot be deducted because the official trip is part of task. However, there are weaknesses in this data validation where official travel data is not always updated on time because they have to wait for employees to return from their official trips. Another weakness is related to the transfer employees to Representatives of the Republic of Indonesia, where the performance allowance should be stopped when the employee has left for duty, but the departure time data is usually not submitted directly to the personnel sub-section as a basis for validating attendance data.

c. Prepare the Payroll

This activity is carried out by PPABP of the Directorate General of Multilateral Cooperation Affairs. In preparing the payroll, PPABP will be guided by the employee salary master data produced by the general and human resources departments so that if the data is not yet up to date, there will be a risk of errors in calculating the amount of employee salaries. In addition, in relation to the payment of performance allowances, PPABP is also preparing a list of performance allowances that are guided by the master data and the results of attendance data validation carried out by the personnel sub-section. However, if there is an error in validating the attendance data due to the weaknesses mentioned above, the risk of calculating the performance allowance will also occur.

d. Disburse Payroll

This activity is carried out by the finance department. In accordance with standard operating procedures, the stages of disbursement are:

i) After PPABP prepares list of salary generated through the GPP application, then the list will be submitted to the SAS operator to be inputted into the SAS application and a Payment Order (SPP) and Payment Order (SPM) will be made;
ii) Subsequently, the SPP and SPM will be submitted to the Commitment Making Officer (PPK) and the Official Signing the Payment Order (PPSPM) for approval. PPK and PPSPM will match the SPP and SPM suitability with the salary list prepared by PPABP;
iii) If it has been authorized, then the SPM document will be sent to the State Treasury Service Office (KPPN) along with the GPP Computer Data Archive (ADK) as an attachment. The SPM functions as an order letter to the state treasury to disburse an amount of funds as stated in the SPM;
iv) Then the KPPN will check the suitability of the SPM data with the ADK GPP and if it is suitable, the KPPN will issue a Fund Disbursement Order (SP2D) and submit it to the correspondent bank of the state treasury. The SP2D functions as an order to make payments / transfers of funds to the unit treasurer account or to employee accounts.

e. Calculate Employer Tax and Deductions

This activity is carried out by PPABP. In this activity PPABP will compile a recapitulation of tax deductions that have been deducted from the salary of each employee and deposit it into the state treasury every month. The tax deduction data is obtained from salary master data. In addition, PPABP will also compile a recapitulation of health insurance that have been deducted from each employee's salary and deposit it to the insurance agency every month.

In authorizing documents, the official authorized must pay attention to the completeness and validity of the documents as required in the existing standard operating procedures. Due to weaknesses in data validation in salary payment activities, the official authorized rarely validate data before authorizing a document, which can lead to errors in calculating salaries and benefits. In addition, the separation of functions aims to ensure that each transaction has been recorded accurately by the related functions in accordance with established procedures. However, as previously mentioned, with regard to payroll cycles, there are still data / transactions that are not recorded in a timely manner, such as data on mutations or official trips.

2) Government agencies select and develop general control activities over information technology.

Regarding the payroll cycle activity, the Directorate General of Multilateral Cooperation Affairs has utilized information technology so that it is no longer done manually. Some of the information technology used in these activities includes:

a. The AMS application, which is a presence tool that is owned by the Ministry of Foreign Affairs and is managed by the HR Bureau whose function is to record evidence of employee attendance by displaying arrival times and return times.
b. The GPP application is an application created by the Ministry of Finance in order to support the administrative management of civil servant expenditure, which functions to calculate various types of civil servant salaries and allowances. Through this application, the management of employee expenditure administration will be easier and can also produce data with high accuracy and save more energy and time.
c. The SAS application is a desktop-based application that is used as a means to create contract data, treasurer bookkeeping, treasury fund withdrawal plans, Payment Orders (SPP), Payment Orders (SPM), and treasurer accountability reports.

The existence of these three applications is very helpful in the payroll cycle activity, but the three applications are not applications designed by the Directorate General of Multilateral Cooperation Affairs themselves so that they have weaknesses if an error occurs in the application, they cannot be fixed immediately. Based on these conditions, this research did not obtain standard operational procedures documents for the use of these three applications, so that the security of information and data in them is prone to being stolen or changed. The only security applied to the three applications is the request for a password before logging into the application. However, from the information available, a password can be given to anyone who wants to access the application. Furthermore, the absence of standard operating procedures causes access to the use of the three applications to become uncontrollable, which means that anyone can access the three applications as long as they know the existing password. Operators for the three applications were only determined verbally, resulting in minimal responsibility for application security. Furthermore, according to the existing risk register document, the Directorate General of Multilateral Cooperation Affairs has not carried out risk identification up to the activity or transaction level. This has resulted in no risk assessment of the use of information technology systems.

3) Government agencies implement policies and procedures for implementing the policies.

Every operating activity, whatever its form and type, requires clear guidelines in its implementation, which are usually outlined in a policy and procedure. In the payroll cycle activity, the Directorate General of Multilateral Cooperation Affairs has prepared standard operating procedures for paying salaries with the aim of ensuring a clear separation of duties and authorizations. However, due to the large number of transactions that must be carried out in the payroll cycle, more detailed policies and procedures are required for each transaction. For example, regarding the use of information systems that have been discussed previously, requires separate procedures so that information security can be maintained. Or in relation to the payment of performance allowances, it is necessary to develop a standard operating procedure separately from the existing procedure, considering that the procedure for paying salaries is different from the procedure for paying performance allowances. From the policy and procedure documents obtained in this study, they do not include procedures for activities or activities that are more detailed, so that this causes errors, irregularities or ineffectiveness, as found by the examiner.

4. CONCLUSION

Based on the results of the analysis, the conclusion that can be obtained is that there are still weaknesses in the component of control activities over the payroll cycle at the Directorate General of Multilateral Cooperation Affairs, including: 1) inadequate standard operating procedures, 2) authorization is carried out without validation / matching. prior data and 3) there are still data that are not recorded accurately.

5. REFERENCES

COSO. (2013). *Internal Control – Integrated Framework.* 2013.

Romney, Marshall and Steinbart, Paul. (2016). *Accounting Information System*. New York: Pearson.

Law No.17. (2003). State finances.

Law No.1. (2004). State treasury.

Law No.15. (2004). State Financial Management and Accountability Audit. Law

No.15. (2006). Audit Board of the Republic of Indonesia.

Law No.5. (2014). State Civil Apparatus.

Regulation Government of Republic of Indonesia No.60. (2008). Government Internal Control System.

Regulation of the Minister for Empowerment of State Apparatus and Bureaucratic Reform No.63. (2011). Guidelines for Structuring the Performance Allowance System for Civil Servants.

Regulation of the Head of the State Civil Service Agency No.20. (2011). Guidelines for Calculating Performance Allowances for Civil Servants.

Regulations of the Minister of Finance No.190. (2012). Payment Methods for Implementing the State Revenue and Expenditure Budget.

Regulation of the Minister of Foreign Affairs No.4. (2013). Implementation of Providing Performance Allowances for Employees at the Ministry of Foreign Affairs.

Regulation of the Minister of Foreign Affairs No.2. (2016). Organization and Work Procedure of the Ministry of Foreign Affairs.

Regulation of the Minister of Finance No.80. (2017). Procedures for Payment of Employee Performance Allowances at State Ministries / Institutions.

Regulation of the Minister of Foreign Affairs No.2. (2018). Technical Guidelines for Implementing Government Internal Control Systems at the Ministry of Foreign Affairs.

Sekaran, Uma. 2013. Research Methodology for Book Business 1. Jakarta: Salemba Empat.

FACTOR ANALYSIS ON CUSTOMER PAYMENT TERM TO IMPROVE FINANCIAL PERFORMANCE OF A TIC COMPANY IN INDONESIAN MARITIME INDUSTRY

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ABSTRACT

Indonesian classification society is a state-owned Testing, Inspection, and Certification (TIC) company that leads in the maritime sector in Indonesia. The business sector of the company is divided into two services: the first sector is classification services including ship component certification services, and ship statutory certification services, and the second sector is consulting and supervision services related to TIC. Since 2015, the company faces hard conversion of their net accounts receivables into cash, as shown in the financial report and internal gap analysis. The invoice collection period is more than 100 days with up trends for five years in conjunction with an increase in the cash flow of the company. In this study, we estimated the opportunity cost for the company is more than thirty billion and the cost of money is up to fifty billion was caused by a delay of payment of invoice using the time value of money approach. Furthermore, we extracted the company's transaction record from the database and proposed a Generalized Additive Model (GAM) method to identify the main customer transaction type that can reduce the payment term rate of the company's customers. We divided it into two analyzes based on the company's business sectors. The first analysis is for the classification service sector and the second is for the TIC consulting service sector, both using GAM method. This study found that customers of several criteria are potentially late to pay invoices. The result of customer identification based on several criteria shows that the company has 93.68% customers from the classification service sector and 89.55% customers from the TIC consulting service sector that are potentially late to pay invoices.

Keywords: payment term, time value of money, opportunity cost, invoices, generalized additive model

1. INTRODUCTION

Indonesian classification society is a state-owned Testing, Inspection, and Certification (TIC) company that leads in the maritime sector in Indonesia. The business sector of the company is divided into two services: the first sector is classification services including ship component certification services, and ship statutory certification services, and the second sector is consulting and supervision services related to TIC. Since 2015, the company faces hard conversion of their net accounts receivables into cash, as shown in the financial report and internal gap analysis. The invoice collection period is more than 100 days with up trends for five years.

Essentially, the key bloodline of a company is cash. A business without profit may survive for a while, but a company will become insolvent without capital and have a risk of bankruptcy. Cash flow projection may serve various purposes for a company, such as treasury management, funding of working capital, and valuation (Tangsucheeva & Prabhu, 2014). Higher ICQ businesses have fewer irregular cash holdings (either surplus cash or deficit cash), suggesting that efficient internal controls help a company targets cash holdings at the optimum level and handle both upside and downside risks associated with cash holdings (Chen, Yang, Zhang, & Zhou, 2020). Time value of money reads an amount of money at the present time to be worth more than the same amount in the future (Baye & Prince, 2014).

Cergnul JD, Russell, & Sunshine (2005) analyzed the accounts receivable survey to include comparative data and analysis with respect to performance requirements for accounts receivable management. The conflicting trends between adjusted collection percentage (ACP) performance and day's charges in accounts receivable performance may be explained by the increasing sophistication of accounts receivable management processes. Antoine & Rabie (2006) developed an innovative model to optimize the debt collection process for a mobile phone operator. It was based on a Markovian method to model debt collection by considering both the financial risk and the churn risk. The model and the indicator have been implemented for a major French mobile operator. Bechlioulis & Brissimis (2019) explored whether a borrowing- constrained household's spending conduct is influenced by non-payment of debts using nonlinear Generalized Method of Moments (GMM) and derived a two-equation model from the intertemporal maximization problem of the household. The equation was found to be stable under various types of household preferences for a range of specification measures. GAM & CQP and CMARS provide an efficient alternative in predictions. The methods show that the continuous optimization techniques used in data mining are also very successful in financial theory and application (Alp et al., 2011).

2. METHOD

2.1 Dataset and Exploratory Data Analysis

We designed three analysis from the sample construction with the company's transaction record from the internal company database. We started by compiling a dataset of some data obtained internally, such as transaction data from 2000 - 2020, then added some variable information to describe customer profiles such as invoice amount, customer grade, customer status, number of transactions, type of services, etc. As a first step, we carried out exploratory data analysis developed by Tukey (1977) to see summaries in the form of statistical descriptions and visualize the data that had been processed to see data patterns, differences, and other features of the data. Furthermore, we looked at the correlation and influence between data in order to determine the direction of analysis as needed.

2.2 Financial Analysis

The second step was to conduct financial analysis using the time value of money approach developed by Baye & Prince (2014) to calculate the value of the company's potential losses due to late payment of accounts receivable or even unpaid receivables. In this step, the opportunity cost, depreciation, and present value of the company's receivables that the customers have not paid were calculated. The present value (PV) formula of a future value (FV) received in the upcoming years is in equation (1).

$$PV = \frac{PV}{(1+i)^n} \quad (1)$$

2.3 Modeling and Predicting Using Generalized Additive Model (GAM)

In profiling our customers, we divided the data into two datasets according to the business sectors in the company. We compiled the first dataset for the classification business sector with several variables used, including amount of invoice, customer grade, customer status, number of transactions, type of sub-services, while the second dataset for consulting business sector related to TIC only used two variables, namely customer status and number of transactions to predict the payment period based on the criteria developed in each company business sector. The third step was to conduct a customer profiling who usually paid late using the Generalized Additive Model (GAM) method so that several significant criteria were obtained to describe customers who have the potential to pay late to the company.

3. RESULTS AND DISCUSSION

In Figure 1, the business process of the company is listed in brief. As defined in the internal procedure number Pro-A-09 (Debit Note Handling Procedure), the company policy has decided that the due date for each invoice is 30 days, except for premium customers which are otherwise determined by the internal procedure Pro-A-29 (Premium Customer Handling Procedure) which is the due date for each invoice is 90 days.

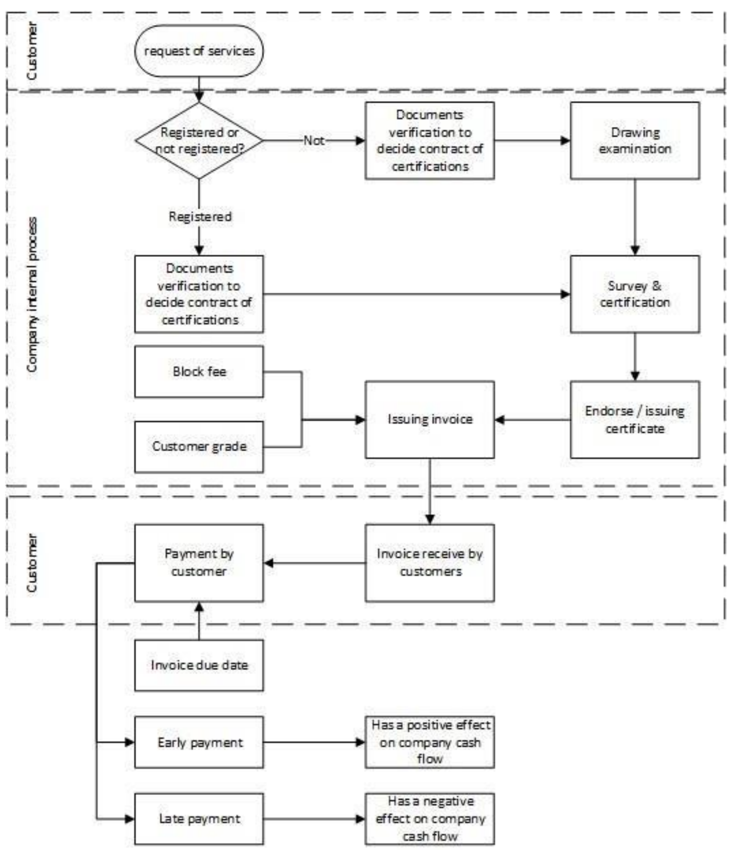

Figure 1. The company's business process

The company has migrated its operating system from self-developed ERP to the commercial ERP system SAP HANA system in 2017. Therefore, the data that can be taken as material for this study is transaction data from 2017 to 2020. However, some accounts receivable data were still recorded in the new system as they have not been paid by the customers. These data were taken into account in this study, especially for financial analysis. The company transaction extraction resulted in 47,415 data which was calculated from the number of invoices issued by the company. In designing our datasets, we combined transaction data and customer grade data. The combined data were used as a dataset for financial analysis. Furthermore, to do modeling and prediction using GAM analysis, the datasets were divided based on the existing business sectors in the company.

Exploratory data analysis was carried out to analyze and summarize the statistical characteristics of the datasets which focused on four main aspects: the measure of central tendency (mean, mode, and median), the size of the spread (standard deviation and variance), the shape of the distribution, and the presence of outliers. Descriptive statistics of the data are shown in Table 1. The distribution plot of payment terms can be seen in Figure 2 and 3.

Table 1. Descriptive statistics for transaction

Predictor variable	Number of data (N)	Mean	Min.	Max.	Mode
Amount	47415	Rp30,567,775	Rp500	Rp4,654,998,922	Rp500,000
Payment_amount	32108	Rp35,005,843	Rp800	Rp4,654,998,922	Rp500,000
Unpaid_amount	15307	Rp21,258,475	Rp500	Rp4,391,000,000	Rp100,000
Payment_period	32108	23	0	214	0
Unpaid_period	15307	513	49	7600	79

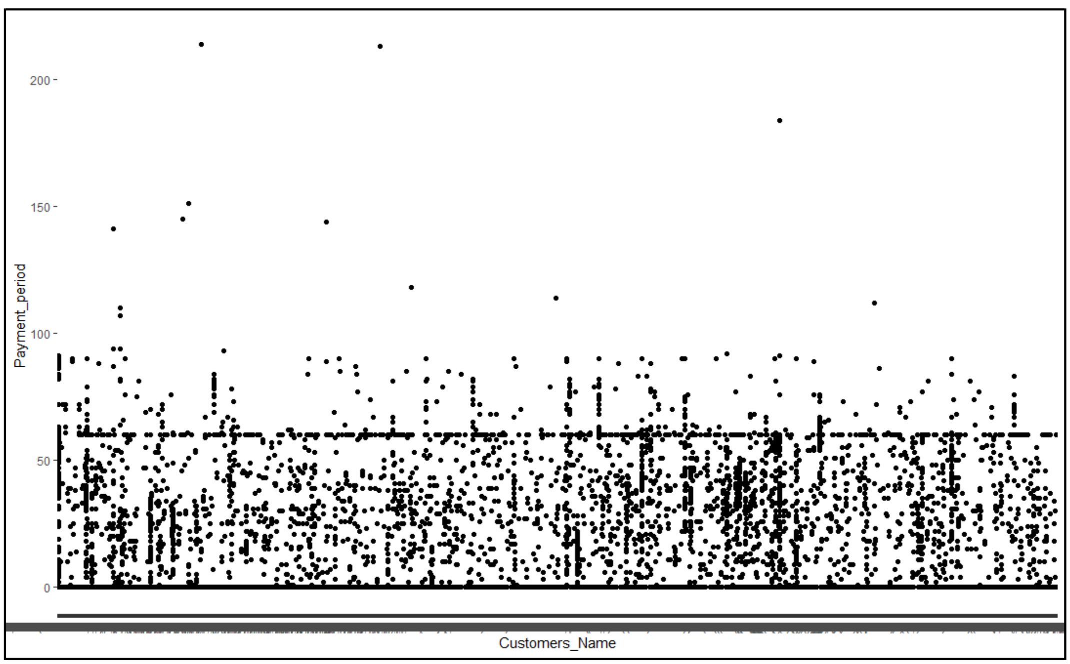

Figure 2. The distribution plot of payment terms for each customer

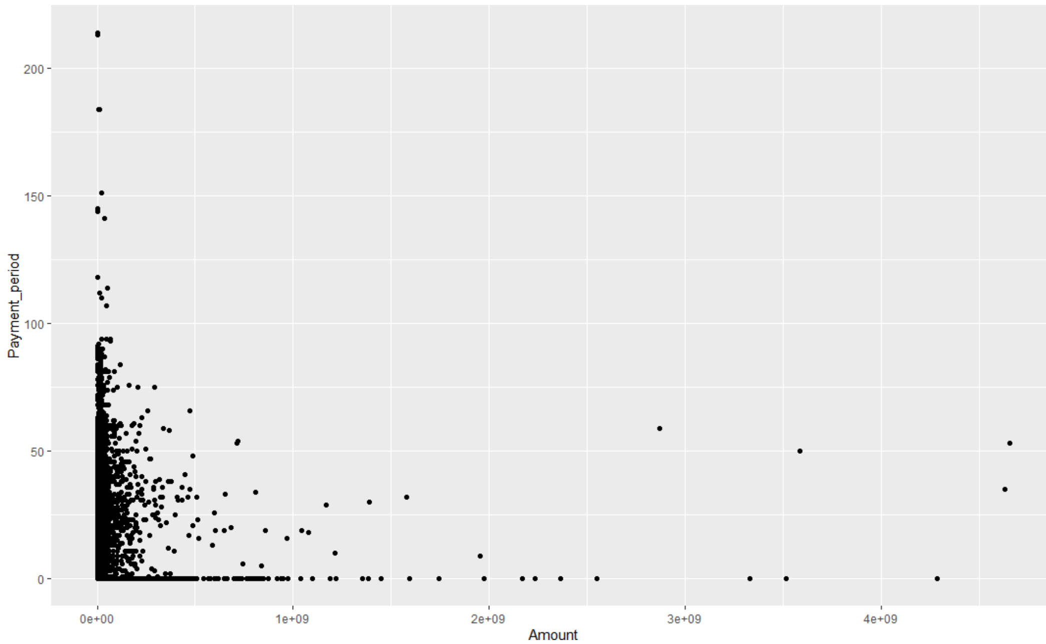

Figure 3. The distribution plot of payment terms for each invoice amount

Based on descriptive statistics, data transaction extraction up to November 18, 2020 shows that the highest invoice value is Rp4,654,998,922 and the lowest is Rp500 out of 47,415 transaction data where the average invoice value is Rp30,567,775. At the end of November 18, 2020, 67.72% of invoices had been paid by customers and 32.28% remained unpaid. The average invoice value is Rp30,567,775. The length of time for unpaid invoiced reaches 7,600 days with an average of 513 days until 18 November 2020 with a sum of the invoice value of Rp322,002,440,014 (recorded at the end of September 2020).

Financial analysis of this study reveals that the calculation of the company's potential depreciation/loss is due to late payment or unpaid invoices. By using the time value of money approach, the simulation of present value, future value, and depreciation were carried out using the reference interest rate, namely the average deposit interest rate at the bank appointed by the company to manage the company's cash, where the deposit interest rate is determined by a value of 6% per year, and inflation growth used the average historical inflation data from Bank Indonesia, which is determined by a value of 3.11% per year. Based on the results of financial analysis calculation, the accounts receivable value is Rp322,002,440,014, which has a depreciation by the inflation rate of Rp6,856,041,205, with the calculation of the present value of Rp315,146,398,808 by value as per time value of money approach. The calculation estimates that
the opportunity cost for the company is Rp30,626,016,154 and the potential cost of money is estimated up to Rp53,740,352,649 caused by the delay of payment of the invoice if the company implements charge for some cost of money for every delayed payment.

GAM analysis was used for all existing variables in order to obtain results of the analysis on software R with a backward stepwise approach to get the best model. GAM analysis on classification service sector data obtained several experimental combinations with several variables added or subtracted. Modeling results are shown in Table 2, where the best formula/model obtained significant criteria. The invoices value (amount) and the number of transactions are significant smooth terms. There are several variables that have a significant effect with a p-value of less than alpha 0.05, including customer grade for the premium category, class survey type, and customer status for BUMN (state-owned company) category. Some of the variables that have a negative correlation are customer grade variables for the premium category, class survey type for the component survey category, periodic survey and statutory survey, and customer status for the BUMN category. On the other hand, the analysis results for the TIC consulting service sector show that only the customer status variable for the category of government institutions and private companies have a significant influence.

Furthermore, based on the results of the GAM analysis, an evaluation was carried out to identify customers that are potentially late to pay their invoices. The result of the customer identification based on several criteria shows that the company has 93.68% customers from the classification service sector and 89.55% customers from the TIC consulting service sector that are potentially late to pay invoices.

4. CONCLUSION

The researchers estimated that the opportunity cost for the company is more than thirty billion and the cost of money is estimated up to fifty billion, caused by the delay of payment of the invoice. Several significant criteria of the customers that are potentially late to pay their invoices are BUMN (state-owned company), premium customer grade for classification service customers, while government institutions and private companies are significant criteria for TIC service customers.

Modeling using the Generalized Additive Model (GAM) for the classification service sector shows that the invoice value (amount) and the number of transactions are significant smooth terms. There are several variables that have a significant effect with a p-value of less than alpha 0.05, including customer grade for premium category, class survey type, customer status for BUMN (state-owned company) category. Some of the variables that have a negative correlation are customer grade variables for premium category, class survey type for the component survey category, periodic survey and statutory survey, and customer status for the BUMN category.

Prediction using the Generalized Additive Model (GAM) shows that the invoice value (amount) and the number of transactions are significant smooth terms and there are several variables that have a significant effect with a p-value of less than alpha 0.05, including TIC consulting service sector. Only the customer status variable for the category of government institutions and private companies have a significant influence.

The result of the customer identification based on several criteria shows that the company has 93.68% customers from the classification service sector and 89.55% customers from the TIC consulting service sector that are potentially late to pay invoices.

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6. REFERENCES

Alp, Ö. S., Büyükbebeci, E., Çekiç, A. İ., Özkurt, F. Y., Taylan, P., & Weber, G. W. (2011). CMARS and GAM & CQP—Modern optimization methods applied to international credit default prediction. *Journal of Computational and Applied Mathematics*, 4639–4651. doi:https://doi.org/10.1016/j.cam.2010.04.039

Antoine, D., & Rabie, N. A. (2006). Modelling of the Debts Collection Process for Service Companies. *IFAC Proceedings Volumes*, 349-354. doi:https://doi.org/10.3182/20060517-3-FR-2903.00188

Baye, M. R., & Prince, J. T. (2014). *Managerial Economics and Business Strategy*. New York: McGraw-Hill/Irwin.

Bechlioulis, A. P., & Brissimis, S. N. (2019). Consumer debt non-payment and the borrowing constraint: Implications for consumer behavior. *Journal of Banking and Finance*, 161–172.

Cergnul JD, J. J., Russell, P. J., & Sunshine, J. H. (2005). Selected Accounts Receivable Performance Statistics for Radiology Practices: An Analysis of the Adjusted Collection Percentage and Days Charges in Accounts Receivable. *Journal of the American College of Radiology*, 1019-1029. doi:https://doi.org/10.1016/j.jacr.2005.08.014

Chen, H., Yang, D., Zhang, J. H., & Zhou, H. (2020). Internal controls, risk management, and cash holdings. *Journal of Corporate Finance*, 101695. doi:https://doi.org/10.1016/j.jcorpfin.2020.101695

Dhulipala, S., & R. Patil, G. (2020). Freight Production of Agricultural commodities in India using multiple linear regression and generalized additive modelling. *Transport Policy*. doi:https://doi.org/10.1016/j.tranpol.2020.06.012

Morabito, R., & de Avila Pacheco, J. V. (2011). Application of network flow models for the cash management of an agribusiness company. *Computers & Industrial Engineering*, 848-857. doi:https://doi.org/10.1016/j.cie.2011.05.018

Reider, R., & Heyler, P. B. (2003). *Managing Cash Flow - An Operational Focus.* New Jersey: John Wiley & Sons, Inc.

Tangsucheeva, R., & Prabhu, V. (2014, July 27). Stochastic financial analytics for cash flow forecasting. *Int. J. Production Economics, 158*, 66. doi:https://doi.org/10.1016/j.ijpe.2014.07.019

Tukey, J. W. (1977). *Exploratory Data Analysis.* Reading: Addison-Wesley Publishing Company.

ANALYSIS OF HOUSEHOLD EXPENDITURES FOR EDUCATION IN SURABAYA CITY, USING PROBIT REGRESSION MODEL

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ABSTRACT

Many factors influence household spending on education. Therefore, analysis is needed to find out how much each household spends on education. This research has taken micro data from SUSENAS March 2019 Surabaya City. The proposed modeling is Probit Regression. Analysis of probit regression start from parameter estimation, testing the model's suitability criteria using deviance, the ROC curve for measuring the criteria for the goodness of fit model and model interpretation. Modeling using probit regression show the significate variables are the age of household head, total household members, the numbers member of working household, the numbers member of household aged 2-5 years and the numbers member of household taking education in high school. Business owner's education who want to win market needs can make the binary probit regression model formed as a consideration in reviewing tuition fees / courses so that they can expand market share to small economies.

Keywords: Probit Regression, Deviance, ROC Curve, Business Education

1. INTRODUCTION

The development of education especially in terms of education costs is felt to be increasingly expensive. Moreover, it is felt by the poor class society with uncertain economic conditions from day to day, being affected by layoffs or due to other reasons. The high cost of education is spread evenly from the elementary school level to public or private universities. At the primary education level, for example, even though the government has provided school operational assistance funds for elementary and junior high school, it is deemed insufficient by most of the lower middle class society to meet education costs, especially the basic operational costs that must be borne by parents of students (Widiputera, 2013).

Different things are shown by societies with high educational awareness. They want quality education supported by professional teaching staff and the best learning technology. They have made the cost of education a basic necessity in the household. Even though they are aware of the high cost of education, they will try to work hard to meet these needs. All these things are done so that children can get higher education and have a better future.

This research took the case of the cost of education in the city of Surabaya using the probit regression method. The probit regression is used to analysis the relationship between the binary response and predictor variables. This study analyzes the factors that influence household spending on education in the city of Surabaya. There are 14 predictor variables consisting of the highest education of the head of the family, mother's education, the main occupation of the household head, the age of household head, total household members, the numbers member of working household, the numbers member of household aged 2 up to 5 years, the numbers member of household taking education in high school, school fees (such as development contributions, school fees, committee fees and other school fees), course fees outside of school, area or location of residence, home telephone bill , cellphone credit and internet or internet cafe fees. The results of this study are expected to provide information about the allocation of sources of intra-household funds that can provide insight into educational policy and program design. This research is also expected to be taken into consideration in terms of determining the promotion strategy for the development of educational businesses and determining educational products according to the needs of the people of Surabaya.

2. PROBIT REGRESSION

Based on (Long, 1997), the probit model is a way of performing regression for binary outcome variable. A binary outcome variable is a dependent variable with two possibilities such as yes or no, positive or negative test result, single or non-singular. The word of probit is combinations of the word probability the value will fall into one of two possible binary results (i.e. units). Binary probit regression modeling begins by considering the following model.

$$\boldsymbol{Y}^* = \boldsymbol{\beta}^T \boldsymbol{X} + \varepsilon \tag{1}$$

a category is carried out Y^* in binary probit regression by providing a limit or *threshold* (γ), namely for $Y^* \leq \nu$ categorized with Y = 0, for $Y^* \geq \nu$ categorized Y=1, so that the following model is obtained.

$$P\ (Y = 0|\boldsymbol{X}) = \Phi\ (\gamma - \boldsymbol{\beta}^T \boldsymbol{X}\ ) \tag{2}$$

$$P\ (Y = 0|\boldsymbol{X}) = 1 - \Phi\ (\gamma - \boldsymbol{\beta}^T \boldsymbol{X}\ ) \tag{3}$$

Where $\Phi\ (\gamma - \boldsymbol{\beta}^T \boldsymbol{X})$ is cumulative distribution function of the standard normal distribution (0, 1).

$$\Phi\ (x) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} exp^{\left(-\frac{x^2}{2}\right)} dx \tag{4}$$

2.1 Maximum Likelihood Estimation (MLE)

The log likelihood value is a measure of the goodness of the probit regression line in the maximum likelihood method. The likelihood function is formulated as follows.

$$L\ (\boldsymbol{\beta}) = \prod_{i=1}^{n} \{1 - \Phi(\gamma - \boldsymbol{\beta}^T \boldsymbol{X}_i)\ ^{y_i} [\Phi(\gamma - \boldsymbol{\beta}^T \boldsymbol{X}_i)\ ]^{1-y_i}\} \tag{5}$$

Perform the transformation ln on the likelihood function because mathematically it will be easier to maximize $L\ (\boldsymbol{\beta})$ with the transformation ln. Then it process by performing the first and second derivatives of the function ln $L\ (\boldsymbol{\beta})$ against $\boldsymbol{\beta}$. Based on the results of the parameter assessment using the maximum likelihood method above, it turns out that an implicit function is obtained. As a result, the parameter estimator cannot be obtained. The way to get parameter estimator can use the Newton Raphson iteration method as follows.

$$\boldsymbol{\beta}^{(m)} = \boldsymbol{\beta}^{(m-1)} - \left(\frac{\partial^2 \ln L(\boldsymbol{\beta})}{\partial \boldsymbol{\beta}^{(m-1)} \boldsymbol{\beta}^{(m-1)}}\right)^{-1} \frac{\partial \ln L(\boldsymbol{\beta})}{\partial \boldsymbol{\beta}^{(m-1)}} \tag{6}$$

The iteration process will stop if convergent conditions are me

$$\left\|\beta^m - \beta^{(m-1)}\right\| \ \leq \varepsilon,$$

with ε is a very small number (Ratnasari, 2012).

2.2 Likelihood Ratio Test

Statistic test is the likelihood ratio test which is used to test the role of the independent variables in the model together. The G test is used in simultaneous testing because the probit equation is a log of the likelihood function and is a categorized variable, so the G test is the correct test in testing the parameters simultaneously (Hosmer & Lemeshow, 2000). The hypothesis used is

$H_0: \beta_1 = \beta_2 = \cdots = \beta_P = 0$

H_1: at least one $\beta_j \neq 0, j = 1,2,\dots,p$

Statistics of the test performed is statistic test G or likelihood ratio test.

$$G^2 = -2ln\left(\frac{\left(\frac{n_0}{n}\right)^{n_0}\left(\frac{n_1}{n}\right)^{n_1}}{\prod_{i=1}^{n}((p_i)^{y_i}(1-p_i)^{1-y_i})}\right) \quad (7)$$

G test statistic follows the distribution $\mathcal{X}^2$, then the test is carried out by comparing between the statistical value of the G test and the table value $\mathcal{X}^2$ with the degrees of freedom v (number of parameters) at a significant level α. H_0 rejected if the value $G^2 > \mathcal{X}^2\,(v,)$ or p-value < α

2.3 Wald Test

Partial testing aims to test the effect of the coefficients by comparing estimation with its standard error estimator. The W test is used in partial testing because the data used in binary probits is category data. The hypothesis used in the partial test.

$H_0: \beta_j = 0$ (No influence independent variable to$-j$ on the dependent variable)

$H_1: \beta_j \neq 0$ (There is the influence of independent variable to$-j$ on the dependent variable)

The test statistics used are Wald tests with the following formula.

$$W = \frac{\hat{\beta}_j}{SE\,(\hat{\beta}_j)} \text{ , dengan } j = 1,2,\dots,p \quad (8)$$

The hypothesis is rejected if $|W| > \mathcal{X}^2_{((n-1),\alpha)}$ or $p\text{-}value < \alpha$. Decision to reject H_0 show the effect of dependent variable on independent variables (Hosmer & Lemeshow, 2000).

2.4 Goodness of Fit Test

Fit test is based on the ratio criteria likelihood by comparing the model without the predictor variable to the model with the predictor variable. The hypothesis used in testing the suitability of the model is as follows

H_0 : Model is fit

H_1 : Model is not fit

The test statistics used are deviance tests with the following formulas.

$$D = -2\sum_{i=1}^{n}\left[y_i\, ln\left(\frac{p_i}{y_i}\right) + (1-y_i) ln\left(\frac{1-p_i}{1-y_i}\right)\right] \quad (9)$$

The D test statistic will follow the distribution $\mathcal{X}^2$ with degrees of freedom that can be searched by notation $n-p-1$. Decision reject H_0 if the value $D > \mathcal{X}^2_{(\alpha,(n-p))}$ are significance α or $p\text{-}value < \alpha$.

2.5 Classification Model

A receiver operating characteristic curve or ROC curve is one way of analyzing the classification model. The ROC curve uses sensitivity and specificity values. The accuracy of the model in predicting failure events (y=0) was expressed as specificity. Meanwhile, the model's ability to predict success (y=1) is sensitivity ((Hosmer et.al 2013). The ROC curve is obtained from the plot between sensitivity and 1-specificity for all possible values π_0. The predicted value will be 1 when $\pi_i > \pi_0$, whereas it will be is 0 when $\pi_i > \pi_0$. The area under the ROC curve ranges between 0 and 1.

3. METHODOLOGY OF RESEARCH

3.1 Research Data Sources

The data source is used in this research taken from micro data from the March 2019 National Socio-Economic Survey (SUSENAS) issued by the Surabaya City Statistics Agency (BPS). The number of samples taken was 4620 data for module category variables in consumption or expenditure packages and 4037 data for core category variables for individual household members in Surabaya City. The data will be processed using software R.

3.1 Model

Response variables (Y) are grouped into 2 groups. Households with above-average expenditures (Y=1) and households with below-average expenditures (Y=0). The classification details of variables in this study are as follows.

Table 1. The Research Variables

No.	Variable	Scale	Category
1	School/course expenses for the last 1 year (Y)	Nominal	0 : Low 1 : High
2	The highest level education of Household Head(X1)	Ordinal	1. Didn't Pass in Primary School 2. Primary School 3. Secondary School 4. High School 5. University
3	The highest level education of housewives (X2)	Ordinal	1. Didn't Pass in Primary School 2. Primary School 3. Secondary School 4. High School 5. University
4	The main occupation of Household Head(X_3)	Ordinal	1. Self-employed 2. Self-employed assisted labor is not fixed 3. Self-employed assisted by permanent workers 4. Labor/employees 5. Free labor

Table 1. The Research Variables (Continued)

No.	Variable	Scale	Category
			6. Family/unpaid workers
5	The age of Household Head (X_4)	Ratio	-
6	The number of household members (X_5)	Ratio	-
7	The number member of working household (X_6)	Ratio	-
8	The numbers member of household aged 2-5 years (X_7)	Ratio	-
9	The number member of household taking education in high school (X_8)	Ratio	-
10	Home phone account fees for the last month (X_9)	Ratio	-
11	Mobile Credit Fee last month (X_{10})	Ratio	-
12	Internet Charges last month (X_{11})	Ratio	-
13	Other School Support Fees (X_{12})	Ratio	-

Analysis of probit regression start from parameter estimation. After the estimation of binary probit regression parameters is obtained, then parameter testing is carried out to determine whether the independent variable in the model has a significant effect on the dependent variable. The G test statistic is used to test the significance of the parameters simultaneously. Wald test statistics are used to test the partial significance of parameters. Furthermore, testing the model's suitability criteria using deviance, the ROC curve for measuring the criteria for the goodness of fit model and model interpretation.

4. RESULT AND DISCUSSIONS

The likelihood ratio test shows that the p-value is 0.000. It can be decided reject H_0, which means that at the 95% confidence interval there is at least one parameter that is significant to the probit model. Whereas for partial testing using Wald's test statistic, the variables that have a significant effect on the model with α=0.05 are the age of household head (X4), the number members of household (X5), the number members of working household (X6), the number members of household aged 2-5 years (X7) and the number members of houshold taking education in high school (X8). The results of Binary probit regression model with significant parameters are explained in Table 2.

Table 2. Significant Variable Binary Probit Regression Model

Variable	Estimate	P-Value	Conclusion
Intercept	-0.663	0.000*	Significant
The age of household Head (X4	-0.027	0.000*	Significant

Table 2. Significant Variable Binary Probit Regression Model

Variable	Estimate	P-Value	Conclusion
The number members of household (X5)	0.895	0.000*	Significant
The number members of working household (X6)	-0.254	0.000*	Significant
The number members of household aged 2-5 years (X7)	-0.996	0.000*	Significant
The number members of household taking education in high school (X8)	-0.479	0.000*	Significant

* Significant in α=0.05

Binary probit regression model obtained as follows.

$$y^* = \left(-0{,}663 - 0.027(X4) + 0.895(X5) - 0.254(X6) - 0.996(X7) - 0.479(X8)\right)$$

Interpretation of the above models with reference to statistical analysis. The average age of household is head 48 years, the average number members of household is 4, the number members of working household is 2 people, 1 household member who is less than 5 years old and 2 household members who take a senior high school education. The estimated result is that the five variables have a tendency to influence school/course expenses by 90.7% for below average expense categories (Y=0) and have a tendency to influence school/course expenses by 9.3% for above average expense categories (Y=1).

Furthermore, the deviance statistical test was performed. The Test statistic deviation can prove statistically whether there is a difference between the results of the observation and the possible prediction of the model. The result, using α = 5% obtained a p-value of 0.000. It can be decided that the model is fit.

The data in this research didn’t have a time sequence so that it was possible to be partitioned randomly. Referring to descriptive statistical analysis shown that the proportion of data of variable group Y is 75.36% category Y = 0 and 24.64% category Y = 1. Partition data on the test criteria goodness of this research model is for the group below average (Y = 0) taken 80% data training and 20% data testing. The above average group (Y = 1) took 80% of the training data and 20% of the testing data. Training and testing data for category Y = 0 are combined with training and testing data for category Y = 1 using the command "Rbind" in software R. Figure 1 below is the result of the ROC curve.

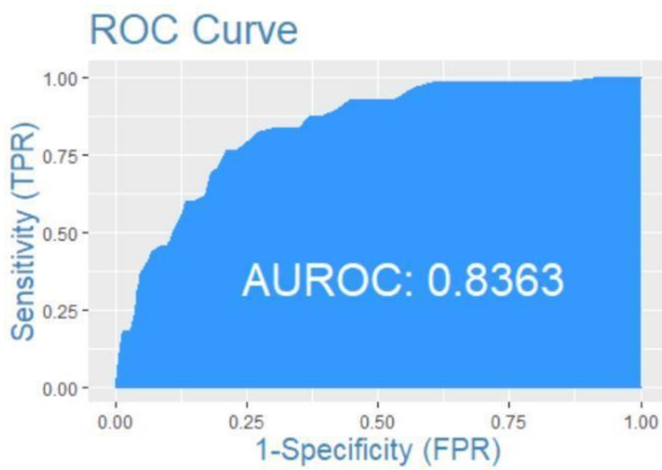

Figure 1. ROC Curve

Based on Figure 1, the model is fit because the resulting curve is close to number one. This is also supported by the outside area under the ROC curve, which is 0.8363. According to Hosmer and Lemeshow (2000) which argues that the model classification is acceptable if the area under the ROC curve is ≥ 0.7. Referring of Kleinbaum & Klein (2010), the category of results for 0.8 <outside the area under the ROC curve ≤ 0.9 = Good discrimination. The value of sensitivity (or True Positive Rate) is 16.36% and the specificity (or False Positive Rate) is 98.69%. So it can be concluded that the model is good for explaining household expenses for school / course fees in the category Good discrimination.

5. CONCLUSION

Referring to the results and discussion that has been done, it is obtained 2 conclusions. First, the model selected in this research was a probit regression model for each variable studied by determining the best model selection criteria such as likelihood ratio test, Wald's test, deviance test and ROC curve. Second, Modeling using probit regression show the significate variables are the age of household head, total household members, the numbers member of working household, the numbers member of household aged 2-5 years and the numbers member of household taking education in high school.

6. REFERENCES

Hosmer, D. W., & Lemeshow, S. (2000). *Applied Logistic Regression*. A Wiley Interscience Publication.

Kleinbaum, D., & Klein, M. (2010). Logistic Regression: A Self Learning Text. *Springer-Verlag*.

Long, J. (1997). Regression Models for Categorical and Limited Dependent Variables. USA: *SAGE Publishing*.

Ratnasari, V. (2012). Estimasi Parameter dan Uji Signifikansi. *Disertasi Jurusan Statistika Fakultas Matematika dan Ilmu Pengetahuan Alam Institut Teknologi Sepuluh Nopember.*

Widiputera, F. (2013). Financial of Education: A Theoritical Study. *Jurnal Pendidikan dan Kebudayaan*, 19, 565-578.

ASSESSMENT OF CONTRACTOR PREQUALIFICATION IN CONSTRUCTION PROJECT

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ABSTRACT

The selection of the winning contractor candidate must be carried out in order to get the best prospective contractor. Prequalification is done to ensure the company gets the best contractor and meets the desired quality. At present the Prequalification is not yet complete, while the Prequalification is more in line with the formality requirements, it still needs an inadequate contractor to qualify. As examples of development projects in the field that correct delays due to inappropriate selection of contractors.

Therefore a process of pre-qualification construction contractor was chosen using the Analytical Hierarchy Process (AHP) method. Before entering into the multi-criteria evaluation process using the AHP method, the criteria, sub-criteria and alternatives are in accordance with the pre-qualification of the construction contractor. Data collection criteria based on questionnaires were processed using the Delphi Method. Questionnaire data were obtained from expert expert evaluations that were directly related to the pre-qualification process of construction contractors as well as from published literature studies.

In the results of this study, a construction contractor prequalification model is obtained that can be used to assess the competence of the contractor by weighting the criteria for Human Resource capacity based on work experience (20%), financial support (15%), competency based human resource capacity (15%), Tax Compliance (9%), Quality of Work (7%), Reputation (6%), Field of work being done (5%), Similar Experience (5%), Having awareness of K3 and Quality (5%), Business Permit (4%), company data (4%), equipment data (4%), and the last legal foundation of establishment (3%).

Keywords: Prequalification, Analytical Hierarchy Process (AHP), Delphi Method, Construction Contract.

1. INTRODUCTION

The selection of candidates for the winning contractor tender must be carried out an assessment process in order to get the best contractor candidates. Prequalification is carried out to ensure the company gets the best contractor and meets the desired quality.

PT PJB is one of the subsidiaries of PT PLN Persero engaged in generating. All electricity supply produced by PT PJB is distributed to PLN, then the electricity supply is distributed to all Indonesians.

Currently Prequalification has not been done comprehensively, where prequalification is more based on formality requirements so as to still allow unfit contractors to be able to qualify. Prequalification procedure, namely the elimination of incompetent contractors based on certain criteria, has been widely used in the process of selecting contractors because currently it can be known that the bidder with the lowest price does not always promise the project will run smoothly and the quality produced in accordance with the wishes of the project owner.

The entire prequalification process has fulfilled the requirements in the decree of the Board of Directors of PT Pembangkitan Jawa-Bali No. 100.K/l0/DIR/2017 concerning Amendments to the Decree of the Board of Directors of PT Pembangkitan Jawa Bali No. 024.K/020/DIR/2016 concerning the General Guidelines for The Procurement of Goods/Services of PT Pembangkitan Jawa Bali.

Prequalification is now being done by PT PJB using a system of fulfilling or not meeting. So quantitative criteria cannot be measured. Whereas in the qualification criteria there must be priorities that can be rated. So that we can know the weight of each criterion and apply passing grade to determine the right contractor in a project.

Decision making at the time of contractor selection is not easy, so a decision-making model is needed to help solve the problem. AHP (Analytical Hierarchy Process) is one of the MCDM (Multi Criteria Decision Making) methods that is very good in modeling the opinions of experts in decision support systems.

Based on the problems mentioned above, the objectives of this research are:

- Identify a representative method to be the basis for choosing a good construction contractor.
- Analyze the determination of the above criteria as the basis of the model of evaluation of the contractor selection process at PT PJB.

2. RESEARCH FRAMEWORK

2.1 Contractor Prequalification

Prequalification is one of the auction methods where before entering an offer, the contractor must meet several generally owned criteria. Broadly speaking, contractors who follow this Prequalification must follow the qualification requirements required by the job owner.

Prequalification aims to eliminate incompetent contractors, contractors who are expected to be unable to complete projects on time, are low financially capable, and inexperienced from the auction process. Prequalification can assist job owners in achieving the success and efficient use of their funds after ensuring that only qualified contractors can work on construction projects. Furthermore, due to the skills, capabilities, and efficiency of such qualified contractors, the completion of a project can be carried out in accordance with the estimated cost and time specified (Clough and Sears, 1994).

From the description above, it shows that prequalification is not just the submission of documents of certain requirements, but is a screening process with predetermined criteria for project success. With the initial screening during prequalification, it will facilitate the auction process where the evaluation will be more complicated and more competent.

2.2 Contractor Prequalification Method

Prequalification can provide employers with facilities that can represent effective and efficient spending of money. Russel and Skibniewski (1988) tried to describe the contractor's prequalification process along with the decision-making strategies and factors that influenced the process. They presented 5 methods that had been found to be used for the contractor's prequalification process: dimensional weighting, two-step prequalification, dimension-wide strategy, prequalification formula, and subjective assessment (Russel and Skibniewski, 1988).

Dimensional weighting method, selection of criteria and weights depending on the employer. The contractor's total score is calculated by summing the rankings multiplied by the weight of each criterion. Then, the contractor is ranked on the basis of the total score used for prequalification. The most critical thing with this method is to determine the weight of each criterion. Where AHP (Analytical Hierarchy Process) can be used as a suitable methodology.

These methods are designed with the general purpose of introducing efficient and systematic procedures for contractor prequalification. In relation to the procurement of construction contractors at PT PJB, dimentional weighting can be an alternative.

2.3 Criteria in Prequalification

Some researches that have been done, found the application of AHP for contractor selection and few discussed its application for Prequalification. In his journal, (Kamal M.Al-Subhi Al Harbi, 1999) discussed the application of AHP in the process of selecting contractors in Saudi Arabia. In the study using AHP not to select contractors, but to use pairwise comparison to make priority of 6 criteria used in the Prequalification process. Namely Experience with sub-criteria, Work quality, Equipment resources, Financial stability, Human resources, and current workload.

Other research by (Russel and Skibniewski,1988) included several criteria for prequalification as follows: reputation, previous performance, financial stability, reference, experience, contractor capacity, current workload, and technical expertise. And other research by (Guntur Gantara, 2013) included the following prequalification criteria: Contractor Experience, Financial Stability, Performance and Quality of previous projects, Human resources from contractors, as well as Organization / Management of contractors.

By considering the criteria of existing criteria related to prequalification in previous research, then the criteria can be recommended for alternatives in this study.

2.4 Delphi Method

Delphi method itself is usually used as a method of networking group opinions whose participants consist of resource persons or experts who have competencies in their fields. This approach can be used as a means of communicating information in obtaining a deep understanding of how the dynamics of an individual's opinion in a survey/pollling can develop and then gain legitimacy into group opinions (Doke and Swanson, 1995).

Conventionally, Delphi's approach controlled the response feedback from his participants by creating a panel consisting of several rounds of surveys and then developing and updating kuesitioner. Every time there is a response from a round of surveys, the re-exposure of the iktisar.. So that each participant could have the opportunity to reevaluate each response compared to the response from his group, in anticipation of the evaluation of the response in the next round of surveys.

The use of the Delphi method precedes the AHP approach intended on the grounds of:

- Delphi method bases on subjective opinion respondans, so as to formulate the overall objective or criteria expressed more flexibly.
- The results of opinion networking from Delphi's approach has not been tested consistency of responsibility, so the AHP method complements the proposed procedures for testing the consistency of individual and group opinions as well as weighting the priority of the interests of each criterion / objective.

2.5 AHP (Analytic Hierarchy Process) Method

AHP method can be utilized to get optimal weighting criteria. The Analytic Hierarchy Process (AHP) was developed by Thomas Saaty in 1970 to provide a simple but theoretical methodology in the criteria for evaluating alternatives. It aims to measure relative priorities for an alternative set on a ratio scale, based on the judgment of the decision maker and emphasizes the importance of intuitive assessment of decision makers as well as consistent from alternative comparisons in the decision making process (Saaty, 1988).

By applying AHP, the criteria can be prioritized and sorted based on a list of contractors who follow the prequalification and can be sorted to select a contractor who is eligible for the auction. In addition, the determination of the feasibility of a contractor to participate in the auction can also be done based on the value (scoring) obtained from the results of the AHP model where it has been taken into account different weighting for each criteria in accordance with its priorities.

3. RESEARCH METHODOLOGY

3.1 Data Collection Methodology

The data collected in this study is all the data needed for the contractor assessment model, ranging from the determination of criteria, sub criteria, comparison judgement, assessment of contractors. Determining the criteria and sub-criteria of researchers through the Delphi Method with resource persons related to construction contracts that represent each field.

Questionnaire Preparation After determining the criteria, sub-criteria and alternatives for consideration of the selection of the best contractor, then make a questionnaire. The preparation of questionnaires is based on paired comparison methods to determine the weight level of each criterion, and alternatives. The value of the weight ranges from 1 to 10, the giving of this weight depends on the level of interest between them. The resource persons will answer based on their information, knowledge and experience. The speakers give their answers or opinions on a likert scale between 1 (one) to 10 (Ten) based on the level of importance of the instrument to be developed. Where scales 1 (not very important) and 10 (very important). The questionnaire contains comparisons between each criterion and other criteria, and comparisons between each alternative and other alternatives.

For the determination of prequalification criteria, identification is carried out through resource persons representing teams related to construction project contracts in PJB, namely representatives from the Procurement Planner, Procurement Implementation, Procurement Control, Legal, and Financial Fields teams. There are 5 resource persons related to the auction process of this Prequalification stage, all of them managerial equivalent officials. Selected to these 5 speakers because they include experts in their respective fields so that they are expected to get the right questionnaire answers.

3.2 Data Analysis Method

Data analysis method used using AHP (Analytic Hierarchy Process) method. The Delphi method is used during decision making from the project owner's side to determine the criteria and sub-criteria. While the AHP (Analytic Hierarchy Process) method is used when doing weighting. The process of selecting and assessing contractors using the AHP (Analytic Hierarchy Process) method because with the AHP (Analytic Hierarchy Process) method is expected criteria and weighting of selected criteria are well detected so that the best contractor results can be obtained and can be considered for use in future projects.

Determination of weights against each criterion using the AHP method. To process questionnaires given to resource persons with the help of Expert Choice software until weights are obtained from each existing criteria.

In the processing of data, an assessment of the contractor's prequalification data based on the descriptor has been determined. The results of the assessment are then incorporated into the AHP model and multiplied by the Likert Scale. In this study the scale used is a value range between 1-5 for each contractor criteria.

To determine whether a contractor passes prequalification or not, a threshold is set from the construction contractor who follows the Prequalification. In this study, the method of determining the minimum value has not been done academically. As a reference in this research used the figure of 75% as a graduation limit or score between 75-100, the reference is conveyed in the regulation of the Minister of Public Works Regulation NUMBER: 07/PRT/M/2011.

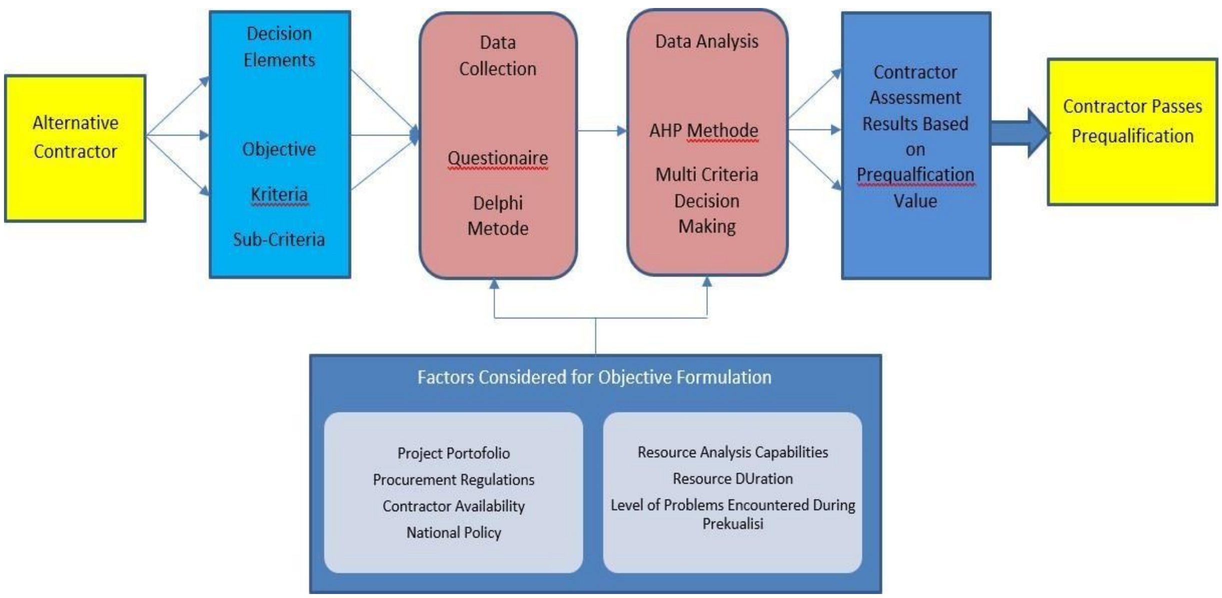

Figure 1. Research Framework

4. RESULTS and DISCUSSION

4.1 Prequalification Criteria

In the next step determine the criteria in the contractor's prequalification. With the Delphi Method, questions were made to the resource persons consisting of a team of Procurement Planners, Procurement Executors, Procurement Control, Legal Companies, and Finance to formulate the criteria that must be owned by a qualified contractor.

As a result, the prequalification criteria of existing construction contractors are as described below:

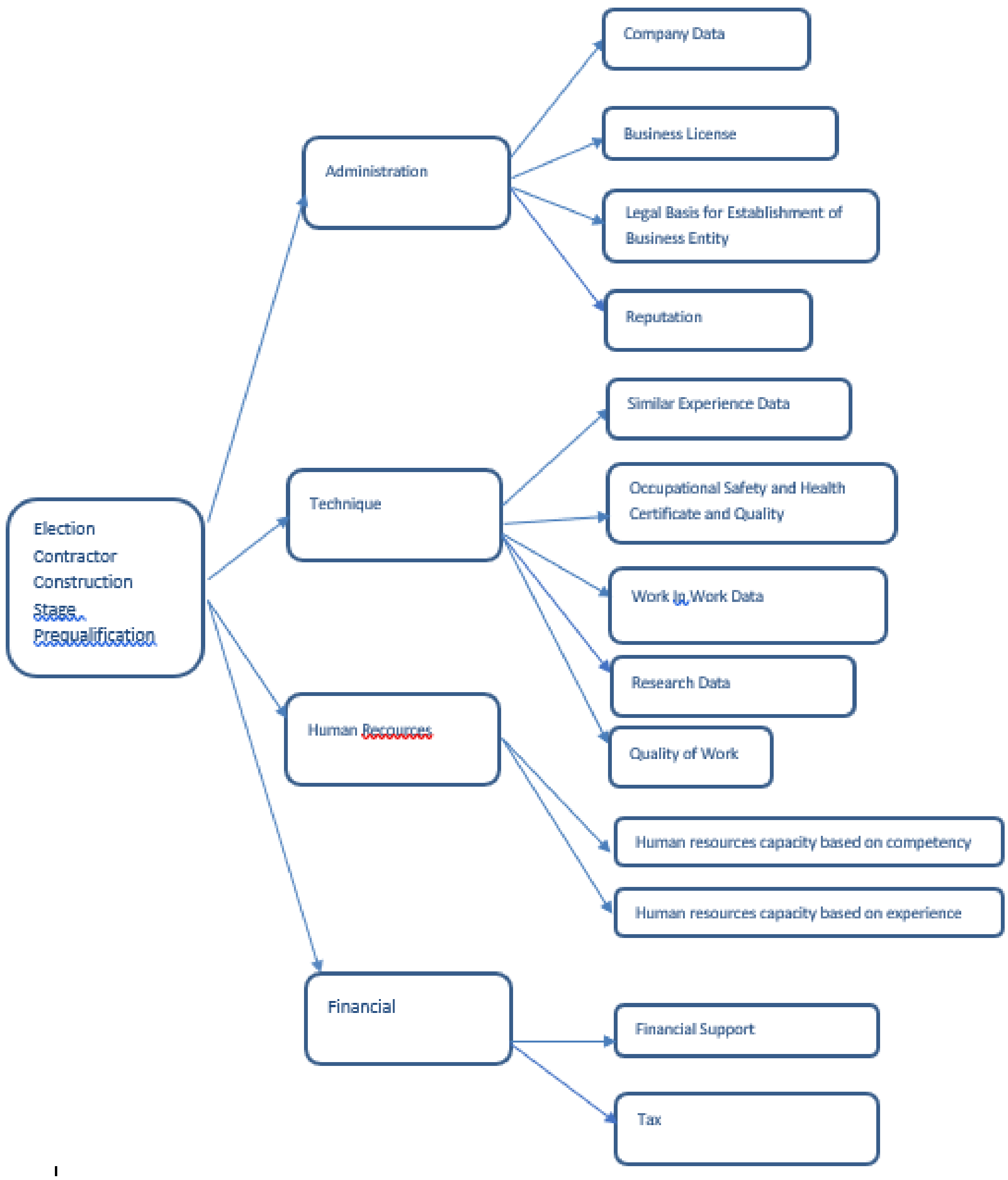

Figure 2. Criteria and Subcritteria of Construction Contractors

4.2 Weight determination for Criteria and Subcriteria

Once it is known what criteria are included in the contractor's prequalification process and the determination of the heirarki of the prequalification, weighting is carried out against each criterion. The priority determination of each of these criteria is to use the Analytical Hierarchy Process (AHP) method through a questionnaire given to the decision maker.

The next step is data processing with the help of Expert Choice (EC) software to gain weight from each criteria. From the results of the calculation of the main criteria 1 to the main criteria 4 based on questionnaires to the speakers and using expert choice software obtained weights for each criteria, namely Administration: 0.168, Technical: 0.256, HR: 0.343, Finance: 0.233.

Then done weighting (pairwise comparation) for subcriteria so that the results of the Expert Choice program are obtained as follows :

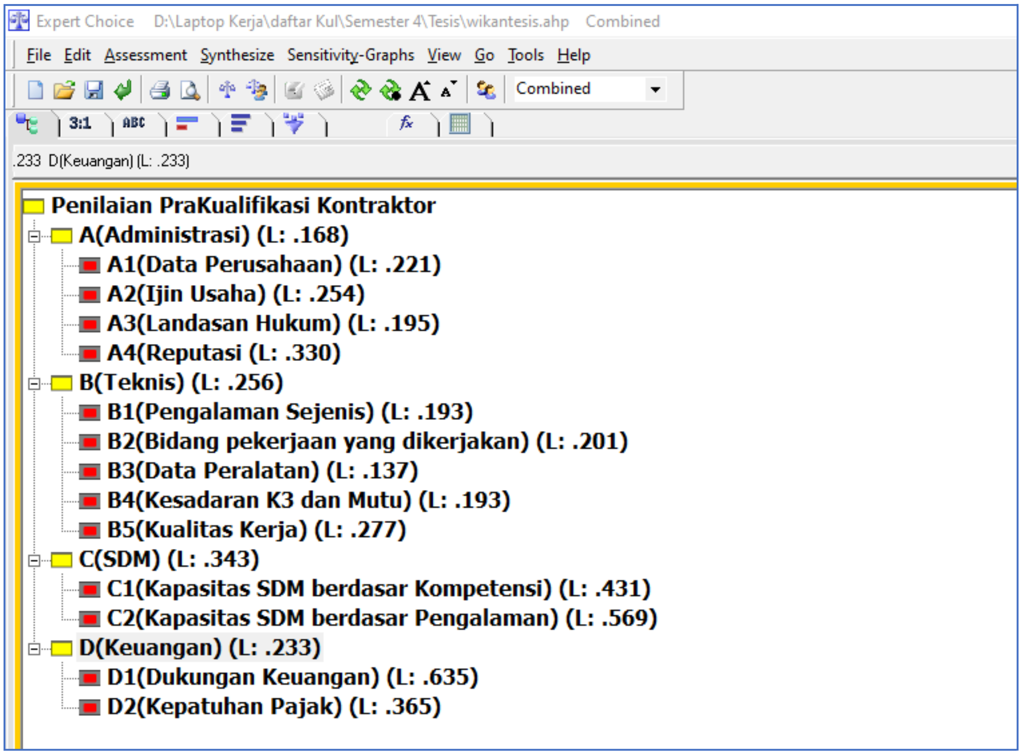

Figure 3. Weighting Pairwaise Comparison Subcryteria

Furthermore, the actual weighting calculation can be seen in Table 1.

Table 1 . Actual Weighting Calculation

Sub Criteria	Code	Global Weighting
Company data	A1	0.04
Business License	A2	0.04
Foundation of The Law of Establishment	A3	0.03
Reputation	A4	0.06
Similar Experiences	B1	0.05
Field of work being done	B2	0.05
Equipment data	B3	0.04
Have awareness of Occupational Safety and Health (K3) and Quality	B4	0.05
Quality of Work	B5	0.07
Human resources capacity based on competency	C1	0.15
Human resources capacity based on work experience	C2	0.20
Financial Support	D1	0.15

Tax Compliance	D2	0.09

Based on the requirements, a score of 75 on a scale of 100 is required to ensure that the contractor has sufficient qualifications to work on the project in PT PJB. Based on these thresholds, the results of 4 contractors who passed the prequalification are as follows:

Table 2. Contractor Prequalification Results

Prequalified Construction Contractors		
No	**Company Name**	**Value**
1	NKE	83.47
2	NK	82.83
3	BA	81.96
4	BKPJ	81.68

5. CONCLUSION

In the screening criteria and subcriteria for Prequalification construction contractors use Delphi Method to several resource persons who are experts in their respective fields to obtain measurable results. In the process can use AHP to gain a comprehensive and measurable weight.

The results of prequalification subcriteria weighting in this study obtained the highest to lowest weight, namely in human resources capacity owned by work experience (20%) , Financial Support (15%), Human Resources capacity owned by competency (15%), Tax Compliance (9%), Work Quality (7%), Reputation (6%), Field of work being done (5%), Similar Experience (5%), Having K3 awareness and Quality (5%), Business License (4%), Company Data (4%) , Data equipment (4%), and the last Foundation of Legal Establishment (3%). So that the subcriteria of human resources capacity owned based on work experience has the most influence in this Prequalification.

6. REFERENCES

Ciptomulyono U (2001), Integration of Delphi Method and Hierarchical Analysis Procedure for Identification and Determination of Objective Priorities/Decision Criteria.

Ciptomulyono U (2008), Fuzzy Goal Programming Approach for Deriving Priority Weights in the Analytical Hierarchy Proces (AHP) Method

Ciptomulyono,U. (1998), Integration of Analytic Hierarchy Process and Goal Programming Approach For Waste Management Strategy, (A paper presented) in "The Third International Conference on Multi-Objective Programming and Goal Programming", 31 May- 3 June, Quebec City-Canada.

Dodi Angga Kusuma (2017). Contractor Assessment Model on Electricity Project Using AHP and Fuzzy TOPSIS Method. Thesis, Master of Technology Management, Sepuluh Nopember Institute of Technology, Surabaya.

Circular of the Board of Directors of PT PLN (Persero) Number: 0014.E/DIR/2014 concerning Circular Amendment of the Board of Directors of PT PLN (Persero) Number 0003.K/DIR/2014 concerning Technical Guidelines for Procurement of Goods/Services of PT PLN (Persero).

El-Sawalhi,N., Eaton.D.,Rustom,R. (2007). Contractor pre-qualification model : State –of-art.
International journal of Project Management 25, 465-474

Thunder Gantara (2013). Model AHP for Prequalification of Construction Contractors in Oil and Gas Companies. Thesis, Master of Technology Management, Sepuluh Nopember Institute of Technology, Surabaya.

Kamal M. Al-Subhi Al-Harbi (1998), Application of the AHP in project management.

Liauwnoto, Suparto (2009) Model of selection of tender-winning contractors in the private sector using analytical hierarchi process. Master thesis, Petra Christian University.

Regulation of the Board of Directors of PT PLN (Persero) Number: 0527.K/DIR/2014 dated October 31, 2014 concerning Amendments to the Decree of the Board of Directors of PT PLN (Persero) Number 0620.K/DIR/2013 concerning General Guidelines for Procurement of Goods/Services of PT PLN (Persero).

Regulation of the Minister of State-Owned Enterprises Number PER-15 / MBU / 2012 concerning Amendments to the Regulation of the Minister of State-Owned Enterprises Number PER-05 / MBU / 2008 concerning General Guidelines for the Procurement of Goods and Services of State-Owned Enterprises.

Saaty, T. L., (1990). Fundamentals of Decision Making and Priority Theory, 2nd Edition. Pittsburgh, PA:RWS Publication.

Saaty, T. L., (1994). How to make a decision : The Analitic hierarchy Process. Interfaces, Vol.24, no.6,pp.19-43.

Saaty, T. L., (2008). Decision making with the analitic hierarchy process. Int.J.Services Sciences, Vol.1, No. 1, pp.83-98.

Silvia Fransiska (2015). Contractor Assessment Model on Construction Project Implementation With AHP (Analytic Hierarchy Process) Case Study : Housing Developer Project PT. Xyz. Thesis, Master of Technology Management, Sepuluh Nopember Institute of Technology, Surabaya.

Soeharto, I. 1995. Project Management : from conceptual to operational, (2 ed), Erlangga, Jakarta. Tantyonimpuno, R. S & Retnaningtias , A. D. 2006. "Application of Analytical Hierarchy Process(Ahp) Method in The Decision Making Process of Foundation Type Selection (Case Study : Royal Plaza Surabaya Development Project)

Watt, D.J., Kayis, B., Willey, K. (2010). The Relative importance of Tender Evaluation and Contractor Selection Criteria. International Journal Of Project Management, 28 (1), 51-60

TOPIC

Strategic Management

STRATEGIC DESIGN OF FAST MOVING CONSUMER GOODS HOME INDUSTRY LOCATED IN BANGGAI, CENTRAL SULAWESI

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ABSTRACT

Industrial centers in Indonesia are basically located in Java, some of which are Surabaya, Sidoarjo, Gresik, Bekasi, and several other areas in Java. Industry will be very rarely found in areas like Sulawesi. Glenz Indonesia is one of the *home industries* engaged in the liquid soap home industry in the Luwuk area, Banggai Regency, Central Sulawesi. The background of this company in establishing a company in the regions is to avoid the *red ocean* in Java. The biggest challenge for a company that has just been established in less than a year is the \absence of a business strategy so that sometimes when running a business there is no clear direction and low *brand awareness* which has an impact on the quantity of sales or buying interest. Problem within Glenz is the decreasing demand from customer, there for appropriate marketing strategy is needed in order for company to survive and compete in the market. This thesis will raise the formulation of the company's vision and mission and the right marketing strategy using a theoretical approach, namely STP (*segmenting, targeting, positioning), marketing mix* 4P (*product, place, price, promotion),* and SWOT and AHP analysis on the impact on the industry. a new house that is engaged in *fast moving customer goods* with a business center in Luwuk City, Banggai Regency. The results found are that the marketing strategy based on being selected through the SWOT AHP analysis can be carried out, namely the preparation of funds for packaging printing which is then followed by *canvassing to unreached* areas. Each of these strategies is a strategy in the ST and SO matrix.

Keywords: vision, mission, marketing strategy, SWOT-AHP, *home-industry*

1. INTRODUCTION

Home industry is an activity to produce small-scale goods and is carried out at home which is a form of Micro, Small and Medium Enterprises (MSMEs) which have an important role in increasing Indonesia's economic growth. Glenz Indonesia is a cottage industry which is engaged in the liquid soap industry in the Luwuk area, Banggai Regency, Central Sulawesi. As a newcomer to the soap industry, Glenz was initially very difficult to accept in society. This can be seen from the sales capacity graph. However, over time and the emergence of the COVID-19 virus caused the need for hand washing soap to increase, until at one time when Kab. Banggai experienced a shortage of hand-washing soap stock for a long time because the supply chain from Java to Sulawesi was hampered. This caused the *demand for* GLENZ hand washing soap to increase, considering that only GLENZ hand washing soap was available at that time. However, over time the supply chain returns to normal and the demand for soap decreases because competitors from big brands have entered. One of the reasons for the decline in sales of IKM Glenz is the absence of a marketing strategy.

Therefore, to maintain the decline in demand for soap, an effective marketing strategy is needed. The right marketing strategy is believed to provide more information for the people of Kab. Proud so that it can increase *awareness* and purchases. This journal will discuss the preparation of a marketing strategy that is supported by the preparation of the company's vision and mission, *marketing mix* 4Panalysis and SWOT analysis with AHP evaluation, which results will be compared so that the appropriate marketing strategy is carried out by the Glenz company in selling new brand soap in Luwuk City, Banggai Regency, Central Sulawesi.

2. METHOD

2.1 Research method

Following type of research is a marketing strategy design according to the characteristics of Glenz's home industry business with a business center in the Luwuk area, Banggai Regency, Central Sulawesi. As for designing the business strategy of this thesis will perform three methods as follows:

1. The formulation of the vision and mission of the company
2. The preparation of the business strategy by using STP and *marketing mix* 4P
3. The preparation of the business strategy by using SWOT-AHP

In this thesis done qualitative and quantitative approaches. The formulation of a qualitative business strategy is taken from the compilation approach using the STP method and the *marketing mix,* while for quantitative it is done by using a SWOT analysis which is then evaluated by the AHP.

2.2. Data Sources The data

Data taken from Glenz industry are based on primary data and secondary data. Primary data for the preparation of vision and mission, as well as STP analysis and *marketing mix* 4Pis data from filling out questionnaires by several customers from Glenz, while primary data for SWOT AHP analysis is data obtained directly from the home industry which is carried out through interviews with parties. Key parties who work in Glenz, in this case interviews are conducted to owners, production employees, and employees in the *sales sector* and also fill out questionnaires from several Glenz customers. The data taken is data about the internal condition of the company, sales, understanding main competitors, and understanding of the company itself. The secondary data obtained is supporting data obtained through indirect sources. Secondary data in this case is sales data, journals, articles, books, and other sources.

2.3. SWOT-AHP

The marketing strategy in this thesis is prepared using a SWOT analysis which is then evaluated and selected using the AHP analysis. The methods used are as follows:

a. The KPI weight values range from 0-1 or 0% -100%
b. The total number of KPI weighted values must be 1 (100%)
c. There is no negative weight (-)

The steps taken in the formulation of the marketing strategy are as follows:

a. forming a SWOT-AHP hierarchy diagram
b. determine the priority value of the KPI. In determining the KPI priority value, it can be seen through the conversion table of the priority statement.
c. Conduct validation analysis using expert choice software

3. RESULT AND DISCUSSION
3.1 Vision and Mission Formulation
3.1.1 Vision Formulation

There are several hopes in the preparation of the IKM GLENZ vision, including being an option for housewives or women who are married as cleaning soap products at the most affordable prices with competitive quality. In addition, it is hoped that IKM Glenz can become a pioneer and celebrity in the soap industry in the Sulawesi area. From these data, Glenz's vision is formulated as follows:

To become the first IKM company to act as a pioneer and celebrity in the soap industry which has always been the choice of housewives in Sulawesi.

3.1.2 Mission Formulation

In order to support the vision that has been compiled, further discussion is conducted to determine actions that must be taken to realize the company's vision which is then devoted to several mission points as follows:

a. Creating the highest quality products with effective and efficient formulations to create affordable prices
b. Continue to innovate on product variations and development of product trends for new markets
c. Providing the best commitment and value to interested parties with due regard to the interests of the community

3.2. STP
3.2.1. Segmentation

Based on the results of research from a demographic perspective, it can be seen that the largest buyers of Glenz products are women and most of them are married. In terms of income, Glenz products were purchased from all types of income scales with insignificant differences. Furthermore, from a job perspective, more customers of Glenz products are civil servants or housewives. Based on the results of interviews with customers and owners, in terms of demographic segmentation, basically the buyers of Glenz products are women who are married and on average are civil servants and housewives, this is because the owners of Glenz themselves carry out many promotions among civil servants and Glenz products are products. synonymous with cleaning the house for housewives.

Based on the results of geographical segmentation, the data obtained is that the majority of buyers are domiciled in Luwuk, Kab. Proud. Furthermore, segmentation is also seen based on psychographic factors which here raise customer pleasure with what he does at home and social class status. The criteria that become points are their enjoyment of cooking, cleaning and laundry, while social class status is categorized based on the value of income data that has been filled through interviews on demographic factors. Based on the results of the interview, it was found that the average buyer of Glenz products has pleasure in the field of hygiene. This is the answer why they buy Glenz products, which are the soap they need to clean the house. Furthermore, based on social class status, it can be seen that Glenz products can be accepted by all social class statuses. This is evidenced from the presentation data that are not much different and spread the average calculated by the average percentage is 33%.

3.2.2. Targeting

Based on the results of segmentation, it can be concluded that the largest market segment in terms of demographics for gender is female as much as 75%; dominated by customers with adult and elderly age as much as 45% and 40%, respectively; with the majority of income ranging from 1,999,999 and under 35%; work as civil servants and housewives as much as 35% and 30%, respectively. Furthermore, for geographical factors the dominant buyer resides in the city of Luwuk, Kab. Banggai with a percentage of 65%. The dominant market segment in terms of psychographics is people who enjoy cleaning with a percentage value of 50% and can be accepted in all social statuses.

3.2.3. Positioning

Glenz producthas is in great advantage because it's more affordable price and a large variety of soap products. Cheaper prices are certainly more attractive for products engaged in FMCG, while the large variety of soap products can meet hygiene needs with different purposes, such as cleaning dishes, floors, hands, clothes, etc. More content is also a distinct advantage of Glenz products, with a more affordable price and more content, of course, making Glenz products a very pocket-friendly product.

The weakness of Glenz's product as an IKM product in this case lies in the less modern packaging with the highest percentage of weaknesses of 80%. This is evidenced by the packaging used only in the form of a sticker pouch, which lowers customer confidence. Furthermore, accessibility is difficult because Glenz products only enter large supermarkets and have not entered small shops or kiosks because small retailers generally ask for smaller packages, because smaller packages tend to be cheaper and sell faster. However, the problem is that Glenz products do not have a small size and only one size is available, namely 800ml.

3.3. Marketing Mix (4P)

Primary data in the preparation of a marketing strategy using the Marketing Mix (4P) method is carried out by distributing questionnaires to 20 respondents who are consumers of Glenz soap using 12 questions, each for product category, promotion, location, and price respectively. three questions, so the total questions become 12. It was found that the majority of people agreed that the price of Glenz soap was affordable, cheaper than competitors and the price offered was comparable to its quality.

In the field of promotion, the majority chose that they absolutely agreed with Glenz in providing discounts for resellers, providing package purchase promos and providing free postage promos. In terms of products, 58% of respondents agreed that Glenz products had good quality, 75% said Glenz products had many product variations, and 60% of people did not agree that Glenz products had modern and attractive packaging. In terms of location, 80% of people do not agree that Glenz products are easy to find in the nearest shop, 70% of respondents agree with the establishment of a product base in Luwuk Kab. Banggai was the right decision, and 70% of respondents agreed that the location of the product was strategic for the distribution of goods to stores.

3.4. SWOT Analysis

After calculating the average results of the questionnaire and determining the categories of strengths, opportunities, weaknesses and threats of the company on internal and external factors, then weighting IFAS and EFAS with the following results:

Table 1. Bobot IFAS dan EFAS

NO		Average	Value	RATING	SCORE
STRENGTHS					
1	Products with competitive / good quality	3,75	0,14	2,12	0,30
2	various product variations	4	0,15	2,42	0,36
3	very competitive prices	3,75	0,14	2,12	0,30
4	Providing PROMO in the form of free shipping and COD through online advertising	3,75	0,14	2,12	0,30
5	Growth in awareness, profit and sales increased	3,25	0,12	1,59	0,19
		TOTAL (S)	0,70		1,46
WEAKNESSES		WEAKNESSES			
1	company does not have a regular operation and management system	1,5	0,06	0,34	0,019
2	Ads that are not maximal	1,5	0,06	0,34	0,019
3	Lack of product promotion programs	1,75	0,07	0,46	0,030
4	Sales performance that is not maximum	1,75	0,07	0,46	0,030
5	Sales targets that are not achieved	1,5	0,06	0,34	0,019
		TOTAL (W)	0,30		0,118
NO		rata-rata	BOBOT	RATING	SCORE
OPPORTUNITIES					
1	competitive price	3,75	0,15	2,23	0,33
2	potential markets	3	0,12	1,43	0,16
3	customer trust (repeat orders)	3,5	0,14	1,94	0,26

4	market shares that have not been touched much	3,25	0,13	1,67	0,21
5	government policies that support IKM	3	0,12	1,43	0,16
		TOTAL (O)	0,65		1,15
THREATS					
1	Other brand competitors who are better known	1,25	0,05	0,25	0,01
2	The actions of a relatively new company	1,5	0,06	0,36	0,02
3	Packaging aesthetics	2	0,08	0,63	0,05
4	Limited distribution area	1,5	0,06	0,36	0,02
5	The emergence of new arrivals	2,5	0,10	0,99	0,09
		TOTAL (T)	0,10		0,20

Based on table 1, the SWOT quadrant position is shown in Figure 1 below:

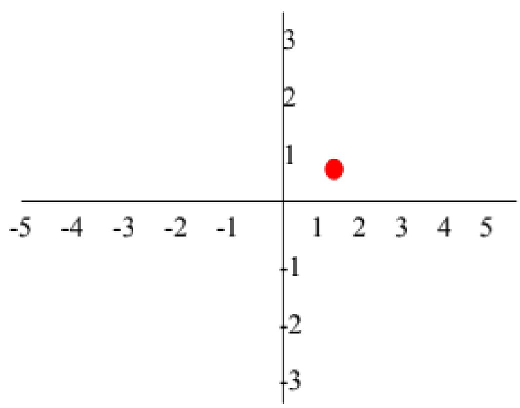


Figure 1. Position of the IKM Glenz SWOT Quadrant

with the difference between S and W = 1.348 which acts as the X axis while the difference between O and T = 0.95 which acts as the Y axis then plotting and finding the IKM Glenz area is in quadrant I. This shows that IKM Glenz is in a progressive position where the company is expected to continue to increase and expand its marketing reach. To determine alternative priority strategies, the SWOT matrix is used.

SWOT strategy formulation is carried out by using a combination of internal-external strategy interactions to determine priorities and linkages between strategies based on weighting of SWOT.

Table 2. Interaction Matrix IFAS-EFAS SWOT

IFAS EFAS	**Strength** Products with competitive/ good quality 2. diverse product variations 3. very competitive prices Providing promotion in the form of free shipping and COD through online advertising Growth in awareness, profit and sales increased **1.46**	**Weaknesses** The company does not have a regular operating system and management Ads are not maximal 3. Lack of product promotion programs Sales performance is not optimal Sales targets are not achieved **0.12**
Opportunity 1. competitive prices 2. potential market 3. customer trust (repeat orders) 4. unexplored market share	**SO** 1. Improving quality and increasing variety of . reating new promo programs that are more	**WO** Arranging company operation and management systems 2. Increasing capital to sell
5. government policies that support home industry **1 , 15**	attractive to sales activities 3. *canvassing* to more area **2,01**	product promotion. This is very important and **1,27**
Threats 1. Other better known brand competitors 2. New comers 3. Packaging aesthetics 4. Limited distribution area 5. New competitor **0,202**	**ST** 1. Maintaining product quality, increase variety and keep the price offered cheaper than competitors 2. prepare additional funds to prepare attractive promo programs to increase conversion 3. prepare funds to print packaging **1,662**	**WT** 1.Improve work ethic and company management 2. Active and efficient performance results **0.223.**

The next step is taken to determine the best alternative strategy that can be used by IKM Glenz by determining the priority of alternative strategies using AHP. This is because although SO is the best alternative strategy, not all strategies can be carried out simultaneously, so priority is needed in its implementation. Policy Strategy Formulation using AHP

3.5.AHP

The main objective of this strategy development is the expansion of sales of Glenz products. Level 1 is perspective, divided into four targets, including *strength, weakness, opportunity, strength.* Furthermore, for level 2, namely an alternative strategy based on the SWOT matrix that has been prepared previously.

Based on the processed data from the expert choice, it was found that the highest priority weight was the *threats* with a weight value of 0.48. There are several factors that make the value of threats more dominant, including the existence of better known competitor brands, new actions, packaging aesthetics that are still very MSMEs, limited distribution permit areas, and the emergence of new competitors. This shows that in penetrating the market for Glenz products, there are still obstacles in the field of branding Glenz products to the public. Furthermore, the perspective with the smallest priority value is weakness with a weight of 0.078. The summary results of priority weight values can be seen in the following table:

Table 3. Table of Perspective Weight Values from Expert Choice Results

No	Perspective	Priority Score
1	Strength	0,32
2	Weakness	0,078
3	Opportunity	0,123
4	Threat	0,48

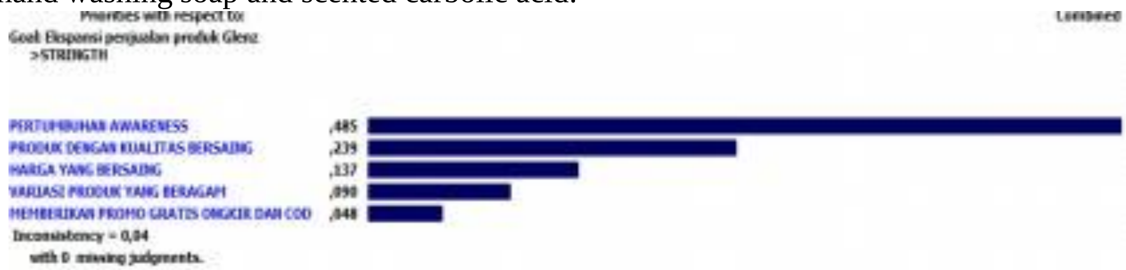
If broken down into several alternatives which affects Threats or threats, the highest weight is shown in the aesthetics of the packaging. It should be noted that the packaging aesthetics of Glenz products can be said to be very MSME. Packaging that is less modern or not like the manufacturer affects the level of customer confidence in the

credibility and quality of Glenz products. This then results in customers tending to prefer competitors' products that are better known. Complete data can be seen in Figure 4.2.

Packaging aesthetics
Other better known brand competitors
New comers
Limited distribution area
New competitor

Figure 2. Graph of Priority Factors Affecting Perspective: Threats

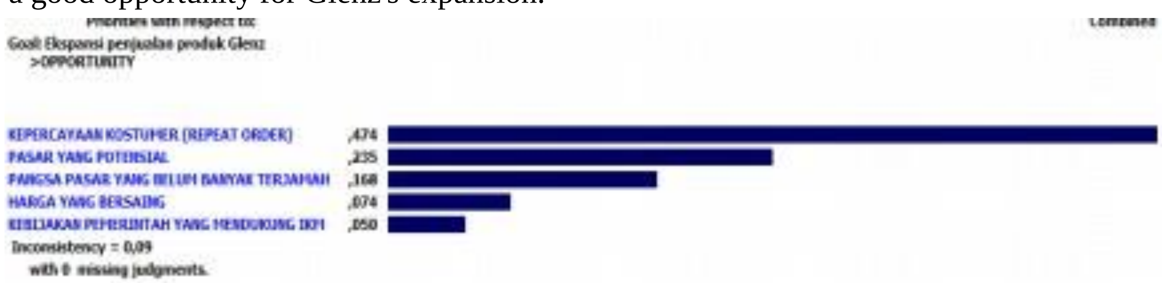
Furthermore, the perspective with the second highest priority weight based on Table 3 is strength. Based on the results of the questionnaire that has been processed, the factor that greatly influences this perspective is the growth of awareness. It should be noted that the growth in awareness occurred due to the scarcity of hand washing soap and scented carbolic acid during the May 2020 pandemic. The scarcity resulted in *demand for* an increasinghand washing soap and Glenz scented carbolic acid. *Thedemand for* increasinghand washing soap and scented carbolic acid then had an impact on increasing sales of other Glenz products because at first people were not interested in buying and after trying to feel fit so they were interested in trying Glenz products other than hand washing soap and scented carbolic acid.



Growth in awarenes
Products with competitive/ good quality
very competitive prices
diverse product variations
Providing promotion in the form of free ship

Figure 3. Graph of Priority Factors Affecting the Perspective: Strength

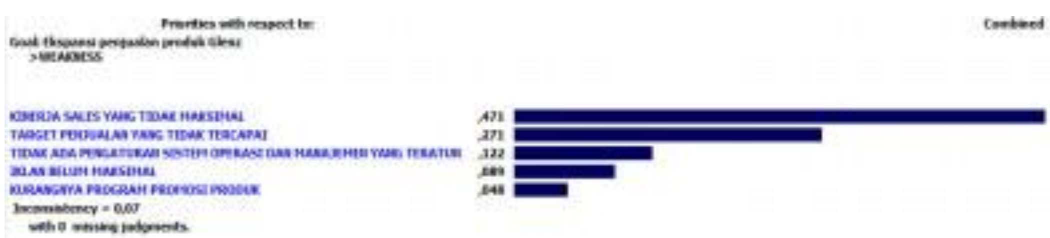
Furthermore, the next highest priority weight is opportunity with a total perspective of 0.123. The most influencing factor based on weighting is the number of repeat orders or the trust of customers who always repurchase, followed by potential markets. The potential market referred to here is that there are still many areas and potential customers who have not been touched, making this a good opportunity for Glenz's expansion.



customer trust (repeat orders)
potential market
unexplored market share
competitive prices
government policies that support home
industry

Figure 4. Graph of Priority Factors Affecting Perspective: Opportunity

The perspective with the lowest priority value, namely 0.078, is weakness. In this perspective, the most influencing factor is the sales performance that is not optimal, which causes sales targets that are not achieved. This can be seen in Figure 4.5.



Sales performance is not optimal
Sales targets are not achieved
The company does not have a regular operating system and management
Ads are not maximal
Lack of product promotion programs

Figure 5. Graph of Priority Factors Affecting Perspective: Weakness

The data is filled in by three Glenz experts, namely owners, production employees, and sales employees of Glenz. The appropriate output strategies for IKM Glenz based on the results of filling out the questionnaire processed through expert choice can be seen in the following figure:

prepare funds to print packaging
canvassing to more area
Creating new promo programs that are more attractive to sales activities
Increasing capital for promotion.
Prepare additional funds to prepare attractive promo programs to increase conversion
Arranging company operation and management systems
Active and efficient performance results
Maintaining product quality, increase variety and keep the price offered cheaper than competitors
Improve work ethic and company management
Improving quality and increasing variety of product.
structured

Figure 6. Overall SWOT Strategy Output

Based on the picture above, it can be seen that to expand Glenz products, the strategy that can be done is to prepare funds for packaging printing with a total weight of 0.247 which is then followed by *canvassing* to unspoiled areas with a weight of 0.189. Each of these strategies is a strategy in the ST and SO matrix. Based on the above data can also be seen that for both target value calculation inconsistencies and alternative strategies below 0.1 indicating that the questionnaire data from experts is consistent and can be used as the basis of the data researchers

4. CONCLUSION

Based on the results of thesis research, while the conclusions obtained are:

1. Based on interviews and in-depth discussions with key people of IKM Glenz, a vision was formulated: To become the first IKM company to act as a pioneer and celebrity in the soap industry which has always been the choice of housewives in Sulawesi which is supported by three mission points, namely Creating products. with the best quality with effective and efficient formulations to create affordable prices, continue to innovate on product variations and development of product trends for new markets and provide the best commitment and value to relevant parties with an interest with regard to the public interest
2. The marketing strategy based on being selected through the SWOT-AHP analysis can be done is to prepare funds for packaging printing with a total weight of 0.247 which is then followed byunreached *canvassing* toareas with a weight of 0.189. Each of these strategies is a strategy in the ST and SO matrix.

5. ACKNOWLEDGEMENT

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6. REFERENCES

Amirullah, Hardjanto. (2005). *Pengantar Bisnis,* Edisi 1, Yogyakarta: Graha Ilmu.

Buchari, Alma, (2008). *Manajemen Corporate dan Strategi Pemasaran Jasa Pendidikan,* Bandung: Alfabeta.

Chandler, Alfred. (1962). *Strategy and Structure: Chapters In The History Of American Industrial Enterprice*

Idris, Amiruddin. (2016). *Ekonomi Publik*. Yogyakarta: Deepublish.

Kotler, Philip & Armstrong. (2004). *Prinsip-prinsip Pemasaran. Edisi Ke 12 Jilid 1*. Jakarta: Erlangga

Kotler, Philip. (1992). *Marketing, jilid 1*. Jakarta: Erlangga.

Mas'ari, Dkk, (2019). Analisa Strategi Marketing Mix Menggunakan Konsep 4P (Price, Product, Place, Promotion) Pada PT. Haluan Riau. *Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri. Vol 5,* 79-86.

Rangkuti, Freddy. (2013). *Teknik Membedah Kasus Bisnis Analisis SWOT Cara Perhitungan Bobot, Rating, dan OCAI*. Jakarta: Gramedia Pustaka Utama.

Sasono, E., dan Yuliana, R, (2014). Manajemen Inovasi Pada Usaha Kecil Menengah. *Jurnal STIE Semarang. Vol 6(3),* 74-90.

Tjiptono, Fandy. (2006). *Strategi Pemasaran*. Yogyakarta: Andi.

Turban E., King D., Lee J., Warkentin M. and Chung H.M (2002). *Electronic Commerce 2002 – A Managerial Perspective.* New York: Prentice Hall.

Wijaya & Srine, (2016). Strategi Segmenting, Targeting, Positioning serta Strategi Harga pada Perusahaan Kecap Blekok di Cilacap. *Asian Journal of Innovation and Entrepreneurship. Vol 1*, 175-190.

Yulvia, dkk, (2016). Strategi Pemasaran Pada UD. Sinar Tallasa Melalui bauran Pemasaran Menggunakan Analisis SWOT dan Analytic Hierarcy Process. *Jurnal Fakultas Kehutanan.*

CHANGE MANAGEMENT STRATEGY WITH ADKAR MODEL IN E-CATALOGUE SYSTEM IMPLEMENTATION

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ABSTRACT

In the company, technology developed to increase competitive advantage and maintain company sustainability. Companies are able to improve efficiency in terms of business processes and financial aspects with technology, but companies often fail to implement due to the problems cannot be resolved properly. One of the key success factors in system implementation is to create a change management strategy. PT XYZ has a strategic initiative to implement E-Catalogue system in 16 Subsidiaries. This implementation has an impact to business process changes that involve many stakeholders from each subsidiary. PT XYZ should avoid failures in e-catalogue implementation by manage changes properly. This research aims to identify the differences between conventional purchasing and E-Catalogue business processes. After that, formulate a change management strategy using the ADKAR Model. The research methodology developed by creating a strategy at every stage of the ADKAR model. ADKAR has five main objectives, there are awareness, desire, knowledge, ability, and reinforcement which emphasize the importance of individual involvement and support from leaders in the organization. By implementing the ADKAR model, PT XYZ can make changes to the procurement process in 16 subsidiaries and reinforce the changes in the e-catalog system implementation.

Keywords: ADKAR Model, Change Management, Electronic Catalogue.

1. INTRODUCTION

Companies need to concern about their ability to innovate because their future depends on the result of innovations (Christensen & Raynor, 2003). The benefit of implementing innovation of technology is to increase the efficiency of business processes in the company that impact on improving the quality of customer services. Currently, the purchasing process at subsidiaries of PT XYZ is not consolidated, resulting in variations in prices and quality standards for similar goods. PT XYZ will innovate by implementing an Electronic Catalogue (E-Catalogue) in 16 subsidiaries to improve the efficiency of the procurement processes. Implementation of technology will lead the changes to business processes and human resource needs (Bolognese, 2002). One of the change management models which proved successful is the ADKAR change management model, developed by Jeffrey Hiatt (2006) from the Prosci Learning Center. ADKAR change management model consists of five elements, namely awareness, desire, knowledge, ability, and reinforcement that build each other, and focus on important areas of change, such as evaluation, management leadership, employee involvement, training, and reinforcement (Hiatt, 2006).

The implementation of E-Catalogue causes changes in the business process for users to purchase goods/services. The changes can lead the resistance from some users to operate the system. The role of change management in this research is very important, due to the involvement of many stakeholders from 16 subsidiaries of PT XYZ and changes in procurement business processes. E-Catalogue implementation in 16 subsidiaries needs to apply the change management strategy to minimize the failures. One of the key success factors in change management are creating a change plan and forming change agents from each subsidiary.

2. METHODS

2.1 Change Management Concept

A number of change management models have been developed. One of them was developed by Nadler and Tushman (1980) with focuses on organizational performance and the leadership roles that performed in change management process. The change management process developed consists of five stages, namely diagnosis, preparation, implementing change, consolidating change, and sustaining change (Veiga, 2018). Although the model presented is structured, it can involve a long and expensive process to implement (Basu, 2018).

Another approach was developed by Kotter (1996) by describing the change management model into eight stages consisting of :

a. Establishing a sense of urgency
b. Creating the guiding coalition
c. Developing a vision and strategy
d. Communicating the change vision
e. Empowering board-based action
f. Generating short-term wins
g. Consolidating gains and producing more change
h. Anchoring new approaches in the culture

Kotter's model (1996) is designed for a strategic perspective and is one of the most widely used models, although it does not have a tactical focus (Leban and Stone, 2008). A criticism of Kotter's model is the lack of integration with project management (Kazmi and Naarananoja, 2014).

Another change management model is the ADKAR model, developed by Prosci in 2006 and published in a book entitled "ADKAR, A Model for Change in Business, Government and Our Community: How to Implement Successful Change in Our Personal Lives and Professional Careers" (Hiatt, 2006). Different from another change management model, ADKAR focuses on adapting changes in people, as opposed to change. Prosci develops a change management approach that consists of three phases, namely, preparing for change, managing change and reinforcing the change after implemented. The ADKAR model emphasizes the importance of individual involvement and support from leaders in organizations. ADKAR has five main objectives to achieve, there are:

a. Awareness of the need for change
b. Desire to participate and support the change
c. Knowledge on how to change
d. Ability to implement required skills and behaviors
e. Reinforcement to sustain the change

2.2 ADKAR Model

The ADKAR model was developed by researching and studying change in more than 1,600 organizations that reviewed individual change management and organizational change management (Prosci, 2008). The Prosci methodology integrates the change process into project management which emphasizes individual change management and organizational change management to ensure its objectives are achieved. Figure 1 describes the organizational change management process in the ADKAR model which built in 3 stages.

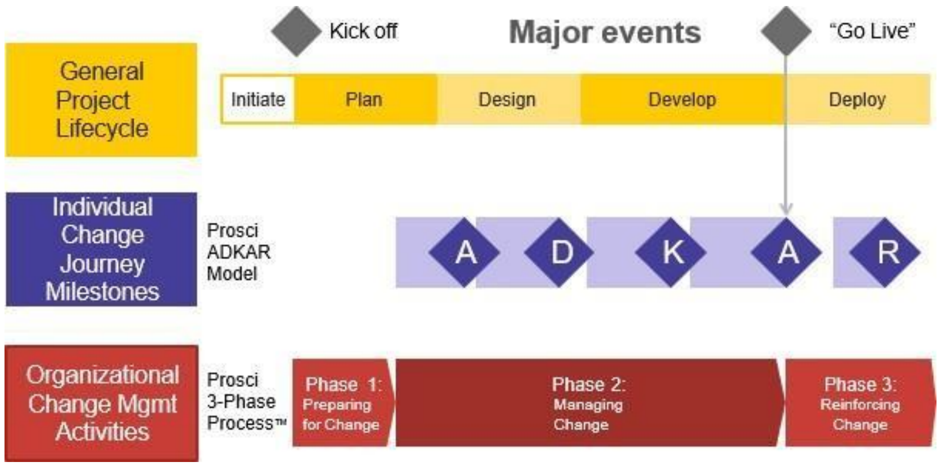

Figure 1. ADKAR Process Stages

2.2.1 Awareness

Lack of awareness about the reasons for change is a main source of employee resistance (Prosci, 2016). This is caused by failure to communicate the details of the change to employees. When awareness is ignored, projects will face increasing resistance, slowing progress and reducing returns on investment. The following are strategies to build awareness effectively:

1. Effective Communication
   The initial stage of building awareness is performed by designing a communication channel based on the identified stakeholders. Communication channel is an effective tool because all of activities to make the changes can be defined properly by determining the main message to participants, delivery time, message recipient, and determining the person delivering the message.
2. Effective Sponsorship
   Sponsor is a key person to communicate with all employees. The sponsor must be directly involved in the entire change process in the company.
3. Coaching by Direct Managers
   One of the methods to build awareness is coaching. Managers must be the first to understand about change, such as what changes will be made, when changes are implemented, and how to make changes.
4. Easy to Access Information
   Ease of access to information by employees is important to find out the company's performance, corporate strategy, and strategic initiatives that will be carried out by the company and have an impact on future changes.

2.2.1 Desire

Desire is the most challenging element of ADKAR to achieve. The following are strategies to build desire effectively:

1. Effectively Sponsor the Change

Similar to awareness, at the desire stage, sponsors have an important role. Employees will have the desire to make changes if supported by an active and directly involved sponsor.

2. Equip Managers to Be Change Leaders
   At this stage the manager must be able to make changes at a more technical level. After managers understand the changes to be implemented, managers need to inform employees of their impact. The manager is the best position to be an agent of change.
3. Assessing Risk and Anticipating Resistance
   All risks must be identifiable so that their implementation can be properly mitigated. as with resistance, the potential for resistance must be identified to avoid failure to make changes.
4. Involving Employees in the Change Process
   Employees have an important role in making changes and determining success in implementing change. Employees can provide feedback to get better results.
5. Incentive Programs
   Incentive programs can be a consideration for management to reward employees. If management has initially committed to providing incentives, then after the changes are successful, the incentives need to be given appropriately.

2.2.2 Knowledge

Knowledge is the third stage of the ADKAR model to provide training related to changes to be implemented. The following are strategies to build knowledge effectively:

1. Build Training Programs
   The training strategy is an important thing that must be defined at the beginning of the knowledge stage. The training schedule must be aligned to the project schedule. To get optimal results, the training schedule is not too far from the go live schedule.
2. Job Aids
   Job aids are used to help employees / users know how to operate the system. This tool is very important during the transition of change
3. Personal Coaching
   The advantage of personal coaching is that training can be performed customized according to the needs of each individual and the problems it faces.
4. User Groups and Forums
   User groups and forums are media that can be used to share the knowledge that has been given and used to deepen the knowledge of employees / agents of change.

2.2.3 Ability

The third stage of the ADKAR model is the ability. sometimes there is a gap between the knowledge and abilities that employees have. The following are strategies to build ability effectively:

1. Daily Involvement of Managers
   Managers affected by business process change have a key role to making changes. The new process will be carried out by the employees and the manager must guide so that the new business process can be done properly.

2. Access to Subject Matter Experts
   Experts are the main resource in supporting and building abilities. Easy access to subject matter experts can provide added value to affected employees and managers to improve their abilities.
3. Hands-On Training
   Training programs that have been designed should involve users directly by using adapted work scenarios. Work simulations that are carried out directly and approach the desired state can accelerate capacity building.
4. Performance Monitoring
   Performance monitoring is important to identify aspects that need to be improved by employees.

2.2.4 Reinforcement

Reinforcement aims to make changes that can be implemented over a long period of time so that it becomes an organizational culture. The following are strategies to build reinforcement effectively:

1. Celebrations and Recognition
   Celebrate the successful implementation of the project to reward the hard work of the team involved during the work
2. Rewards
   Reward is the realization of the commitment agreed upon earlier by management. Rewards can build employee motivation in the change process.
3. Feedback from Employees
   Receiving feedback from employees is an evaluation of the change management implementation. From this feedback, the company can find out the maturity level in the changing business processes and know the alignment of objectives with their realization.
4. Audits and Performance Management Systems
   One of the methods to measure performance is direct assessment to find out that the changes have been made properly.
5. Accountability Systems
   Building an accountability system can have an impact on sustainable change.

3. RESULTS AND DISCUSSION

3.1 Business Process Change Analysis

Change analysis is used to identify the need for change management from the current state to the desired state.

Table 1. Business Process Changes

No	Process Change	Current Process	Desired Process	Implications of Change
1	Purchase document preparation	Users compare the similar product to get the prices.	Product prices from the contract catalog	E-catalog users get the best and standardized prices for 16 subsidiaries
2	Budget submission	Budget allocation submission is done before purchase request	Budget allocation submission is done after users get confirmation of	Budget allocation is more accurate according to purchasing needs

No	Process Change	Current Process	Desired Process	Implications of Change
			product availability by the e-catalogue supplier	
3	Purchase request process	Purchase request process with manual documents	Purchase request process through the e-catalogue system	The purchase request process can be done faster and managed properly through the system
4	Purchase approval process	The purchase approval process is done manually	The purchase approval process performed in the E-Catalog system and tiered according to the purchase amount	The process of reviewing purchases to approving can be done faster in the system
5	Purchase Order creation	The purchase order creation process is done manually in the Subsidiary's ERP system	The purchase order creation process is performed in the E-Catalog system and automatically created in the Subsidiary's ERP system.	Purchase orders that integrated with the ERP system can improve the accuracy of financial records
6	Receiving process	The process of receiving goods / services is done manually in the Subsidiary's ERP system	The process of receiving goods / services is performed in the E-Catalog system and integrated with the Subsidiary's ERP system.	The process of receiving goods / services can be done in real time and financial records can be recorded more accurately
7	Payment process	The payment process is based on Purchase Requisition (PR), Purchase Order (PO), and Handover Documents	The payment process is based on Purchase Requisition (PR), Purchase Order (PO) documents, Handover Documents, and Catalog Contracts.	Verification of payment document more accurately by comparing the contract catalog data

3.2 Business Process Change Analysis

Table 2. Procurement Policy Changes

No	Current Policy	Desired Policy	Implications of Change
1	Purchase only for goods	Purchases for goods and services	The scope of purchases is wider because e-catalogue can purchase goods and services
2	Traded goods in the market	E-Catalog Vendor are Producer / Principal / Manufacturer / Distributor / Subsidiary	The source of goods comes from the same vendors, there are Producer / Principal / Manufacturer / Distributor /

			Subsidiaries
3	Price commonly used in the market	The specifications and prices of goods / services have been determined in the catalog contract	Prices are cheaper than market prices, because catalog contracts require vendors to provide prices below the published price
4	Urgent goods	Goods / services that are used regularly	Users can make procurement plan correctly
5	Goods that can disrupt operations	Goods / services required by users	Users can make procurement plan correctly
6	Goods that are safety threatening and need to be procured immediately	Standardized goods / services	Users can make procurement plan correctly

3.3 Technology Change Analysis

The E-Catalog system will be integrated with ERP and e-procurement system in subsidiaries to minimize repetitive processes. Analysis of the surrounding system at the subsidiaries to assess the complexity of integration. There are 11 subsidiaries that have the same ERP system as the Head Office of PT XYZ. Furthermore, in the procurement system, there are 5 subsidiaries that have implemented an e-procurement system.

3.4 Change Management Design

3.4.1 Awareness

The first stage of ADKAR Model is Awareness. To build effective communication at this stage, its performed by build a communication channel based on the stakeholder identification for each subsidiary.

3.4.2 Desire

In Desire, communication is carried out more personally from managers to employees to solve problems and build a desire for make changes. To build Desire, companies should able to solve the “what's in it for me” (WIIFM) problem.

In the E-Catalog implementation of 16 subsidiaries, building Desire was done by building change agents, equipping change agents, and involving stakeholders.

3.4.3 Knowledge

E-Catalog implementation led to changes in business processes, policies, and technology. To support these changes, building effective knowledge needs to be done to all stakeholders. In this research, the formulation of training was carried out in 3 stages, there are:

1. Build Training Strategies
   Effective training is developed based on impacted stakeholders.

Table 3. Training Strategy

Type of Training	Objective	Target	Trainer
Policy Socialization	Introducing new policies that have been created	Impacted stakeholder	Change Sponsor and Change Leader
Process Introduction	Introducing changes in business processes, and	Impacted stakeholder	E-Catalog Implementers (Third Party)

Type of Training	Objective	Target	Trainer
	technology		
Train the Trainer	Train and equip internal trainers related to changes in business processes and technology	Change agents	E-Catalog Implementers (Third Party)
Business Simulation	Exploring the complexity of the business process	Impacted stakeholder	Change Agents
Knowledge Transfer	Provide a hands-on approach to process and technology changes	Impacted stakeholder	E-Catalog Implementers (Third Party)
External Socialization	Introducing a new system used by the company	Vendors/Suppliers (external stakeholders)	Change Leader, Change Agent, and E-Catalog Implementers
Inhouse Training	Provide training after go live system to keep new process maintained	Based on request	Change Agents

2. Build Training Materials
   The training material is customized based on the type of training, namely:
   - Changes in procurement policy,
   - Roles and responsibilities involved in the E-Catalogue,
   - Purchase limitation in E-Catalogue,
   - Overview of E-Catalogue,
   - Introduction of E-Catalog business process,
   - Introduction of new technologies adopted, and
   - Key changes from the new E-Catalog business process.
3. Build Training Evaluation
   Training evaluation aims to determine the effectiveness of the training that has been performed. Training evaluation is divided into three types, namely material evaluation, participant evaluation, and trainer evaluation.

3.4.3 Ability

At this stage, all stakeholders are expected to be able to apply their knowledge. The following are strategy to build Ability:

1. Involvement of Direct Managers
   In this strategy, direct managers / superiors need to build relationships openly to encourage their team to ask questions.
2. Access to Subject Matter Expert (SME)
   Subject Matter Expert (SME) is needed to ensure the learning process from manager to team can be performed properly.

3.4.4 Reinforcement

The final stage of the ADKAR model is Reinforcement. The first approach in Reinforcement is the celebration and recognition of all stakeholders involved during the E-Catalogue implementation. After that it is necessary to develop reinforcement strategy to sustained the change. The following are the approaches to build reinforcement in E-Catalogue system implementation:

1. Create a Corrective Action Plan
   This strategy aims to make stakeholders confident that the system can operate normally, but if problems are found, stakeholders can resolve them quickly.
2. Feedback from Employees
   Regular meetings with E-Catalogue system stakeholders to get feedback.
3. Build Audits System
   Procurement Division supervises purchases in subsidiaries by comparing the catalog contract with all purchase transactions in subsidiaries.
4. Build Performance Management System
   Performance measurement is very important to implement and ensure the sustainability of the system. The Head Office of PT XYZ needs to set a Key Performance Indicator (KPI) related to the efficiency of spending in the E-Catalog system subsidiaries.

3.5 Change Management Strategy

3.5.1 Implementation Strategy

The implementation strategy is divided into 4 stages based on the identified complexity of the implementation.

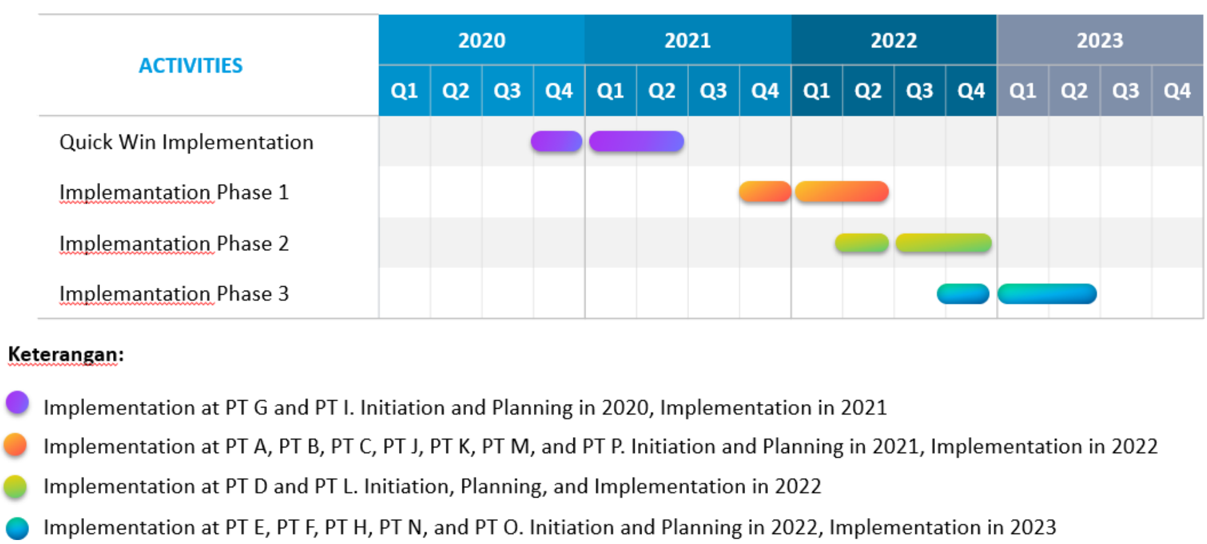

Figure 2. Implementation Strategy

3.5.2 Change Management Strategy

Based on the change management strategy with the ADKAR model that has been developed, the following is a change management roadmap that can be used as a guide for making changes.

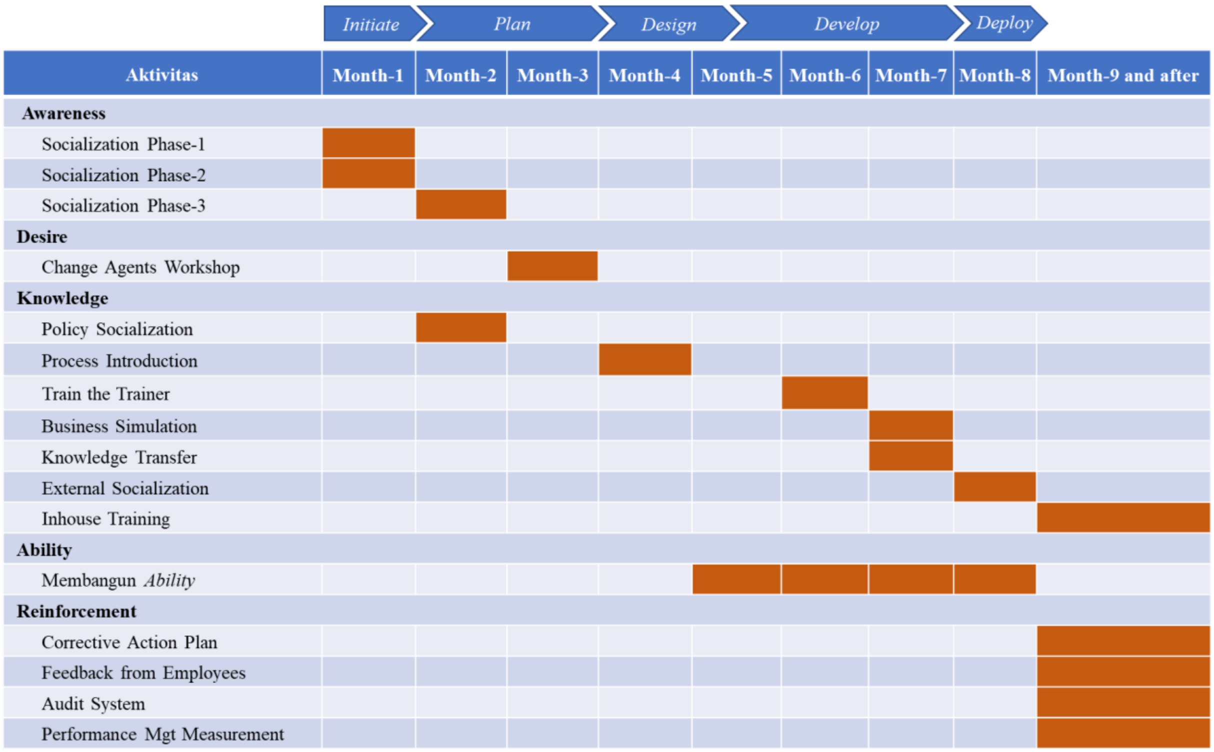

Figure 3. Change Management Strategy

4. CONCLUSIONS

The following are conclusions of this research:

1. Business processes changes in E-Catalog system implementation in 16 subsidiaries of PT XYZ can be mapped. There are 7 main changes to the purchasing business process, namely purchase document preparation, budget submission, purchase request process, purchase approval process, Purchase Order creation, receiving process, and payment process. All of the business process changes have a good impact on the company. In addition to changes in business processes, the implementation of e-catalog also impacted to technology and procurement policies in each subsidiary.

2. The change management strategy based on the ADKAR model is formulated as follows:
   a. Awareness
      Building the Awareness through effective communication by two-way communication. The strategy to build communication is done by creating communication channel that emphasizes communication activities, target participants, message / main information, sender of messages, and time of delivery the messages.
   b. Desire
      The desire to build change is performed by build and equip change sponsors, change leaders, and change agents in each subsidiary.

c. Knowledge
Building Knowledge strategies through build training strategies, build training materials, and build training evaluation. There are 7 types of training, there are policy socialization, process introduction, train the trainer, business simulation, knowledge transfer, external socialization, and inhouse training.
d. Ability
The ability to implement change is built by engaging managers to build an effective environment and provide access to subject matter experts (SME).
e. Reinforcement
Building Reinforcement through creating a corrective action plan, receiving feedback, building audit systems, and building performance management systems.
Please note that the submitted paper must be 6-10 pages long. If your paper significantly exceeds these limits, we will ask you to shorten you paper before deciding to accept it.

5. REFERENCES

Babin, Paul and Ghorashy, Ardi. (2019), "Leveraging Organizational Change Management to Strengthen Benefit Delivery in Innovation", Technology & Engineering Management 10 (1109), 1-8.

Galli, B.J. (2018), "Change Management Models: A Comparative Analysis and Concerns", Engineering Management 46(3), 124-132.

Galli, B.J. (2019), "An Engineering Manager's Guide for Commonly Used Change Management Approaches from One Practitioner's Experience", Engineering Management 47 (3), 118-126.

Godwin, R.E. (2019), Navigating Change: How Emotional Intelligence Competencies Drive Successful Transformational Change Within the Electric Utility Industry, Dissertation, The Chicago School of Professional Psychology, Chicago.

Grovom, R.D. (2013), Assessing Lean 5S As Industrial Laboratory Culture Change Utilizing the ADKAR Model and The PDSA Concept for A Sustainable 5S System, Thesis, California State University Dominguez Hills, California.

Kazmi, S.A.Z. Naarananoja, Marja. (2013), "Collection of Change Management Models– An Opportunity to Make the Best Choice from the Various Organizational Transformational Techniques", Business Review 2 (4), 44-57.

Neville, S.C. (2017), Foreign Object Debris Elimination in Military and Commercial Systems: Utilizing the Adkar Model to Improve Safety, Thesis, California State University Dominguez Hills, California.

Prosci. (2016), Succeed with Six ADKAR Resources, Entry from Prosci. https://www.prosci.com/adkar/adkar-model, last accessed on July 1, 2020.

Senge, Peter M, (1990), The Fifth Discipline The Art and Practice of Learning Organization, Doubleday Dell Publishing Group, Inc, New York.

Sulistiani, Endang. (2015), Perencanaan Strategi Manajemen Perubahan Penerapan Sistem Informasi Absensi Berbasis Fingerprint Pada Jurusan Sistem Informasi ITS Menggunakan Model ADKAR, Tesis, Institut Teknologi Sepuluh Nopember, Surabaya.

Trott, Paul, (2017), Innovation Management and New Product Development, 6th edition, Pearson Education., Harlow.

Veiga, A.D. (2018), "An Approach to Information Security Culture Change Combining ADKAR and the ISCA Questionnaire to Aid Transition to the Desired Culture", Information & Computer Security 26 (5), 584-612.

STRATEGIC MANAGEMENT MODEL FOR CLASSIFICATION AGENCY

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ABSTRACT

To become a growing and sustainable company, the National Classification Agency must have significant capabilities and roles in the shipping industry, as well as develop business in commercial sector. From the financial statements and gap analysis results of RJPP 2020-2024, the company's performance has not been optimal and its realization has not been in accordance with the company's targets. Therefore, it requires a strategic management model in order to increase optimal performance in accordance with the objectives, vision, and mission of the company. The formulation of strategic management model starts from the input stage by identifying, evaluating the company's internal and external factors, and creating competitive market profile. The results of scoring were entered into matching stage using Internal-External Matrix, Grand Strategy Matrix, and SWOT analysis. Furthermore, in decision stage, the Quantitative Strategic Planning method was used to determine priority strategies. The priority strategies obtained were developing the business to achieve high revenue; improving service quality; creating market plan for effective market penetration; and becoming an IACS member to expand the business to global market. This paper is an intermediary research to obtain a comprehensive strategic management model in order to improve company performance.

Keywords: classification agency, company performance, priority strategy, strategic management model.

1. INTRODUCTION

Several factors that can significantly influence the value of a company are growth opportunities (sales or income), capital structure, and profitability (Hermuningsih, 2013). Growth opportunities are the probability of a company growing in the future (Mai, 2006). Sales growth is an increase in the number of sales from year to year or from time to time where companies that have high sales growth rates will require more investment in various asset elements. According to Fabozzi and Peterson (2003), capital structure is a combination of debt and equity that is used to finance company projects. The capital structure of a company is a mixture of debt, internally generated equity and new equity. Husnan (2001) defines profitability as the company's ability to increase profits from sales, assets, and certain capital stocks. On the other side, Shapiro (1991) defines profitability as the ability of companies to earn profits using all the capital they have.

The National Classification Agency, is a state-owned enterprise (survey services) that has two core business sectors, namely: classification and commercial. As a National Classification Agency as well as a survey service state-owned enterprise has the main task of classifying

Indonesian-flagged vessels and foreign-flagged vessels operating in Indonesian waters, as well as carrying out statutory surveys and certification on behalf of the Government of the Republic of Indonesia. Apart from classification business activities, National Classification Agency also develops its activities in the commercial sector (independent assurance) which includes several business fields, namely marine, offshore, energy, and industry.

From the two business sectors, National Classification Agency has the ability and opportunity to obtain potential revenue and profitability in accordance with the targets set. In the shipping industry value chain, National Classification Agency has a significant ability and role, starting from approval of designs, materials, and components to survey and statutory activities. In terms of market size, the commercial sector (testing, inspection, and certification) has a wide and large potential market (opportunity).

In line with one of National Classification Agency's 2020-2024 missions, maximizing National Classification Agency's resources with all their potential in order to become a market leader in the independent marine assurance business, as well as a growing and sustainable company, a strategic management model is required for the priorities of the business sector that will be used as a target for achieving company revenue accompanied by increased profitability, effective resource development, and cost efficiency. From the analysis that has been carried out, in addition to a financial perspective, it is necessary to complement with a strategic management model analysis related to the perspective, namely business processes, customers, learning, and growth to make it more comprehensive.

2. METHOD

2.1 Strategic Management Model

The strategic orientation of the company describes the tendency of decision-making and company principles that direct its activities and produce behavior for the achievement of company performance according to targets in the existing market. According to (Wales et al, 2018), there are three main strategic orientations that can influence the sales growth of a company, namely market orientation, entrepreneurial orientation, and learning orientation. The combination of the three main strategic orientations results in a construction called a proactive learning culture. The results of the analysis signifies that entrepreneurial orientation is the most dominant factor in influencing the company's sales growth compared to market and learning orientation.

The business model defines a business based on a unique value proposition in a network of users, organizations, and stakeholder collaboration (Zott & Amit, 2008). Business models emerge as a holistic response to certain business challenges, particularly in building e-business (Amit & Zott, 2001), commercialization technology (Arora & Ceccagnoli, 2006), building new businesses/ventures (Fiet & Patel, 2008), and providing the means to exploit the commercial potential of information technology (Osterwalder & Pigneur, 2010).

According to David & David (2017), the definition of strategic management is the art and knowledge of formulating, implementing, and evaluating cross functional decisions that enable an organization to achieve its goals. Important strategy formulation techniques can be integrated into a three-stage decision-making framework, namely input stage, matching stage, and decision stage.

Input stage requires a strategy to measure subjectivity during the early stages of the strategy formulation process. Making small decisions in the matrix regarding the relative importance of external and internal factors allows strategists to more effectively generate, prioritize, evaluate, and choose among alternative strategies. At the input stage, there are three Matrix, namely IFE Matrix, EFE Matrix, and Competitive Profile Matrix (CPM). The stages of the Internal & External Evaluation Factor (IFE & EFE) include identification of strengths &

weaknesses (internal company factors) and opportunities & threats (company external factors) according to references in the annual report or RJPP; weighting according to the level of urgency of the factors that have been determined; rating each of these factors according to the current conditions of class & commercial business sector (scale 1-4); and scoring the weighting and assessment results according to predetermined factors which refer to RJPP 2020-2024. The next input stage is the creation of a Competitive Profile Matrix (CPM) with key success factors consisting of information technology, company reputation, marketing, service quality, and rates/prices. The process of weighting and rating on the CPM (on each key success factor) is the same as the process in IFE & EFE. Competitors used as a comparison in the classification business are foreign classification bodies of IACS and non-IACS members, while for commercial business competitors, the competitors are multinational TIC companies, other state-owned survey service companies and private TIC companies.

The strategy formulation framework matching stage consists of three techniques that can be used, namely IE Matrix, Grand Strategy Matrix, and SWOT Matrix. The matching stage, especially for the Internal-External (IE) and Grand Strategy (GS) matrix, uses input values of IFE, EFE, and relative market & competitive growth rates. IE Matrix analysis is used to determine the company's current position. After finding out the internal conditions, the next step is finding out what strategies have the potential to the existing external conditions. From the results of the strengths & weaknesses identification (company internal factors) as well as opportunities & threats (company external factors), a SWOT matrix can be created so that a strategy is made to optimize existing weaknesses and opportunities against existing weaknesses and threats.

One way to choose an alternative strategy is to use the Quantitative Strategic Planning Matrix (QSPM) which is a technique designed to objectively implement alternative strategies, based on external and internal factors that have been previously identified, and are relatively feasible. The key factors used are the results of the identification of strengths & weaknesses (company internal factors) as well as opportunities & threats (company external factors). Lastly, the weighting and assessment are carried out according to the previous selected strategies. This matrix shows the best alternative based on the information obtained from the input and matching stages.

2.2 Priority Strategy

From the results of the strategy formulation, several generic or grand strategies were obtained as references for determining strategic priorities using a canvass business model perspective which consists of 11 building blocks (customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure) and 4 balanced scorecard perspectives (finance, customer, internal business process, and learning & growth). Afterwards, the goals and work programs that refer to these perspectives were made so that they become more detailed and get priority work programs.

3. RESULTS AND DISCUSSION

3.1 Strategy Formulation

Internal Factor Evaluation (IFE) results obtained scores of 2.70 for class and 2.63 for commercial, while the results of External Factor Evaluation (EFE) obtained a score of 2.63 for the class and 2.63 for the commercial (1-4 scale). The assessment factors on the excess variables are state owned enterprise status, networking, branch offices, quality management, and human resources. Meanwhile, the weakness assessment factors include IACS membership, reputation & customer satisfaction, market share, customer relations, and R&D. The opportunity assessment factors involve market growth, government regulations, MoU, the need for service quality, and information technology. The threat assessment factors consist of competitors, global pandemic, domestic market, government tariff policies, and global market barriers. From the competitive profile matrix that has been made, the score of 2.80 was for the classification field and 2.80 was for the commercial field where the lowest & highest scores for other competitors are on a scale of 2.60 to 3.00.

The results of the Internal External Matrix plot, the classification, and commercial business positions are in quadrant V, namely in the hold & maintain position with recommendations for generic strategies that can be applied are market penetration and product development. Meanwhile, for the plot in the Grand Strategy Matrix, the classification and commercial business positions are in quadrant I, meaning that the strategy is already running well with generic strategy recommendations that can be applied including market development, market penetration, and product development. Figures 1 and 2 show the Internal External Matrix and Grand Strategy.

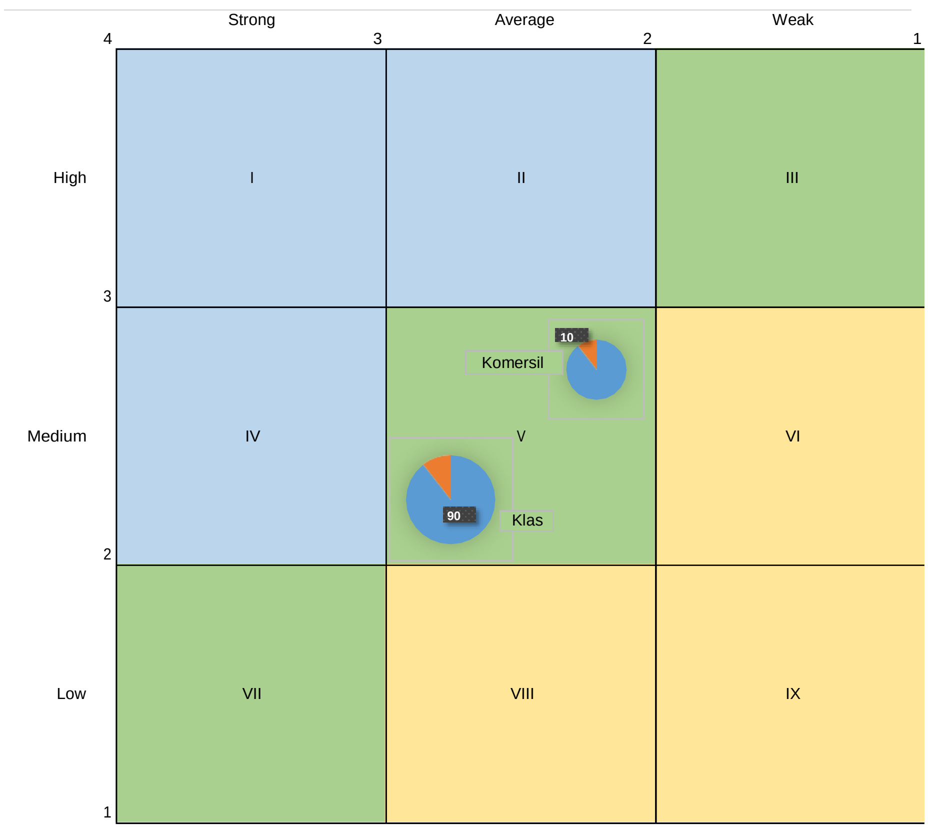

Figure 1. Internal-External Matrix

Kuadran II 1. Market development 2. Market penetration 3. Product development 4. Horizontal integration 5. Divestiture 6. Liquidation	Kuadran I 1. Market development 2. Market penetration 3. Product development 4. Forward integration 5. Backward integration 6. Horizontal integration 7. Concentric diversificatio
Kuadran III 1. Retrenchment 2. Concentric diversification 3. Horizontal diversification 4. Conglomerate diversification 5. Divestiture 6. Liquidation	Kuadran IV 1. Concentric diversification 2. Horizontal diversification 3. Conglomerate diversification 4. Joint venture

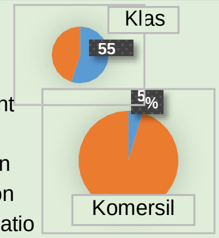

Figure 2. Grand Strategy Matrix

From the results of the identification of strengths & weaknesses (internal company factors) as well as opportunities & threats (company external factors), a SWOT matrix was created so that a strategy is made to optimize the existing weaknesses and opportunities against existing weaknesses and threats as shown in Figure 3. Some of the main strategies that are obtained in particular for the classification business sector include improving service quality & customer satisfaction and becoming a member of the IACS so as to expand the classification & TIC business to the global market. Meanwhile, the main strategies for the commercial business sector include improving service quality & customer satisfaction and developing new portfolios.

	STRENGTHS (S)	**WEAKNESSES (W)**
	1. State Owned Enterprise 2. Strong networking 3. Branch offices 4. Good quality management 5. Qualified knowledge & skills	1. Non IACS member 2. Reputation & customer satisfaction 3. Market share 4. Customer relation management 5. Research & development
OPPORTUNITIES (O)	**SO**	**WO**
1. Market growth 2. Government policy 3. MoU 4. The need for quality service 5. IT is growing rapidly	1. Make rates competitive[S1,S3,O1,03,O5] 2. Existing businesses intensification [S1,S2,S4,S5,O1,O2,O4] 3. Get the trust of the government [S1,O1,O2] 4. Forge strategic alliances [S1,S2,S5,O1,O3]	1. Increased customer satisfaction & loyalty [W1,W3,W4,O1,O3,O4] 2. Business process efficiency [W2,W4,W5,O2,O4,O5] 3. Build a competency based system [W4,W2,W4,O1,O4]
THREATS (T)	**ST**	**WT**
1. Tighter competitors 2. Global pandemic that happened 3. Domestic market 4. Tariff policy 5. Global market barrier	1. New portfolio development [S3,S4,S5,T1,T2] 2. Effective marketing plan [S1,S3,T1,T2,T5] 3. Quality management improvement [S3,T1,T3]	1. Become IACS member [W1,T1,T3,T4] 2. Digitization of business processes [W5,W2,W4,W5,T1,T2] 3. Increased Brand awareness [T5] 4. IT and R&D development [W4,W5,T1]

Figure 3. SWOT Matrix

From the input and matching process, generic strategies were obtained, namely market penetration, market development, and product development. The strategic forms of the generic strategy are strengthening market share by improving service quality & customer satisfaction, making an effective marketing plan & pricing strategy (market penetration); becoming a member of IACS so as to expand the classification and TIC business to the global market (market development); and developing new portfolio (product development).

The three predetermined forms of strategy were then selected for priority strategies using the Quantitative Strategic Planning Matrix method. The key factors used were the results of the identification of strengths & weaknesses (company internal factors) and opportunities & threats (company external factors). Subsequently, the weighting and assessment were carried out according to the three previously selected strategies. From the QSPM process, a priority strategy that can be done by the company was obtained, namely developing a new portfolio (product development). The full results of the QSPM are shown in Table 1.

Table 1. Quantitative Strategic Planning Matrix (QSPM)

KEY FACTOR		Weight	Expansion of Class & TIC business to global market (S1)		Strengthening domestic market share by improving service quality & customer satisfaction, as well as making effective marketing plans (S2)		Development of new portfolios in IT, logistics, port, and other industries (S3)	
			AS	TAS	AS	TAS	AS	TAS
STRENGTHS	BUMN	0,11	1	0,11	3	0,33	2	0,22
	Networking	0,09	4	0,36	4	0,36	4	0,36
	Branch offices	0,11	3	0,33	3	0,33	3	0,33
	Quality management	0,12	4	0,48	4	0,48	4	0,48
	Human resources	0,11	3	0,33	3	0,33	3	0,33
WEAKNESSES	IACS member	0,12	4	0,48	1	0,12	1	0,12
	Reputation	0,09	4	0,36	4	0,36	4	0,36
	Market share	0,11	2	0,22	2	0,22	3	0,33
	CRM	0,09	3	0,27	3	0,27	3	0,27
	R&D	0,05	3	0,15	3	0,15	3	0,15
SUM WEIGHTS		1,00		3,09		2,95		2,95
OPPORTUNITIES	Market growth	0,13	3	0,39	2	0,26	3	0,39
	Government policy	0,11	0	0	4	0,44	3	0,33
	MoU	0,08	4	0,32	2	0,16	3	0,24
	Need for quality services	0,11	4	0,44	3	0,33	4	0,44
	IT	0,10	3	0,3	3	0,3	3	0,3
THREATS	Competitors	0,12	3	0,36	3	0,36	3	0,36
	Global pandemic	0,10	4	0,4	2	0,2	2	0,2
	Domestic market	0,11	2	0,22	4	0,44	3	0,33
	Tariff policy	0,09	0	0	2	0,18	2	0,18
	Global market barrier	0,05	3	0,15	3	0,15	3	0,15
SUM WEIGHTS		1,00		2,58		2,82		2,92
SUM TOTAL ATTRACTIVENESS SCORES				**5,67**		**5,77**		**5,87**

3.2 Priority Strategy Selection

In the next stage, the priority strategy selection stage, a new canvass business model (BMC) was made from National Classification Agency in accordance with the chosen grand strategy. In the new BMC, there will be additional segments from BMC, such as value proposition, customer segment, and others according to the additional strategy. After that, a combination of BMC and balance scorecard was made for one grand strategy that would be implemented. After that, an execution baseline was made as a reference for the activity plan.

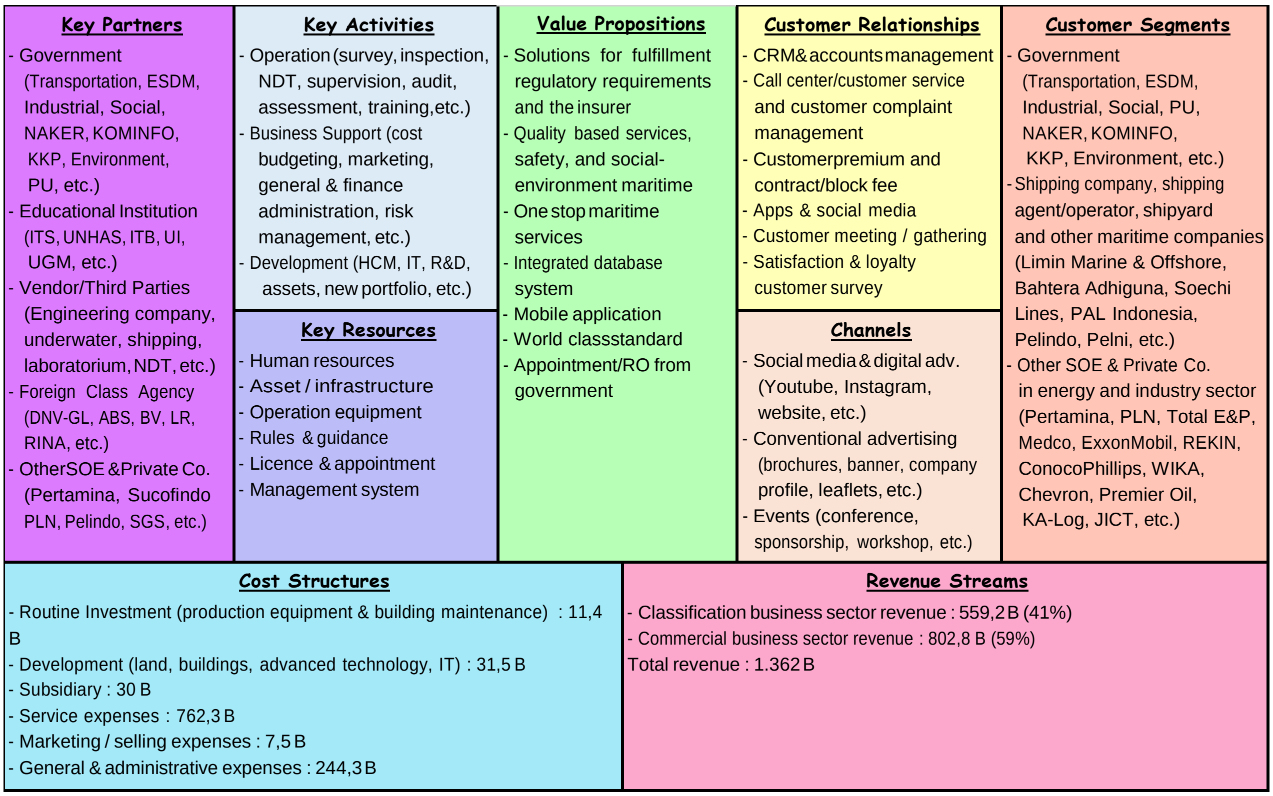

Figure 4. Business Model Canvas (Projections for the Next Five Years)

From the new BMC as shown in Figure 4, the building blocks on the BMC were put into the 4 balanced scorecard perspectives where the final goal must be in line with the company's vision & mission, illustration of merging BMC building blocks, and the 4 balanced scorecard perspectives. Furthermore, from the strategic objectives and work program according to Figure 5, a program was made according to each theme of the grand strategy that has been chosen so that priority program initiations were obtained for each theme, for example the business development theme shown in Figure 6.

BSC Perspective	Tematic	Building Blocks BMC	Strategy objective	Work Program
Financial	Financial Healtier	Revenue Stream	Profitability, increase profits	New business development, market penetration, acquisition of high revenue impact projects, and effective & efficient project management
			Revenue, increase revenue	
		Cost Structure	Cost Efficiency, reducing operating expenses	

Customer	Customer Satisfaction	Value Preposition	Customer Satisfaction, increase customer satisfaction	Customer intimacy & loyalty program
			Low Prices, competitive prices compared to competitors	Conducting marketing intelligence to create strategic management reports including Industry environment analysis
			Market share, increased market share	
			Sales, product sales increase	Marketing program
	Customer Loyalty	Customer Relationship & Customer Segments	Customer Loyalty, Increase customer loyalty	Customer intimacy & loyalty program
Internal Business Process	Increase Productivity	Key activities	Excellence quality delivery, improving service quality to customers	Continues Improvement quality services according to ISO standards
			Effective market plan, increase marketing effectiveness	Making a market plan and regular reviews
			New maritime solution product, creating a new product which is still Classification Agency's main business core at this time	Strengthening the R&D department
	Quantity Partnership	Channels	Strategic Partnership, expanding market share	Strategic partnership program
		Key partners	Strategic Partnership, to increase the number of strategic partners	Strategic partnership program
	Operational Excellence	Cost structure	Excellence service delivery, increasing product on time delivery	Service delivery program incentives
				Become IACS member so that it can enter the global class & TIC market
Learning & Growth	Employee Allignment	Key Resources	Human Capital Allignment, improving HR capabilities	Staff Training for IACS standard, Maritime technology & IT certification
			Productivity, increase employee productivity	Rewards & punishment employee program
	Business and Technology Concept	Cost Structure	IT excellence system, increasing technology investment for corporate governance systems	Develop & maintenance IT system

Figure 5. Strategy Objectives and Work Programs

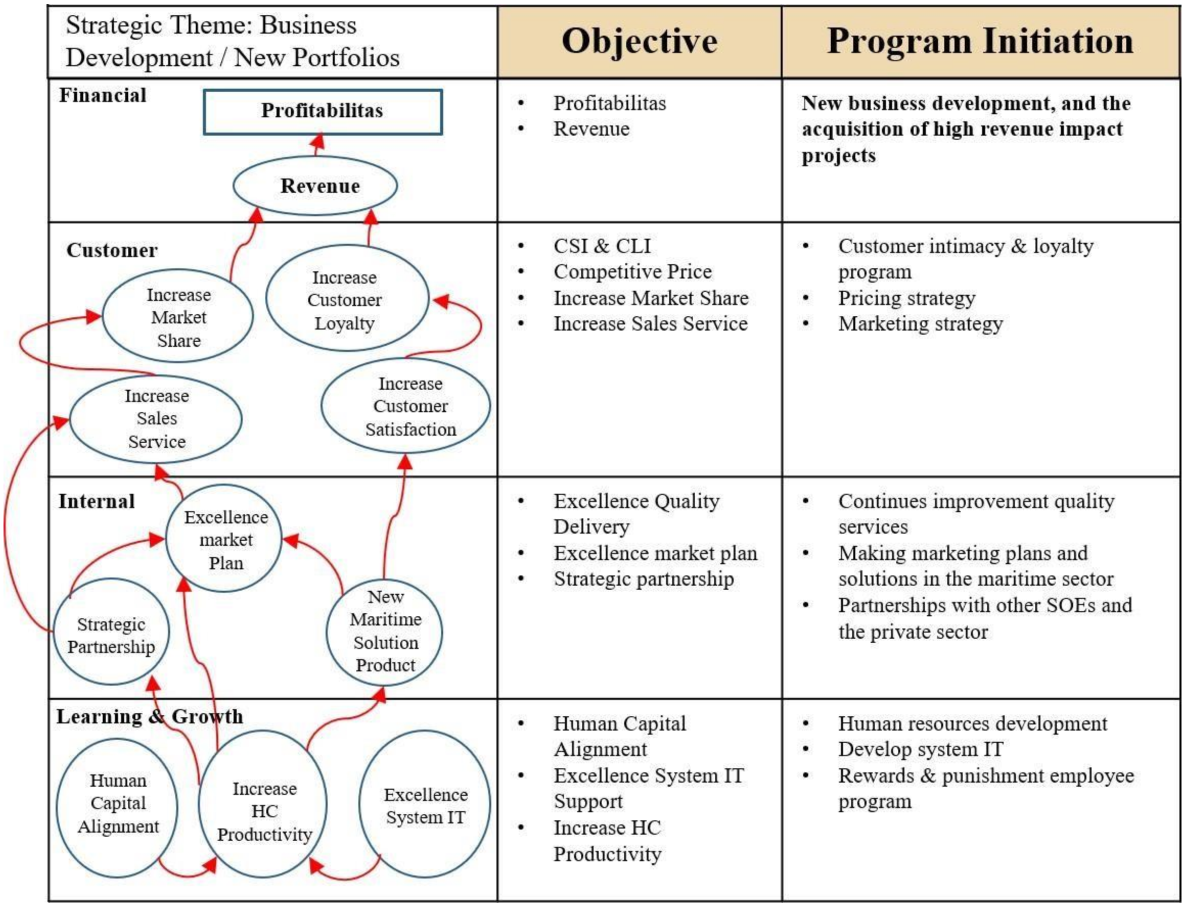

Figure 6. Work Program Theme: Business Development

4. CONCLUSION

Some of the priority strategies and programs aiming at improving company performance are developing new business innovations to achieve high revenue in the commercial sector improving service quality, satisfaction & loyalty of service users; making appropriate market plans for effective market penetration; and becoming a member of IACS to expand the business to the global market, especially the classification sector. Several things that need to be considered in the implementation of the aforementioned strategy are effective budget planning and top management commitment in terms of budget determination and realization (marketing costs, investment in production equipment, human resource development, etc.) making comprehensive business studies and innovative (exploring new market opportunities); carrying out cost efficiency to increase profitability (especially in the commercial business sector), and prioritizing job acquisition with a profitability value according to a predetermined minimum standard (jobs with profitability less than the minimum standard can be taken if the achievement of the revenue and profitability budget has been or is almost fulfilled).

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Amit, R., & Zott, C. (2001). Value creation in e‐business. Strategic management journal, 22(6‐7), 493-520.

Arora, A., & Ceccagnoli, M. (2006). Patent protection, complementary assets, and firms' incentives for technology licensing. Management Science, 52(2), 293-308.

David, F. R., & David, F. R. (2016). Strategic Management: A Competitive Advantage Approach, Concepts and Cases, Global Edition. Pearson Education Limited.

Fabozzi, F. J., & Peterson, P. P. (2003). Financial management and analysis (Vol. 132). John Wiley & Sons.

Fiet, J. O., & Patel, P. C. (2008). Forgiving business models for new ventures. Entrepreneurship: Theory and Practice, 32(4), 749-761.

Hermuningsih, S. (2013). Profitability, growth opportunity, capital structure and the firm value. Buletin Ekonomi Moneter dan Perbankan, 16(2), 115-136.

Husnan, Suad (2001). Manajemen Keuangan Teori Dan Penerapan (Keputusan Jangka Pendek) Buku 2 Edisi 4 Cetakan Pertama. Yogyakarta: BPFE.

Mai, Muhammad Umar., 2006, Analisis Variabel-Variabel yang Mempengaruhi Struktur Modal Pada Perusahaan-Perusahaan LQ-45 di Bursa Efek Jakarta, Ekonomika, Hal. 228- 245. Politeknik Negeri, Bandung.

Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons.

Shapiro, A. (1991). Establishing a capital structure. Modern Corporate Finance, 458-486.

Wales, W., Beliaeva, T., Shirokova, G., Stettler, T. R., & Gupta, V. K. (2018). Orienting toward sales growth? Decomposing the variance attributed to three fundamental organizational strategic orientations. Journal of Business Research.

Zott, C., & Amit, R. (2008). The fit between product market strategy and business model: implications for firm performance. Strategic Management Journal, 29(1), 1-26.

FORMULATION OF MARKETING STRATEGY FOR INSTRUMENTCALIBRATION SERVICES IN ELECTRONIC INSTRUMENTATIONCOMPANIES (CASE STUDY FROM PT. TERMINAL ELEKTRONIKA SEKAWAN JAKARTA)

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ABSTRACT

In such a challenging economic era, the creative economy is one of the sectors that the Indonesian government hopes it will grow and increase. This is not an easy task to do because it requires the ability to predict market trends. To become a major player in the industry, company needs to understand more than existing target markets to raise more revenue. In addition, the company must also improve their "game" in marketing strategies, to attract customers' curiosity about the service that the company offer. This thesis specifically addresses how company can become one of the biggest player in the electronic instrument calibration industry, by analyzing the company business then formulating business and marketing strategies, and ultimately planning short- and long-term implementation plan. This research was conducted by identifying the analysis of the scopeof laboratory calibration, market share and considerations that make the step of drafting this marketing strategy easier. For the scope of the calibration laboratory, which includes is AC/DC electric calibration, temperature calibration and time frequency calibration and oscilloscope. Then, companies need to define which market share they want to expand and enter by redefining their business canvas. After knowing the targeted market and combined with market analysis, the company defines the business strategy using the 5W 1H, SWOT, Focus Group Discussion (FGD) and Structure Equation Modelling (SEM) methods. Ultimately, this research can provide recommendation for implementation plan to increase the success rate of marketing strategy. With the result, the company can use this thesis as a reference.

Keywords: marketing, calibration, SWOT, *Structural Equation Modelling*.

1. INTRODUCTION

Each organization, whether involved in goods or services, has an objective to live and develop. The current state of business growth is very strong, as can be seen by the growth of companies similar to that of rivals, such that rivalry for markets and customers exists. In this scenario, a business that is near the market where it will be or will be sold for the product or service being provided. Maintaining and rising business profits or profits will accomplish this purpose. The rise is carried out by seeking and encouraging buyers, as well as attempts to dominate the industry. This cannot be isolated from the marketing department portion of the business in implementing a successful strategy to be able to leverage the marketing opportunities or possibilities, so that the role of the company in the market can be both retained and strengthened. In achieving business efficiency, marketing strategy plays an important role, so the marketing field plays an important role in the execution of the business plan. This can be achieved if the company wishes to retainand improve sales of the goods or services they sell by increasing sales opportunities, so that the rating or role of the company in the market can be increased or sustained. It has a major role as a direct support for rising company income in conjunction with the introduction of modern marketing today. In this case there is a term Marketing Mix. Marketing Mix is a way in which entrepreneurs can influence their consumers which requires careful planning and supervision and concrete actions are needed. For this purpose, entrepreneurs can take actions consisting of 4 types, namely actions regarding the product, price (price), distribution or product placement (place) and promotion (promotion). In carrying out marketing activities there are several goals that will be achieved both, short-term goals and long-term goals. In the short term, it is usually to attract the winds of the season, especially for new products launched, while in the long term it is done to maintain existing products in order to survive. In order to achieve this goal, the company must be able to attract the attention of its consumers through the products it offers. This can be done by means of promotion. Promotion can be done by participating in exhibitions and through media such as magazines, newspapers, TV, radio, and the internet.

To achieve the maximum marketing strategy, a company can use the SEM (Structural Equation Modeling) method. The SEM (Structural Equation Modeling) method is a statistical modeling technique that is highly cross-sectional, linear and general in nature. Included in this form of SEM are factor analysis (factor analysis), path analysis (path analysis) and regression (regression). The SEM method is improving and has a regression-like feature, but it seems that the SEM method is a better analytical technique since it considers simulation of interactions, nonlinearity, correlated independent variables (correlated independent), measurement error, correlated error disturbance. Many latent independent variables (correlation error terms), numerous latent independent variables (multiple latent independent variables), each calculated using multiple measures, and one or two latent dependent variables, each measured by multiple predictor variables. The SEM approach can therefore be used according to this definition as another alternative that is better than using multiple regression, path analysis, factor analysis, time series analysis, and covariance analysis.

2. RESEARCH METHOD

2.1 Conceptual Framework

To make it easier for researchers to complete this research, the sequence of activities is in the form of a conceptual framework.

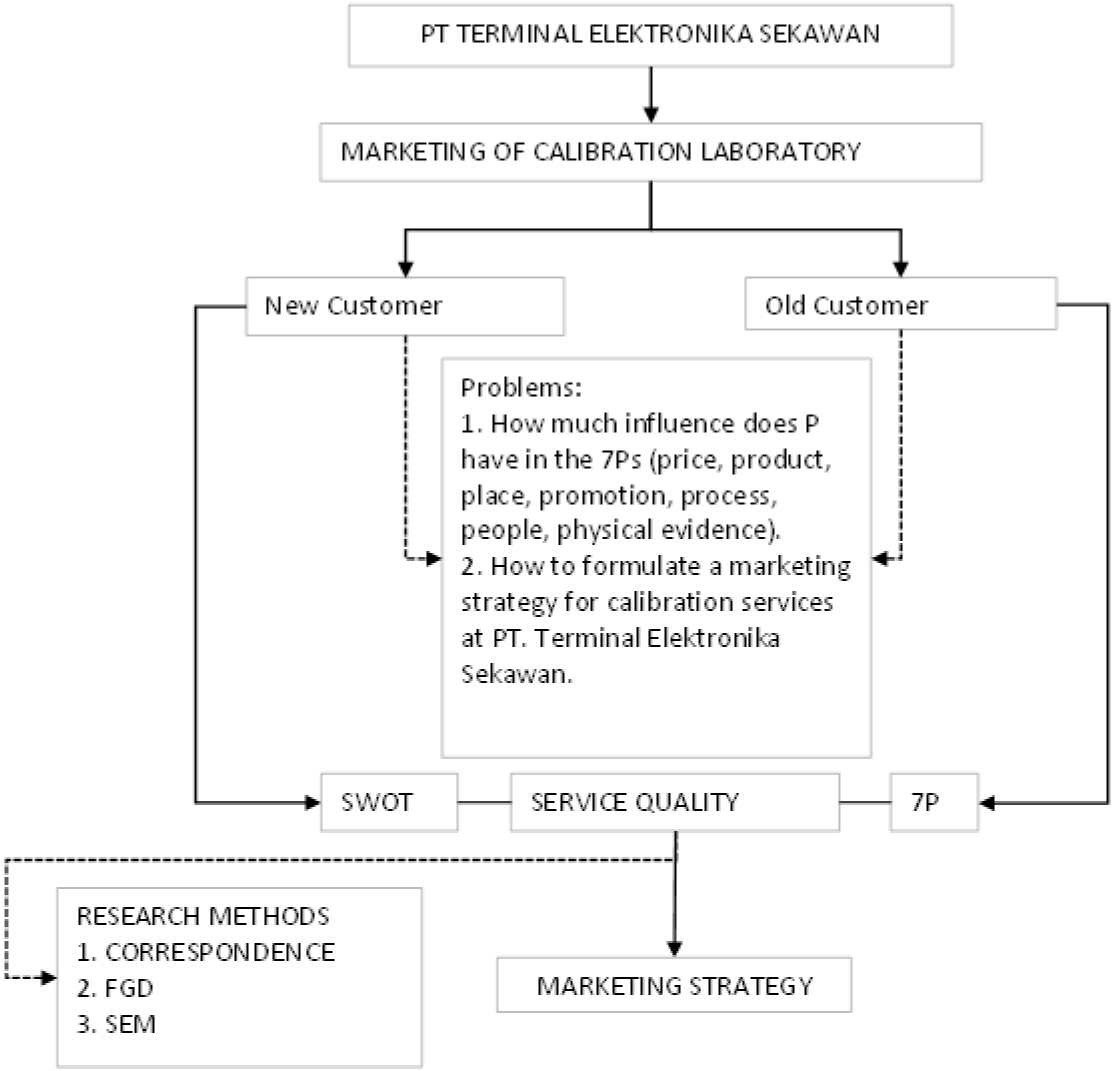

Figure 1. Conceptual framework diagram

2.2 Data Analysis Method

To find out the right strategy for marketing this calibration service, the Structural Equation Modeling method is used with the Partial Least Square method. This analysis was carried out based on the research objectives, as for the steps as follows:

1. Data Exploration
   Data exploration is carried out with the aim of checking the data whether the data obtained actually matches the scale of the data used.
2. Analysis of Structural Equation Model (SEM) using Partial Least Square,
   A. Obtaining a model based on the developed concepts and theories, namely designing astructural model (the relationship between latent variables).
   B. Designing a measurement model that is the relationship between indicators and latentvariables.
   C. Creating a path diagram that explains the pattern of the relationship between latentvariables and their indicators.

3. REFERENCES

Abdullah, S., & Purnomo, A. (2019). Application of Structural Equation Modeling (SEM) for Analysis of the Effect of Perception on Professionality, Knowledge and Motivation of Nurses on the Implementation of Patients Safety Programs. *Asian Journal of Research in Nursing and Health*, 1-12.

Alipour, M., Hajaliakbari, F., & Javanbakht, N. (2011). The impact of web-marketing mix (4s) on development of tourism industry in Iran. *International Journal of Business and Social Science*, *2*(6), 267-274.

Dragan, D., & Topolšek, D. (2014, June). Introduction to structural equation modeling: review, methodology and practical applications. In *The 11th International Conference on Logistics* (pp. 1-27).

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of marketing research*, *18*(1), 39-50.

Georgellis, Y., Joyce, P., & Woods, A. (2000). Entrepreneurial action, innovation and business performance: the small independent business. *Journal of small business and enterprise development*. 7(1).7-17.

Jain, M. K. (2013). An analysis of marketing mix: 7Ps or more. *Asian Journal of Multidisciplinary Studies*, *1*(4), 23-28.

Jones, T. O., & Sasser, W. E. (1995). Why Satisfaction Customer Defect. *Harvard Business Review*, *73*(4), 88-99.

Khatab, J. J., Esmaeel, E. S., & Othman, B. (2019). Dimensions of service marketing mix and its effects on customer satisfaction: a case study of international Kurdistan Bankin Erbil City-Iraq. *TEST Engineering & Management*, *4846*, 4846-4855.

Kotler, P. (1997). *Manajemen Pemasaran : Analisis, Perencanaan, Implementasi, dan Kontrol*. Jilid 1 (Edisi Bahasa Indonesia dari Principles of Marketing 9e). PT. Prenhalindo. Jakarta.

Oflac, B. S., Dobrucalı, B., Yavas, T., & Escobar, M. G. (2015). Services marketing mix efforts of a global services brand: The case of DHL Logistics. *Procedia economics and finance*, *23*, 1079-1083.

Rafiq, M., & Ahmed, P. K. (1995). Using the 7Ps as a generic marketing mix: an exploratory survey of UK and European marketing academics. *marketing intelligence & planning*.

Rahman, W., Shah, F. A., & Rasli, A. (2015). Use of structural equation modeling in social science research. *Asian Social Science*, *11*(4), 371.

Susanti, A. P. (2016). *Analisis Pengaruh Marketing Mix Terhadap Kepuasan Serta Loyalitas Pelanggan, Studi Kasus: Cv. Sego Njamoer Outlet Cabang Sakinah Surabaya* (Doctoral dissertation, Institut Teknologi Sepuluh Nopember Surabaya).

Ullman, J. B., & Bentler, P. M. (2003). Structural equation modeling. *Handbook of psychology,* 607-634.

Weston, R., & Gore Jr, P. A. (2006). A brief guide to structural equation modeling. *The counseling psychologist*, *34*(5), 719-751.

Yasanallah, P., & Bidram, V. (2012). Studying the status of marketing mix (7Ps) in consumer cooperatives at Ilam province from members' perspectives. *American Journal of Industrial and Business Management*, *2*(04), 194.

THE STRATEGY OF BUSINESS INNOVATION DEVELOPMENT: STUDY CASE IN TESTING, INSPECTION & CERTIFICATION COMPANY

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ABSTRACT

Based on the gap analysis carried out by company and demands from shareholders who want company to carry out business development with various innovations in order to achieve the predetermined revenue, profit and growth targets. With the opening of the global market in Indonesia which has an impact on the competition in the Testing, Inspection, & Certification industry, it is getting tougher. The large number of local companies and foreign companies makes company have to adjust. The problem that arises and must be faced by company is the problem of determining a strategy in order to overcome the current condition and the targets set by shareholders. In addition, company must determine the steps in implementing the best strategy, so that the company's vision and mission can be achieved. This study aims to formulate the best business innovation development strategy for company. In order to know the current situation, the researcher conducted an analysis of internal factors using the resource-based view method and analysis of external factors using the PESTEL method, so that strengths, weaknesses, opportunities and threats (SWOT) could be identified for company. Ansoff Matrix and Analytical Hierarchy Process (AHP) to formulate a business innovation development strategy for company. The final objective of this research is to produce the best strategy and implementation steps that can be taken by company in achieving its business development.

Keywords: Strategy, Business Innovation, Testing, Inspection & Certification Industry, Resource-Based View, PESTEL, SWOT, Ansoff Matrix, AHP.

1. INTRODUCTION

Strategy is a pattern of mobilizing and directing all company resources for the realization of the vision through the existing missions of the company. With the right strategy, all of the company's resources are mobilized into enormous strengths to be directed towards achieving the company's mission so as to promise the achievement of the vision. The need to formulate a strategy usually arises in response to received threats, for example many newcomers to the same field, shifting consumer tastes, or new Government Regulations, or responses to opportunities, for example technological innovations, development of new applications of existing products, or product development (Hermawan, 2015). In order to realize the company's vision and mission in the current business uncertainty, companies need to make innovations to implement the strategies that have been made.

According to Sarijani (2015), innovation is creativity which is translated into something that can be implemented and provides added value to the resources owned, thus innovating requires creative intelligence. Innovation aims to turn opportunities into marketable ideas. The implication is that if creativity is a new thing, innovation is a doing new thing. Innovation is more than just a good idea, because innovation is a continuation of an idea whose concept is more mature and then implemented. Therefore, innovation is a combination of creativity, ideas, vision, and dedication to implement the ideas that have been formulated.

The development of business innovation can be in the form of product diversification, business processes, and organization (management) which is carried out to maximize profits so that the company's cash flow can be more stable. In addition, companies do this to overcome the economic crisis, if a company experiences a decline in revenue in one product or country / region, in other products or countries / regions there is still the possibility of getting excess income, so that the shortfall that occurs can be covered. This is done by the company to ensure a more stable income / cash flow thereby increasing the trust of shareholders.

According to Rahayuningsih (2015), one of the main concerns in corporate strategy is to recognize the business areas in which a company must focus its attention on operating and competing to maximize profit in the long term so that the company can continue to grow. Each company has the freedom to determine which strategy will be used in competition, but it must be guided that the chosen strategy has a match between the choice of strategy and the market environment or the company's position (market segmentation) in order to optimize the company's value.

Some of the strategies that companies use in developing business are by entering new businesses through acquisitions of existing businesses, internal development, joint ventures, and choosing how to enter new businesses directly. The development of innovation through business related to the business being carried out will competitively have a link between the cross-business value chain and the resources it owns. Meanwhile, the development of innovation through new businesses that do not exist with an ongoing business can provide business opportunities and potential risks to be faced.

In this study, researchers conducted case studies for companies engaged in testing, inspection, & certification. The general concept of research, based on the ISO/IEC 17000:2004 Conformity Assessment, is that one or more characteristics of a conformity assessment item are defined in accordance with the method. Inspection shall mean inspection of the design of the device, product, procedure or installation and determination of its compliance with special requirements or with general requirements on the basis of professional judgment. Certification is a certification by a third party relevant to a product, process, system or entity. The Testing, Inspection and Certification (TIC) Company is therefore a service sector company that provides testing, inspection and certification services to ensure the protection of an object and device that can work properly and securely.

Formed on July 1, 1964, PT Biro Klasifikasi Indonesia (Persero), commonly referred to as BKI, is the only national classification body appointed by the Government of the Republic of Indonesia to identify commercial vessels with Indonesian flags. This role was subsequently confirmed in the Minister of Sea Transportation Decree No. Th. Th. Th. 1/17/2 of 26 September 1964 relating to the Implementing Regulations for Indonesian-flagged vessels to be accredited as having a ship classification provided by BKI. Classification activity itself is an activity of classifying ships based on the construction of the ship's hull, engine and electricity with the aim of providing an assessment of the seaworthiness of the ship. Based on the market potential and human resource capabilities, in 1982 BKI started to pioneer the commercial sector which is a business development and is a profit maker for companies that provide mapping & survey services, inspection services, assessment & audits, testing services, monitoring services & supervision, consultancy services, certification services, and training services & labor providers, where each service is for the marine, offshore, energy and industrial sectors. Thus, the scope of work of BKI is divided into 2 (two) main sub-jobs, namely Classification Survey Services and Statutory, and Commercial Services.

In the Company Long Term Plan (RJPP) for 2020–2024, one of the gaps that occurs is the lack of business development and innovation. So far, BKI has focused on developing rules, guidance and guidelines for classification and statutory services, while business development in commercial services has not been carried out optimally, so BKI still offers services for the marine, industrial and energy sectors that are already on the list. BKI services. One of the strategic programs that will be carried out by BKI is to carry out business development with various innovations to achieve the revenue, profit and growth targets set by shareholders.

Yulia, et al. (2020) conducted research related to market growth techniques that used the interview and questionnaire method that was then carried out by a SWOT study to sharpen the detection of current problems that were eventually carried out with the BMC approach to enhance the Raja Abon Makmur Lestari business model. By adding the PESTEL approach and Porter's Five-Forces Model to evaluate external variables, Susanto (2017) conducted a market growth strategy study at PT Patrinsakan using the SWOT method, as did research conducted by Ainiyah & Rustiadi (2020) on business strategy formulation to increase income at PT Agung Artomoro who developed strategic recommendations mapped in the BMC that demonstrated how the cost of management strategies can optimize the use of resources and skills to make business efficiency more productive and profitable and to create a competitive advantage for sustainability.

Using a SWOT analysis combined with IFE and EFE matrices, Hatta, et al. (2018) and Ibrahim, et al. (2019) performed research on growth strategies for small-medium scale MSMEs. Ibrahim, et al. (2019) continued this study by using the QSPM matrix to define strategic goals where optimizing advertising and marketing through social media or e-commerce are the priority outcomes of growth strategies that need to be done. And by incorporating BMC to enhance service efficiency, human resource expertise, and help the long-term achievement of the business in a more measurable way, Wahyudi (2017) carried out the same process.

Ardian (2017) carried out the study entitled the strategy of developing the culinary business of X noodles in Surabaya with the BOS method using this methodology, which was considered acceptable for the culinary business where the company had considerable potential to expand with intense competition. In conjunction with the surrounding socio-cultural contexts, this approach proposes alternate alternatives to management. The findings illustrate 2 (two) methods that are included in the groups Exclude, Minimize and Increase. There is research with the same purpose as BKI research in which Wardhana, et al. (2016) conducted research at PT Biro Klasifikasi Indonesia using only the SWOT approach on competitive strategies for non-classification services.

Researchers used the resource-based view approach in this analysis to examine internal factors in which this methodology plays an important role in strategic management. This notion states that if it has resources that are important, unique, uncommon and difficult to imitate, a company can gain a sustainable competitive advantage. Based on the resource-based view, in conjunction with the organization's resources, an organization will decide the approach it will adopt. Analysis of external factors using the PESTEL method since 6 (six) factors, including political, economic, social, technical, environmental and legal factors, significantly affect an entity are included in this method. To evaluate the overall condition of BKI, then continue with the

SWOT process. Integration with the analytical hierarchy method (AHP) is performed for a thorough evaluation of the strategic decision-making process, the SWOT analysis can quantify the value of the individual factors involved in the decision-making process and can be weighted by AHP so that the organization's strategic goals are produced.

In accordance with the needs of the company and the things mentioned above, researchers are encouraged to conduct research with the title Business Innovation Development Strategy Analysis in Testing, Inspection, & Certification Companies.

2. METHOD

2.1 Business Innovation Development Strategy

Innovation, unlike invention, innovation is a method in which innovative ideas are effectively exploited to establish economic, social and environmental values (BIS, 2012). Innovation is therefore better seen as a process or sequence of projects, involving various members, inputs and outputs, both internal and external, all with the goal of generating value. Aligning innovation practices with business strategy is the secret. The introduction of cycles of sustainability and product life is rapidly becoming the way to do business. Innovation is thus a process which breaks down into activities and projects that are interrelated. Innovation management can therefore be seen as creating a common vision of the company for the future, aligning internal and external expertise and information, and implementing substantial gap closing activities assisted by various supporting equipment (Osborn, 2016).

Andrews described business strategy as the selection of product markets by certain parts of the company in the 1971 book entitled Company and Strategy, and corporate strategy as a collection of business strategies in different parts of the company. Porter developed competitive and market strategies based on two categories in 2014, namely internal variables and external variables. The first category of internal factors refers to organizational weaknesses, including human and financial capital, technical expertise, the market position of the company, and the second category of external factors, including industry and business prospects, social expectations, political circumstances, technological values (Shakerian, Dehnavi & Ghanad, 2016).

2.2 PESTEL analysis (Political, Economic, Social, Technology, Environment, and Legal)

According to Song, Sun & Jin (2017) PESTEL analysis is a multi-faceted approach to assess the power of the big picture to better understand the strategic orientation of an organization and to assist in making considered and informed decisions about organizational activities. The PESTEL framework primarily considers six factors, including political factors, economic factors, social factors, technological factors, environmental factors, and legal factors. As a structured way of regulating environmental factors, PESTEL is used to analyze and map how the external environment affects an industry. Taking into account the main external drivers of change, the PESTEL framework can encourage companies to consider long-term goals and to select sustainable business innovation and investment strategies.

There is a simple method called the performance gap, according to Turner (2009), to define the need for change in performance. A material for assessing a performance gap would be the difference between where your current role is and where you want to be reached, and you need to fill this gap by pursuing a project to implement progress. Internal or external pressure may cause a decline in efficiency. An aging population, technical modifications, or strategic interventions may involve internal stresses.

Government regulations, new products launched by rivals, or changes in consumer tastes may include external pressure. The acronym PESTEL is also categorized as political, economic, social, technological, legal and environmental external pressures driving change. Using diagnostics or benchmarking can assist in determining needs for performance enhancement. One way to do this is to make comparisons with other areas of the same business reasonably comprehensive and direct, then compare efficiency, absence, or return on sales, for example (Turner, 2009).

2.3 Resource Based View Analysis

Under a resource-based view strategy, strategic processes can be examined where information becomes a resource for capacity building. Peteraf (1993) notes that the approach of Andrews to strategy development "begins with an assessment of the organization's competencies and resources". The new theory of information-based opinion discusses the role of knowledge in the life and nature of companies (Grant, 2002). An overview of business resources/capabilities, an epistemological view of organizational information and learning, is included in the stream. Based on a company's resource-based viewpoint, it is possible to consider the choice of managers as an essential resource in the manufacturing strategy process, based on their prior experience and expertise (Paiva, Roth, & Fensterseifer, 2007).

Resource-based view theory considers the usage and creation of resources as complex, according to Coates & McDermott (2002). As a result of creative managerial behavior, resources change, because the use of resources and not the resources themselves creates competitive advantage. This model stresses how human, physical and intangible capital converge to generate value over time. This facilitates a complex view of organizational actions and the exploitation of capital.

2.4 SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats)

SWOT analysis is a strategic planning approach used in the assessment of strengths, weaknesses, opportunities and threats in a project or market speculation, according to Rangkuti (2010). This method includes assessing the basic objectives of the speculation of the organization or project and defining internal and external factors that help and do not meet these objectives.

Based on the identification of these four parameters, a SWOT matrix is determined to be applied to identify four types of strategies, namely the strengths-opportunities (SO) strategy, the weaknesses-opportunities (WO) strategy, the strengths-threats (ST) strategy and the weaknesses-threats (WT) strategy.

For this reason, a comprehensive assessment of the strategic decision-making process cannot be carried out through a SWOT. However, if it is integrated with the analytical hierarchy process (AHP) process, SWOT analysis can measure the significance of the individual factors involved in the decision-making process (Khan, 2017).

2.5 Ansoff Matrix Analysis

According to Ansoff (1954), in contrast to market penetration, market growth and product development, which reflect other forms of changes in the product-market structure, the term diversification is generally correlated with changes in the characteristics of a company's product line and / or market. Since these terms are often used interchangeably, by describing each as a particular form of product-market strategy, we can avoid confusion later on. A product-market plan is a joint declaration of a product line and a corresponding set of tasks to be performed by the product.

2.6 Analysis of AHP (Analytical Hierarchy Process)

A methodology used in decision making is the Analytical Hierarchy Process (AHP). According to Saaty & Vargas (2012) AHP is an approach used in making decisions by selecting the best alternative from a number of available alternatives. These alternatives have several criteria, which are then carried out by pairwise comparative assessments to determine priorities and rank alternatives. In accordance with the term, the AHP method arranges decision problems with a hierarchy consisting of three levels, namely:

1. First level (top) where the object of the decision is indicated;
2. The second level which shows the alternatives' criteria;
3. The third level which shows the alternatives to be evaluated.

The objective of solving a problem which consists of only one element is the top level of the hierarchy. After that at the next level, in the form of criteria and alternatives that will be evaluated as the lowest level. According to Brunelli (2015) in his book, entitled Introduction to the analytic hierarchy process, in evaluating these alternatives, decision makers are asked to determine priorities by giving weight vectors to each alternative and then selecting them with the maximum value.

The weight vector shows the priority of an alternative, where the bigger the weight vector, the higher the priority of the alternative. However, decision makers are often faced with difficulties in determining the priority scale because there are several alternatives available at one time. Therefore, pairwise comparison is used to overcome this problem.

There is a priority scale used in pairwise comparisons. Pairwise comparisons are made based on the level of importance between several criteria / alternatives. Pairwise comparison assesses the preference level of several alternatives on each criterion in the form of a matrix.

The stages of using the AHP method can be described as follows:

1. Hierarchy formation
   Hierarchy formation is done by determining objectives in decision making, determining criteria and alternatives. The priorities in the hierarchy are at the top level, which is then followed by second-level requirements and last-level alternatives.
2. Hierarchy related data collection
   Data is collected from experts or decision makers related to a hierarchical structure. In this stage, data processing related to the hierarchical structure is also carried out so that priorities can be determined based on the scale of importance.
3. Prioritization
   Setting priorities on the criteria and alternatives that have been determined using a basic importance scale.
4. Calculation of criteria
   The calculation on the criteria is carried out in the following stages:
   a. Perform the calculation of criteria with a comparison matrix
   b. Perform eigenvector calculations on the results of the criteria pairwise comparison matrix
   c. Perform calculations on the consistency criteria value
5. Alternative calculation
   The calculation of the alternatives is carried out in the following stages:
   a. Perform alternative calculations that have been determined with a comparisonmatrix
   b. Perform eigenvector calculations on the results of the alternative paired comparison matrix
   c. Perform calculations on the alternative consistency values

6. Check the consistency value
   Check the resulting value in the consistency calculation, where the resulting ratio value must have a value of less than 10%.
7. Priority of results
   Perform the final calculation by adding the multiplication between the results of the normalized criteria eigenvectors with the results of the alternative normalized eigenvectors so that the results of the decision are obtained.

In the SWOT context, the aim of using AHP is to systematically qualify the SWOT factors and equalize their strength. In three steps, the proposed method is applied (Görener, Toker, Uluçay, 2012):

1. The first step is to list appropriate internal (strengths and weaknesses) and external (opportunities and threats) variables that make up the SWOT analysis for strategic planning.
2. In order to capture the weight of each SWOT group, the second stage applies pairwise comparisons.
3. Finally, to get the relative priority of each factor in the SWOT community, the third step uses AHP. Then, by multiplying the local factor weightings by the group weightings, the total factor weight rating is obtained.

2.7 Previous Research

Previous research is one of the sources used by the author in creating this thesis, so that the writer can provide some hypotheses that are used to analyze the research carried out. The writer has not found the same title as this study from previous studies.

Yulia, et al. (2020) conducted research related to market growth techniques that used the interview and questionnaire method that was then carried out by a SWOT study to sharpen the detection of current problems that were eventually carried out with the BMC approach to enhance the Raja Abon Makmur Lestari business model. By adding the PESTEL approach and Porter's Five-Forces Model to evaluate external variables, Susanto (2017) conducted a market growth strategy study at PT Patrinsakan using the SWOT method, as did research conducted by Ainiyah & Rustiadi (2020) on business strategy formulation to increase income at PT Agung Artomoro who developed strategic recommendations mapped in the BMC that demonstrated how the cost of management strategies can optimize the use of resources and skills to make business efficiency more productive and profitable and to create a competitive advantage for sustainability.

SWOT is used as a tool for the selection of strategic renewable energy resources for Pakistan, where the Fuzzy AHP method for a multi-perspective approach such as economic, environmental, technical and socio-political parameters is combined in the research carried out by Wang et al. (2019). Provide Pakistan with suggestions on the selection of appropriate renewable energy sources to be established in the region. Meanwhile, by using fuzzy target programming to deal with ambiguities related to decision-makers' judgment, Khan (2017) conducted research related to assessing the strategy of compressed natural gas firms. To conclude, in other nations, these techniques can be used (outside Iran).

Using a SWOT analysis combined with IFE and EFE matrices, Hatta, et al. (2018) and Ibrahim, et al. (2019) performed research on growth strategies for small-medium scale MSMEs. Ibrahim, et al. (2019) continued this study by using the QSPM matrix to define strategic goals where optimizing advertising and marketing through social media or e-commerce are the priority outcomes of growth strategies that need to be done. And by incorporating BMC to enhance service efficiency, human resource expertise, and help the long-term achievement of the business in a more measurable way, Wahyudi (2017) carried out the same process.

Ardian (2017) carried out the study entitled the strategy of developing the culinary business of X noodles in Surabaya with the BOS method using this methodology, which was considered acceptable for the culinary business where the company had considerable potential to expand with intense competition. In conjunction with the surrounding socio-cultural contexts, this approach proposes alternate alternatives to management. The findings illustrate 2 (two) methods that are included in the groups Exclude, Minimize and Increase.

Ansoff (1954) wrote a journal entitled Diversification Strategies that blends a business and a product line called a strategy for the product market. The strategy is split into four (four): market penetration, market growth, strategy for product development, and diversification. A table known as the ansoff matrix contains the four methods. There is research with the same purpose as BKI research in which Wardhana, et al. (2016) conducted research at PT Biro Klasifikasi Indonesia using only the SWOT approach on competitive strategies for non-classification services.

Researchers used the resource-based view approach in this analysis to examine internal factors in which this methodology plays an important role in strategic management. This notion states that if it has resources that are important, unique, uncommon and difficult to imitate, a company can gain a sustainable competitive advantage. Based on the resource-based view, in conjunction with the organization's resources, an organization will decide the approach it will adopt. Analysis of external factors using the PESTEL method since 6 (six) factors, including political, economic, social, technical, environmental and legal factors, significantly affect an entity are included in this method. To evaluate the overall condition of BKI, then continue with the SWOT process. Integration with the analytical hierarchy method (AHP) is performed for a thorough evaluation of the strategic decision-making process, the SWOT analysis can quantify the value of the individual factors involved in the decision-making process and can be weighted by AHP so that the organization's strategic goals are produced.

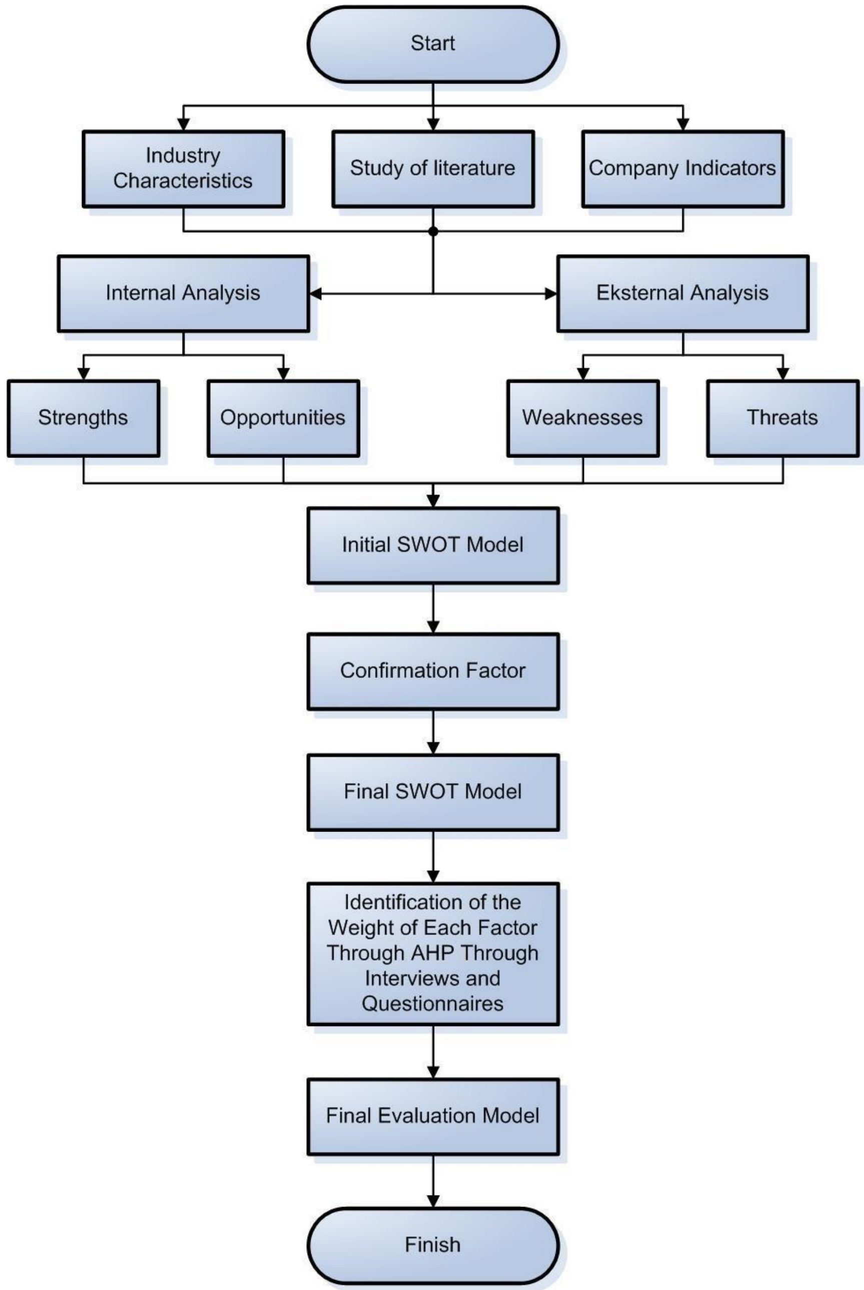

Figure 1. Research Flowchart

In accordance with the research flow chart, in analyzing the decisions of BKI in determining the appropriate strategy related to the development of business innovations, the analytical method used in this study is AHP. In this method several business strategy alternatives will then be evaluated and selected based on the most optimal results.

In detail, the explanation of each stage of the research methodology is as follows:

1. Industry Characteristics, Literature Study and Company Indicators

   At this point, through study on the characteristics of the industrial sector carried out by BKI, literature studies and company indicators decided by shareholders, the author will define the problem by evaluating internal factors and external factors. For the analysis of internal factors, the author uses the resource-based view method where the author will conduct an in-depth assessment and analysis of the organizational competencies and resources. For external factors, the author uses the PESTEL method where the author analyzes the political, economic, social, technological, environmental and legal factors Which exist around the business lines of the company.

2. Initial SWOT Model

The initial SWOT model will continue to be developed from the results of the study of internal factors and external factors, and this model will then be checked and reviewed.

3. Confirmation Factors

At this stage, the authors involved BKI internal experts consisting of Division Heads and Production Unit Heads through surveys, questionnaires, and direct interviews. This stage produces hierarchical elements in the form of goals, alternatives and criteria for decision making.

4. Final SWOT Model

This stage will create a final SWOT model composed of Division Heads and Production Unit Heads that has obtained evaluation and feedback from BKI internal experts. This stage generates priority parameters and alternatives that use a scale of significance to be carried out. The S - O strategy, S - T strategy, W - O strategy, and W - T strategy are the outcomes of this final SWOT.

The S-O strategy is a very profitable strategy, which is to say that the method has both strengths and possibilities. By taking advantage of all strengths and taking advantage of as many possibilities as possible, this approach is based on the BKI mentality. The S - T method is a technique in which the system is strong but faces different challenges. This method was invented by using the power of the BKI to resolve the hazard. The W - O method is a technique that identifies the system as having a good chance but is constrained by internal vulnerabilities. By eliminating perceived vulnerabilities and taking advantage of opportunities, this approach is carried out. The correct solution is to eliminate internal challenges so that they can take full advantage of external possibilities. The W - T solution is rather unfavorable. This approach is focused on defensive practices and aims to mitigate existing vulnerabilities and prevent attacks.

A list of strategies that can be used as guidance to management about business development strategies will be obtained at this point.

5. Identification of the Weight of Each Factor through AHP through Interviews and Questionnaires

To give priority to SWOT components, AHP is used. In this analysis, from the SWOT matrix, the AHP structure is generated and separated into 3 (three) sections, namely:

a. Decision-based goals to be achieved;
b. The SWOT category comprises 4 (four) groups, including strength (S), weakness (W), opportunity (O) and threat (T);
c. Factors included in each SWOT group (sub-criteria), such as strength 1 (S1), strength 2 (S2), weakness 1 (W1), weakness 2 (W2), likelihood 1 (O1), likelihood 2 (O2), likelihood 1 (T1), likelihood 2 (T2) and the third, fourth and so on.

The alternatives obtained are based on the SWOT matrix findings that will be checked by the Head of the Division of Research & Development. While the criteria obtained are criteria which are based on interviews with internal experts of the BKI, including the Head of the Working Unit and the Head of the Production Unit.

Calculation of the criterias for the following phases:

a. Perform the requirements measurement with a matrix of comparisons;
b. Perform eigenvector calculations on the results of the parameters for the pairwise comparison matrix;
c. Calculate the consistency criteria value.

Calculation of the alternatives for the followingphases:

a. Perform the requirements measurement with a matrix of comparisons;
b. Perform eigenvector calculations on the results of the parameters for the pairwise comparison matrix;
c. Calculate the consistency alternative value.

In the consistency calculation, then check the resulting value where the resulting ratio value must have a value of less than 10 percent. The criterias and alternatives have to be recalculated if the value reaches 10 percent. The final approximation was accompanied by the addition of a multiplication between the results of the standardized parameters eigenvectors and the results of the alternative standardized vector eigenvectors. Finally, in order to provide details on the rating stability of the priority outcomes, a sensitivity analysis is carried out such that the final result obtained is the final decision.

6. Final Evaluation Model

This final evaluation model is the final stage in the preparation of the prioritized strategies collected, containing the measures to execute the strategy.

3. CONCLUSION

The final objective of this research is to produce the best strategy and implementation steps that can be taken by company in achieving its business development.

4. REFERENCES

Ainiyah, Mahfudhotul & Rustiadi, Sonny. (2020). Business Strategy Formulation to Increase Profit of Agung Artomoro. International Journal of Management, Enterpreneurship, Social Science and Humanities, Volume 3, Number 1, 34-40.

Ansoff, H. Igor. (1957). Strategies for Diversification. Harvard Business Review, 113-124.

Ardian, Sony. (2017). Strategi Pengembangan Usaha Kuliner Mie X, Surabaya dengan Pendekatan Blue Ocean Strategy (BOS) [Surabaya Mie X Culinary Business Development Strategy, with the Blue Ocean Strategy (BOS) Approach]. Surabaya: Institut Teknologi Sepuluh Nopember.

Bhushan, Navneet & Rai, Kanwai. (2003). Strategic Decision Making: Applying the Analytic Hierarchy Process. Springer-Verlag London Limited.

Coates, Theresa Taylor, & McDermott, Christopher M. (2002). An Exploratory Analysis of New Competencies: A Resource Based View Perspective. Journal of Operations Management 20, 435-450.

Dyer, Robert F. & Forman, Ernest H. (1991). An Analytic Approach to Marketing Decisions.

Göroner, A., Toker, K., & Uluçay, Korkmaz. (2012). Application of Combined SWOT and AHP: A Case Study for a Manufacturing Firm. The 8th International Management Conference, Procedia – Social and Behavioral Sciences 58, 1525-1534. doi: 10.1016/j.sbspro.2012.09.1139.

Gottfried, O., Clercq, D. D., Blair, E., Weng, X., & Wang, Can. (2018). SWOT-AHP-TOWS Analysis of Private Investment Behaviour in The Chinese Biogas Sector. Journal of Cleaner Production. doi: 10.1016/j.jclepro.2018.02.173.

Hatta, Iha H., Riskarini, D., & Ichwani, Tia. (2018). SME Business Development Strategy: SWOT and EFE-EFI Analysis. Journal of Applied Management, Volume 16, Number 3.

Hermawan, Lucius. (2015). Dilema Diversifikasi Produk: Meningkatkan Pendapatan atau Menimbulkan Kanibalisme Produk (Product Diversification Dilemma: Increase Income or Create Product Cannibalism). Jurnal Studi Manajemen, Vol. 9, No. 2, 142-153.

Ibrahim, S., Nurrochmat, Dodik R., & Maulana, Agus. (2019). SMEs Development of Footwear Business. Jurnal Organisasi dan Manajemen 15.

Khan, Muhammad Imran. (2017). Evaluating The Strategies of Compressed Natural Gas Industry Using an Integrated Strength-Weakness-Opportunity-Threat And Multi-Criteria Decision Making Approach. Journal of Cleaner Production. doi: 10.1016/j.jclepro.2017.10.231.

Levary, Reuvan R., & Wan, Ke, 1998. A Simulation Approach for Handling Uncertainty in The Analytic Hierarchy Process. European Journal of Operational Research 106, 116-122. https://doi.org/10.1016/S0377-2217(97)00134-3.

Orlando, B., Renzi, A., Sancetta, G., & Cucari, Nicola. (2017). How Does Firm Diversification Impact Innovation. Rome: Sapienza University of Rome. http://dx.doi.org/10.1080/09537325.2017.1313405.

Osborn, Naomi D., & Osborn, Steve. (2016). Organizational Structure and Business and Technology Strategy of Food Companies to Optimize Development of Foods for Consumers with Specific Dietary Needs. Corby: The Aurora Ceres Partnership Ltd. https://doi.org/10.1016/B978-0-08-100329-9.00003-7.

Paiva, Ely L., Roth, Aleda V., & Fensterseifer, Jaime Evaldo. (2007). Organizational knowledge and the manufacturing strategy process: A resource-based view analysis. Journal of Operations Management 26, 115-132.

PM 61. (2014). Perubahan atas peraturan menteri perhubungan nomor PM 7 tahun 2013 tentang Kewajiban Klasifikasi Bagi Kapal Berbendera Indonesia Pada Badan Klasifikasi (Amendments to the regulation of the minister of transportation number PM 7 of 2013 concerning the Classification Obligations for Indonesian- Flagged Vessels in the Classification Body). Jakarta: Kementerian Perhubungan Republik Indonesia.

PM 7. (2013). Kewajiban Klasifikasi Bagi Kapal Berbendera Indonesia Pada Badan Klasifikasi (Classification Obligations for Indonesian Flag Ships at the Classification Body). Jakarta: Kementerian Perhubungan Republik Indonesia.

Pratiwi, Risda. (2018). Strategi Pengembangan Usaha Rengginang Pulut dengan Metode Analisis SWOT (Studi Kasus Usaha Rengginang Pulut CV. Uul Jaya di Desa Kebun Lada Kecamatan Hinai Kabupaten Langkat [Rengginang Pulut Business Development Strategy using SWPT Analysis Method (Case Study of CV. Uul Jaya Rengginang Pulut Business in Kebun Lada Village, Hinai District, Langkat Regency]. Medan: Universitas Islam Negeri Sumatera Utara.

Rahayuningsih. (2015). Strategi Diversifikasi Bisnis (Business Diversification Strategy). Analisa : Vol. 3, No. 1, 443-451.

Rangkuti, Freddy. (2010). Analisis SWOT Teknik Membedah Kasus Bisnis (SWOT Analysis Technique of Dissecting Business Cases). Jakarta: PT Gramedia Pustaka Utama.

RJPP BKI. (2019). Rencana Kerja Jangka Panjang 2020-2024 (Long Term Work Plan 2020-2024). Jakarta: BKI.

Ruslim, Ferrysa Aprianta & Indriyani, Ratih. (2015). Strategi Pengembangan Bisnis PT ABC (PT ABC's Business Development Strategy). Agora, Vol. 3, No. 2.

Saaty, Thomas L., (2008). Decision Making with the Analytic Hierarchy Process. Int. J. Services Sciences, Vol. 1, No. 1, 83-98.

Saaty, Thomas L., & Vargas, Luis G., (2012). Models, Methods, Concepts & Applications of the Analytics Hierarchy Process. New York: Springer Science+Business Media.

Sarijani, E., Baedhowi, & Sawiji, Hery. (2015). Peran Kreativitas dan Inovasi Pelaku Usaha dalam Diversifikasi Produk pada Kedai Steak & Chicken di Kab. Magetan Tahun 2014 (Implementasi Pendidikan Kewirausahaan). Surakarta: Universitas Sebelas Maret.

Shakerian, H., Dehnavi, Hasan D., & Ghanad, Shima Baradaran. (2016). The Implementation of The Hybrid Model SWOT-TOPSIS by Fuzzy Approach to Evaluate and Rank The Human Resources and Business Strategies in Organizations (Case Study: Road and Urban Development Organization in Yazd). Procedia - Social and Behavioral Sciences 230, 307-316. doi: 10.1016/j.sbspro.2016.09.039.

Song, J., Sun, Y., & Jin, Lulu. (2017). PESTEL Analysis of the Development of The Waste-To-Energy Incineration Industry in China. Renewable and Sustainable Energy Reviews 80, 276-289.

https://doi.org/10.1016/j.rser.2017.05.066.

Susanto, Rendy Indra. (2017). Analisis Strategi Pengembangan Bisnis pada PT Patrinsaka (Analysis of Business Development Strategy at PT Patrinsaka). Agora, Vol. 5, No. 1.

Turner, J. Rodney. (2009). The Handbook of Project Based Management Third Edition. New York: The McGraw-Hill Companies, Inc.

Wahyudi, Adi Novi. (2017). Strategi Pengembangan Usaha Menggunakan Model Kanvas pada PT Nusantara Terminal Services di Makassar (Business Development Strategy Using the Canvas Model at PT Nusantara Terminal Services in Makassar). Makassar: Universitas Hasanuddin.

Wang, Y., Xu, L., & Solangi, Yasir Ahmed. (2019). Strategic Renewable Energy Resources Selection for Pakistan: Based on SWOT-Fuzzy AHP Approach. Elsevier.

Wardhana, A., Kartawinata, Budi R., & Syahputra. (2016). Strategi Bersaing Jasa Non Klasifikasi pada PT Biro Klasifikasi Indonesia (Competitive Strategy for Non Classification Services at PT Biro Klasifikasi Indonesia). Jurnal Ekonomi Modernisasi.

Yüksel, Sedat. (2007). An Integrated Forecasting Approach to Hotel Demand. Mathematical and Computer Modelling 46, 1063-1070 doi:10.1016/j.mcm.2007.03.008.

Yulia, Bahtera, Novyandra I., Evahelda, Hayati, L., & Bahtera, Novyandri Taufik. (2020). Business Development Strategy Using Business Model Canvas Approach. Jurnal Muara Ilmu Ekonomi dan Bisnis, Vol. 4, No. 1, 106-115.

POLICY PLANNING OF SPARE CURRENT TRANSFORMERS IN PT. XYZ TRANSMISSION UNIT SURABAYA

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ABSTRACT

Maintenance of transmission networks is an integrated business or activity carried out on installations and supporting facilities to prevent damage or to repair the installation, so that the continuity of the distribution of electricity can be guaranteed. To realize the mission and duties carried out by PT. XYZ, maintenance activities are very important in the management of transmission assets. Spare components are very important for replacement activities, especially for transformer components. If there is no spare transformer, company's capacity to supply electricity from the plant will decrease, causing high dead costs and losses. However, if you provide too many transformers, the investment costs will be even higher. The purpose of this research is to determine the optimal number of 150kV backup current transformers required at PT. XYZ Surabaya Transmission Unit. Estimated cost of downtime and cost of N backup current transformers have inversely proportional values. The less current transformer supplies, the higher the expected downtime cost. However, the more current transformer supplies, the greater the cost value of the reserve N current transformer. So that it is found that the minimum total cost value is Rp. 880,463,836. Where the optimal number of current transformers is 3 pieces. This amount was chosen because it produces the minimum total cost.

Keywords: spare, current transformer, expected shortage, expected cost of downtime, expected cost of spare machine, total cost of spare machine.

1. INTRODUCTION

PT. XYZ Surabaya Transmission Unit is a company engaged in the management of electric power transmission. Electric power transmission is the process of distributing electricity from generation to distribution network. Maintenance of Transmission Network is an integrated activity to prevent damage or to restore the installation, so that the continuity of the distribution of electricity can be guaranteed. The availability of spare components is very important for component replacement activities, especially for transformer components. If there is no spare transformer, XYZ's capacity to supply electricity from the generator will decrease, causing costs due to high downtime and losses. High downtime also causes significant disruption of economic activity. According to the Industry and Trade Office, the assumed loss that can be calculated based on the company's statement with an hour of blackout, the losses incurred exceed Rp. 75,000,000. The value of this loss is calculated from interrupted production, damaged production goods, employees who are still paid, and opportunity losses. Meanwhile, from the PT. XYZ, the income lost if the current transformer is damaged is around Rp. 1,700,000,000 per hour. However, if you provide too many transformers, the investment costs will be even higher.

Since April 2018 PT. XYZ Surabaya Transmission Unit has replaced 58 current transformers up to October 2019. Unfortunately, in the existing conditions, PT. XYZ Surabaya Transmission Unit often looks for a replacement current transformer to another XYZ unit when the current transformer is breakdown. Recorded until October 2019 PT. XYZ Surabaya Transmission Unit submitted a request for 19 current transformer components to other units because the Surabaya Transmission Unit did not have current transformer supplies in the warehouse. This indicates that PT. XYZ does not yet have a sufficient number of current transformer spare.

2. METHOD

The data used in this study are based on company reports in the 2018-2019 period. To determine the rate of damage to current transformers, this study requires data on the amount of damage that occurs in one period and the lifetime of the current transformer. The number of current transformers operating in the system is also needed to determine the probability of equipment damage in a population. This research requires data on electricity prices per kWh and data on the capacity of a transformer to supply energy as input to determine the costs of downtime. The price of current transformers is also needed for the costs to buy current transformers.

2.1 Damage Rate

The rate of damage (λ) is the number of equipment that experiences failure or damage in a time interval t and its condition is known at the beginning of the interval. The rate of damage is also commonly referred to as the speed at which a machine or component reaches a non-operating or damaged condition which is expressed in the function λ (t). The first step that must be done is to identify the type of distribution data using the Goodness-of-fit Anderson-Darling test. After knowing the type of distribution, then we determine the probability density function and the reliability function.

According to Jardine (1973) the rate of damage to a machine or product follows a basic pattern called the bathtub curve shown in Figure 1. The following is a characteristic function of the rate of damage to a machine or equipment according to the bathtub curve concept.

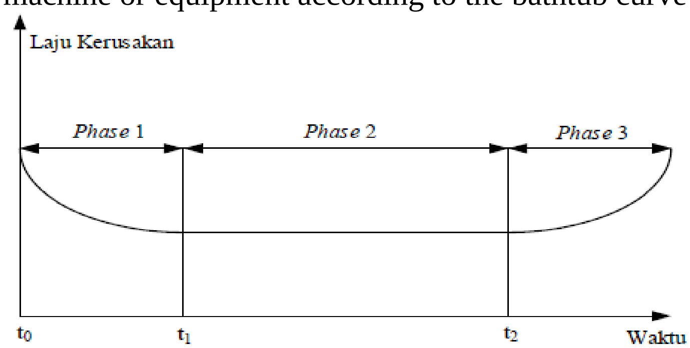

Figure 1 Bathtub Curve

a. Phase 1: early failure or infant mortality
   The components in phase 1 have three probability density functions, namely gamma, hyper exponential and Weibull.
b. Phase 2: failure random in time
   The components in this phase have an exponential or Weibull probability density function.

c. Phase 3: wear out operation
   In this phase, the rate of damage tends to increase and starts at t_2 and continues.

2.2 Poisson Distribution

According to Walpole (1995), the Poisson distribution is a random Poisson X probability distribution, which states the number of successes that occur in a certain time interval or area. The number X that states the number of experimental results in a Poisson experiment is called the Poisson random variable and the distribution of odds is called the Poisson distribution. Because the probability values depend only on μ, which is the average number of experimental results that occur over a given time interval or area. Apart from that, the Poisson distribution is widely used in the following cases:

- The number of phone calls per minute or the number of cars that pass for 5 minutes on a road,
- The number of bacteria in one drop or 1 liter of water,
- The number of typos per page of a book, and
- Number of car accidents on toll roads during the first week of October.

Determination of the probability of the actual number of damages using the Poisson equation, where:

$$P(x) = \frac{e^{-\lambda}\lambda^{x}}{x!} \qquad x = 0,1,2,...$$

λ = the average number of events per unit of time, distance, area, or volume

2.3 Determine the Total Cost of Standby Machine

According to Singh (2014), to determine the total cost of standby machines, an event probability is required for each level of demand, shortage costs and costs arising from providing a standby machine. The formulation to determine the total cost of standby machine is as follows:

$$EC = \sum[P(SN_i)*C_{ij}]$$

Dimana
SN_i = the number of standby machines required
$P(SN_i)$ = probability of occurrence for each level of demand
C_{ij} = shortage costs or costs arising from providing standby machines

However, according to research conducted by Putra (2015), an adjustment was made to the formulation for determining the total cost of standby machine standby. Where to calculate how much the expected capacity shortage or ECS (Expected Capacity Shortage) is calculated using the following formulation:

$$ECS(N) = \sum_{x=N+1}^{n}(x-N)P(x)$$

Dimana
n = Number of machines currently operating
N = Number of standby machines provided
P(x) = Chances of machine failure are x

The calculation results will be poured into a matrix as in Table 2.4 below

Table 1 Expected Shortage Matrix

Number of Standby CT	**Number of Failure x**						**Expected Shortage ECS (N)**
	0	**1**	**2**	**3**	**4**	**N**	
	Probability P(x)						
	P (0)	**P (1)**	**P (2)**	**P (3)**	**P (4)**	**P (n)**	
	Actual Capacity Shortage x – N						
0		1	2	3	4	n	
1			1	2	3	n	
2				1	2	n	
3					1	n	
4						n	
n							

After calculating the actual and predicted shortage of equipment capacity, we start looking for the predicted costs for downtime where the equation is:

$$\begin{bmatrix} \text{Expected cost} \\ \text{of downtime} \end{bmatrix} = \begin{bmatrix} \text{expected} \\ \text{capacity shortage} \end{bmatrix} \begin{bmatrix} \text{cost of} \\ \text{downtime machine} \end{bmatrix}$$

Then we determine the costs incurred as a result of providing standby machines:

$$\begin{bmatrix} \text{Cost of standby} \\ \text{machine} \end{bmatrix} = \begin{bmatrix} \text{number of standby} \\ \text{machines} \end{bmatrix} \begin{bmatrix} \text{cost standby} \\ \text{machine} \end{bmatrix}$$

Then we add up the total estimated downtime costs with the machine standby costs with the equation:

$$\begin{bmatrix} \text{Total cost with } N \\ \text{standby machines} \end{bmatrix} = \begin{bmatrix} \text{expected cost} \\ \text{of downtime} \end{bmatrix} \begin{bmatrix} \text{cost of } N \text{ standby} \\ \text{machines} \end{bmatrix}$$

3. RESULT AND DISCUSSION

3.1 Determination of Damage Rate

The failure rate is expressed in the function λ (t) which is the ratio between the opportunity density function and the reliability function. The data needed is historical data on damage and replacement of current transformers during 2018-2019. The historical data shows the year when the current transformer starts operating and the date of replacement of the current transformer, so that the time to failure of the current transformer is obtained. The identification of data distribution was carried out by testing using MINITAB 16 software. Determination of distribution in terms of the smallest Anderson-Darling test statistic value which is significant when compared with the critical value. The test results on the distribution that is thought to match the distribution of the current transformer damage data shown in Figure 2.

Distribution Identification for C2

Distribution ID Plot for C2

Descriptive Statistics

N	N*	Mean	StDev	Median	Minimum	Maximum	Skewness	Kurtosis
58	0	287,190	105,806	307	32	451	-0,987970	0,497583

Goodness of Fit Test

Distribution	AD	P
Lognormal	6,545	<0.005
Exponential	11,009	<0.003
Weibull	3,142	<0.010

ML Estimates of Distribution Parameters

Distribution	Location	Shape	Scale	Threshold
Lognormal*	5,52914		0,63233	
Exponential			287,18966	
Weibull		3,04357	318,09978	

* Scale: Adjusted ML estimate

Figure 2 Anderson Darling Test Result

The results of the model fit test performed with the Anderson Darling (AD) test, found that the Weibull distribution has the highest p-value compared to other distributions and has the smallest Anderson-Darling test value among other distributions. So that the test results have provided sufficient evidence that the current transformer damage data follows the Weibull distribution with the shape parameter (β) = 3.04357 and the scale parameter (θ) = 318.09978. So, we get the opportunity density function of f (12) = 1.535 with a reliability function of R (12) = 0.999953 so that the damage rate is λ (12) = 1.535.

3.2 Determination of the probability of a number of current transformer breakdowns

To find out the probability of the current transformer breaking, we use the Poisson distribution. With the current transformer failure rate of 1.535, the results of calculating the probability of the current transformer breakdown of n units are as follows.

Table 2 Probability of Current Transformer Damage

N	P(x)	N	P(x)
0	0,21538193	7	0,00085940
1	0,33068280	8	0,00016493
2	0,25385397	9	0,00002814
3	0,12991672	10	0,00000432
4	0,04986633	11	0,00000060
5	0,01531228	12	0,00000008
6	0,00391824	13	0,00000001

3.3 Determination of expected shortage

Expected shortage is the estimated capacity shortage due to current transformer damage. At this stage a simulation will be carried out to get an overview of the lack of capacity if we provide N current transformers and compare to demand. Table 3 shows the results of the expected shortage calculation.

Table 3 Calculation Result of Expected Shortage

N	ECS	N	ECS
0	1,53531639	7	0,00023703
1	0,75070859	8	0,00003895
2	0,29678358	9	0,00000580
3	0,09671254	10	0,00000079
4	0,02655821	11	0,00000010
5	0,00627022	12	0,00000001
6	0,00129450	13	0,00000000

3.4 Expected cost of downtime

Expected shortage is the estimated capacity shortage due to current transformer damage. Expected cost of downtime is the result of multiplying the estimated capacity shortage due to current transformer damage and costs incurred due to current transformer damage causing power outages. The calculation of expected cost of downtime is as follows.

Expected Cost of Downtime = ECS x Downtime Cost

Where ECS is the expected capacity shortage. Meanwhile, downtime costs are costs due to downtime expressed as costs incurred due to damage to current transformers causing power outages. Downtime costs are obtained by multiplying the average electricity tariff, transformer capacity, and outage duration without spare components. So that you get a downtime fee of Rp. 1,766,944,800. Table 4 shows the results of the calculation of the expected cost of downtime.

Table 4 Calculation Result of Expected Cost of Downtime

N	Tcd(N)	N	Tcd(N)
0	Rp 2.712.819.320	7	Rp 418.811
1	Rp 1.326.460.633	8	Rp 68.815
2	Rp 524.400.200	9	Rp 10.247
3	Rp 170.885.714	10	Rp 1.394
4	Rp 46.926.899	11	Rp 175
5	Rp 11.079.135	12	Rp 20
6	Rp 2.287.318	13	Rp -

3.4 Cost of N spare current transformer

At this stage, the calculation of how much it will cost PT. XYZ Surabaya Transmission Unit to provide a transformer as large as N. The data required is the cost of spare times the current transformer as much as N. Rp. 236,526,041. Table 5 shows the calculation results of the cost of N spare current transformers.

Table 5 Calculation Result of Cost of N Spare Current Transformer

N	Tcs(N)	N	Tcs(N)
0	Rp -	7	Rp 1.655.682.286
1	Rp 236.526.041	8	Rp 1.892.208.326
2	Rp 473.052.082	9	Rp 2.128.734.367

N	Tcs(N)	N	Tcs(N)
3	Rp 709.578.122	10	Rp 2.365.260.408
4	Rp 946.104.163	11	Rp 2.601.786.449
5	Rp 1.182.630.204	12	Rp 2.838.312.490
6	Rp 1.419.156.245	13	Rp 3.074.838.530

3.5 Total Cost

After determining the expected cost of downtime and cost of spare current transformer, the two costs are combined so that the total cost will arise if the current transformer is provided as much as N. Expected cost of downtime and the cost of N spare current transformer has a value that are inversely proportional. The smaller the current transformer inventory, the higher the expected cost of downtime. However, the more current transformer supplies, the greater the value of the cost of spare N current transformers. So that an optimum point will be found where at that point is the minimum total cost. The total cost calculation is presented in Table 6 as follows.

Table 6 Total Cost Calculation

N	Tcs(N)	N	Tcs(N)
0	Rp 2.712.819.320	7	Rp 1.656.101.096
1	Rp 1.562.986.674	8	Rp 1.892.277.141
2	Rp 997.452.281	9	Rp 2.128.744.614
3	Rp 880.463.836	10	Rp 2.365.261.802
4	Rp 993.031.062	11	Rp 2.601.786.623
5	Rp 1.193.709.339	12	Rp 2.838.312.510
6	Rp 1.421.443.563	13	Rp 3.074.838.530

4. CONCLUSION

Determination of the number of spare current transformers that must be provided by PT. XYZ Surabaya Transmission Implementing Unit based on the results of the calculation of the total cost. The results of the total cost calculation are also shown in Figure 3 below.

Figure 3 Comparison of costs

Expected costs of downtime and cost of spare current transformers have values that are inversely proportional. The less current transformer supplies, the higher the value of the Expected cost of downtime. However, the more current transformer supplies, the greater the value of the cost of spare current transformers. So, it must be determined an optimum point where the total cost is the minimum. From the graph above, we can see that the total cost is at the lowest position when the number of current transformers reaches 3. So, it can be concluded that the optimal number of current transformers are 3 pieces with a total cost of Rp. 880,463,836. If we compare with the current condition where the company does not have a spare current transformer, the company must bear the cost of Rp. 2,712,819,320. When compared, the savings that will be generated is Rp. 1,832,355,484.

From this research it can be concluded that the calculation using the Poisson distribution approach and estimating the expected capacity deficiency results in a reduction in the total costs that must be borne by PT. XYZ Surabaya Transmission Implementing Unit. The decrease in total costs was due to lower downtime caused by the addition of the supply of spare current transformers to cope with the demand for these components. The smaller the expected number of lacks of capacity, the electricity system availability will increase. By increasing the availability value, the company can minimize the occurrence of the electricity distribution process that is interrupted due to unavailability of spare components when a breakdown occurs. In addition, the presence of spare current transformers in the warehouse can minimize replacement time because PT. XYZ Surabaya Transmission Implementing Unit no longer needs to wait for materials to arrive from other Transmission Implementing Units because it already has sufficient spare current transformer supplies. With this research, it is hoped that the company can repair and plan inventory of spare parts based on damage opportunities so that the costs incurred are more economical.

REFERENCES

Jardine, A. K. (1973). *Maintenance, replacement and reliability.* Australia: Pitman Publishing.

Putra, A. W. (2016). Perencanaan Kebijakan Overhaul dan Analisis Pengadaan Mesin Standby Pada Mesin Hoist Curing Utara dan Selatan Plant I-8 (Studi Kasus PT. Wijaya Karya Beton Bogor). *Industrial Engineering Online Journal, Vol. 4, No. 4.*

Singh, S. P. (2014). *Production and Operations Management.* India: Vikas.

Walpole, R. E. (2012). *Probability and Statistics* (9 ed.). Boston: Pearson Education, Inc.

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