Quantitative Business Forecasting

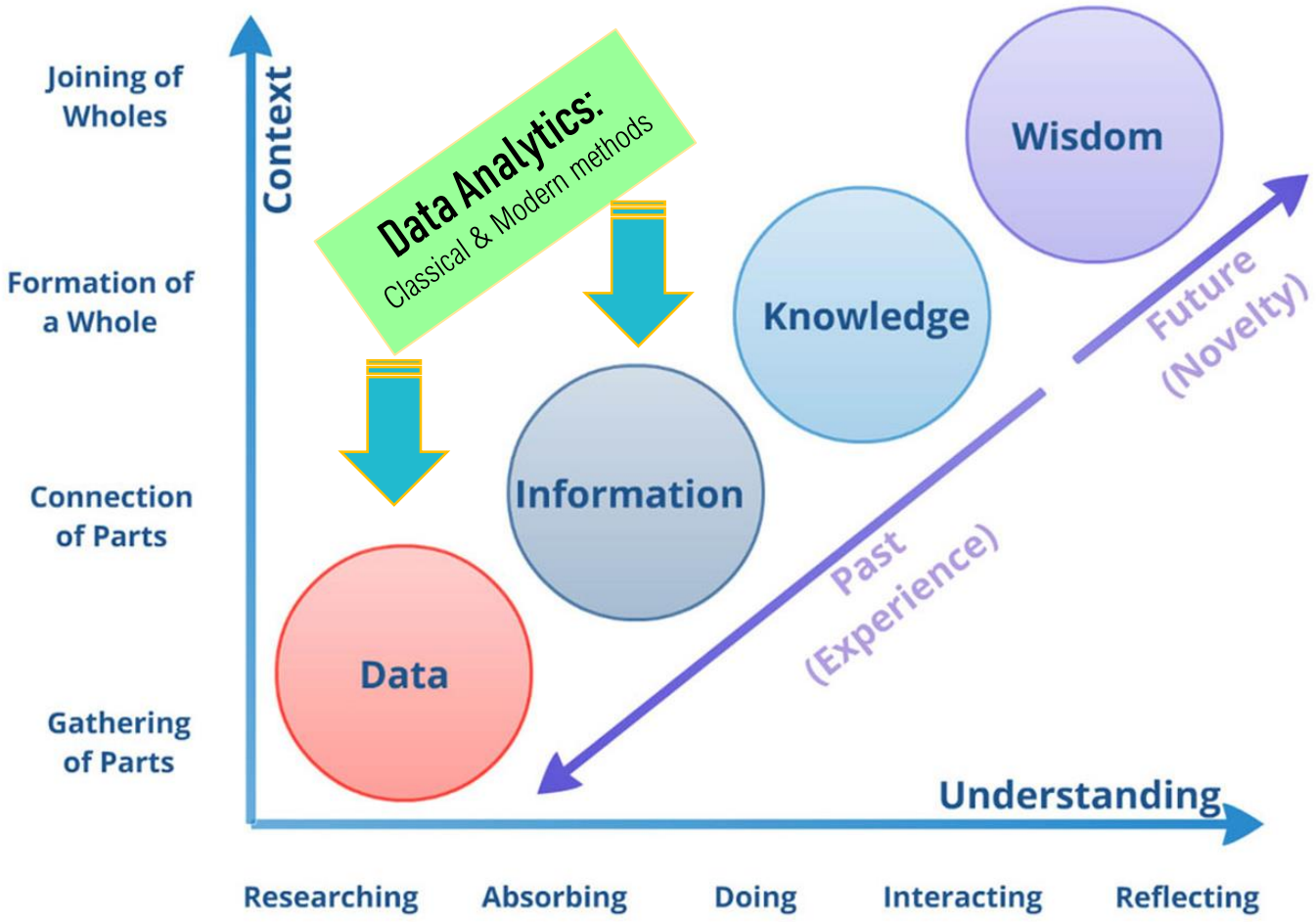
Suhartono

Laboratorium Analitika Data Ekonomi dan Finansial

Departemen Statistika

Institut Teknologi Sepuluh Nopember

Statistical Thinking



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DATA

VALID and RELIABLE

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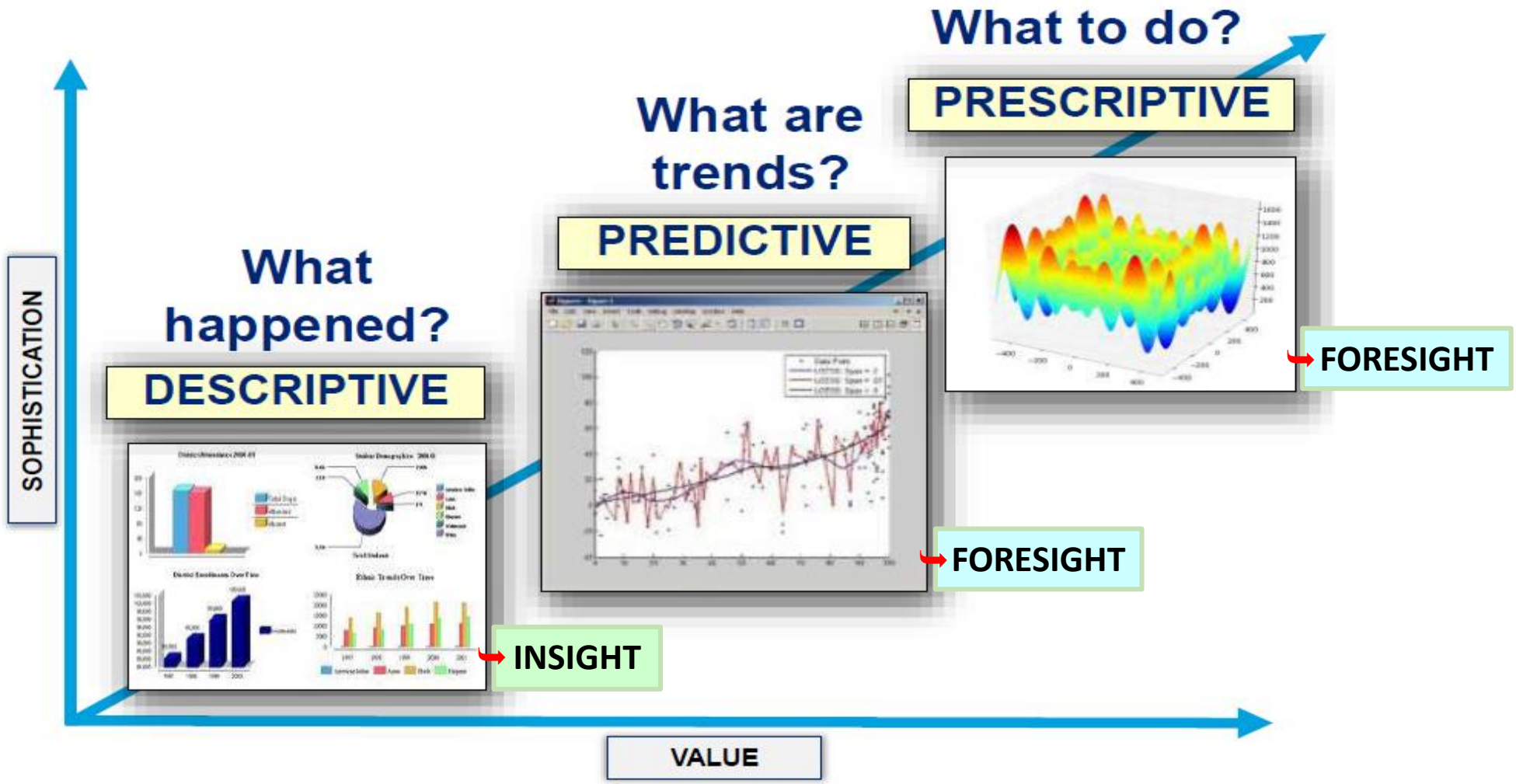
Data Analytics



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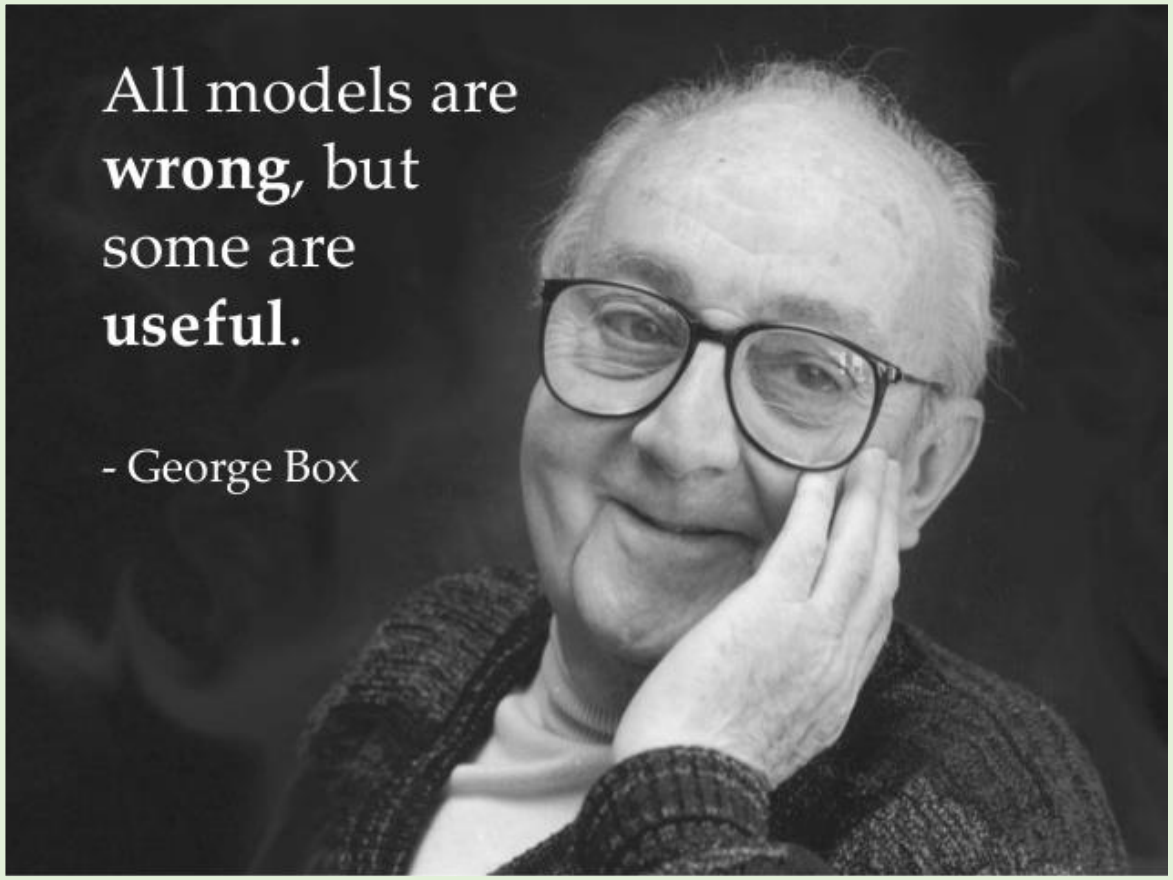
MOTIVATION



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MOTIVATION


Adj Close
SMA20
SMA50
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Mar 2013
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Sep 2013
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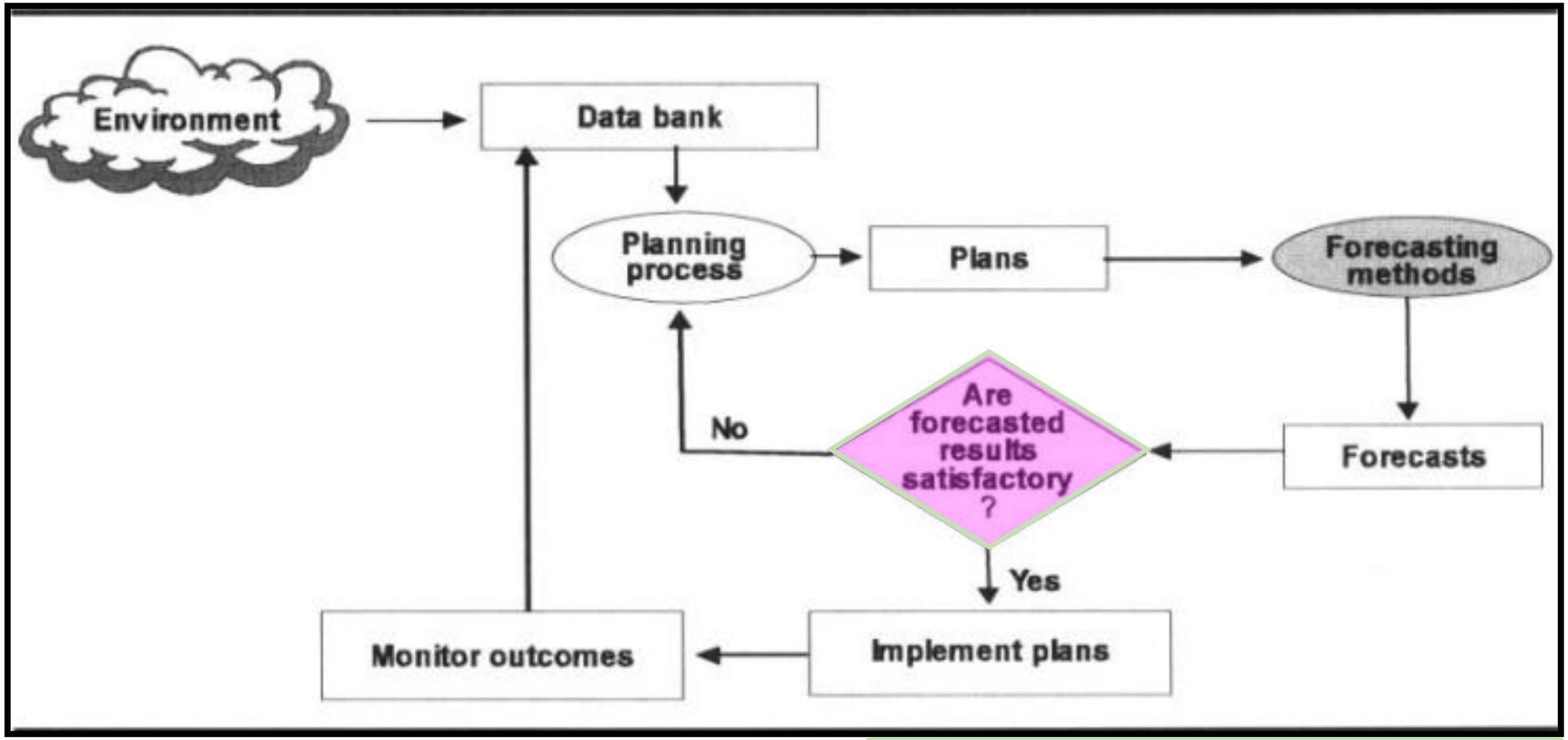
Dec 2013
Jan 2014
Feb 2014
PRINCIPLES
of
FORECASTING
2000
2010

Forecasting & Planning



Source: J.S. Armstrong, "*Principles of Forecasting*"

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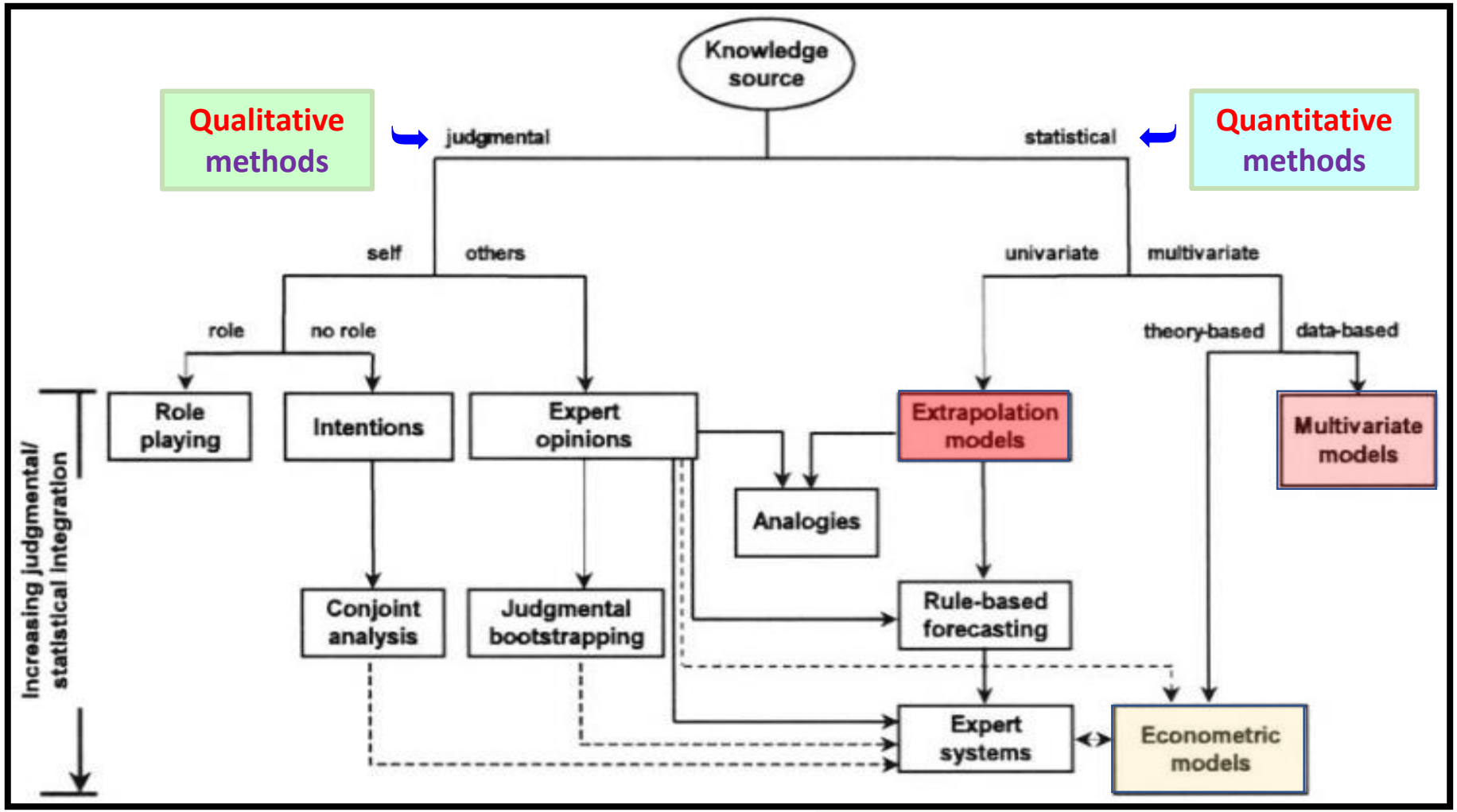
Forecasting Methods



Source: J.S. Armstrong, "*Principles of Forecasting*"

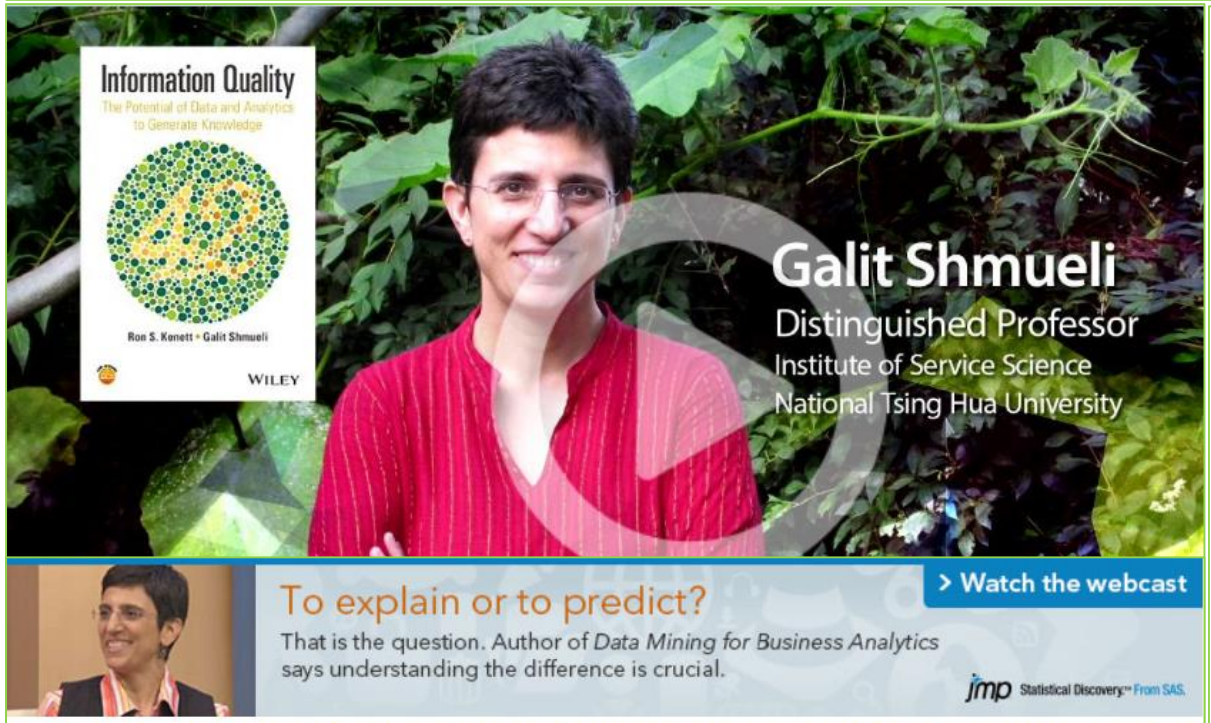
MOTIVATION

ANALYTICALLY SPEAKING

To Explain or Predict? That Is the Question

With Galit Shmueli

http://www.galitshmueli.com/content/explain-or-predict



To explain or to predict? Author of *Data Mining for Business* says the difference is crucial

In her highly acclaimed paper, To Explain or to Predict?, Galit Shmueli writes "statistical modeling is a powerful tool for developing and testing theories by way of causal explanation, prediction, and description." But while it is common to conflate explanation and prediction, understanding the distinction is crucial.

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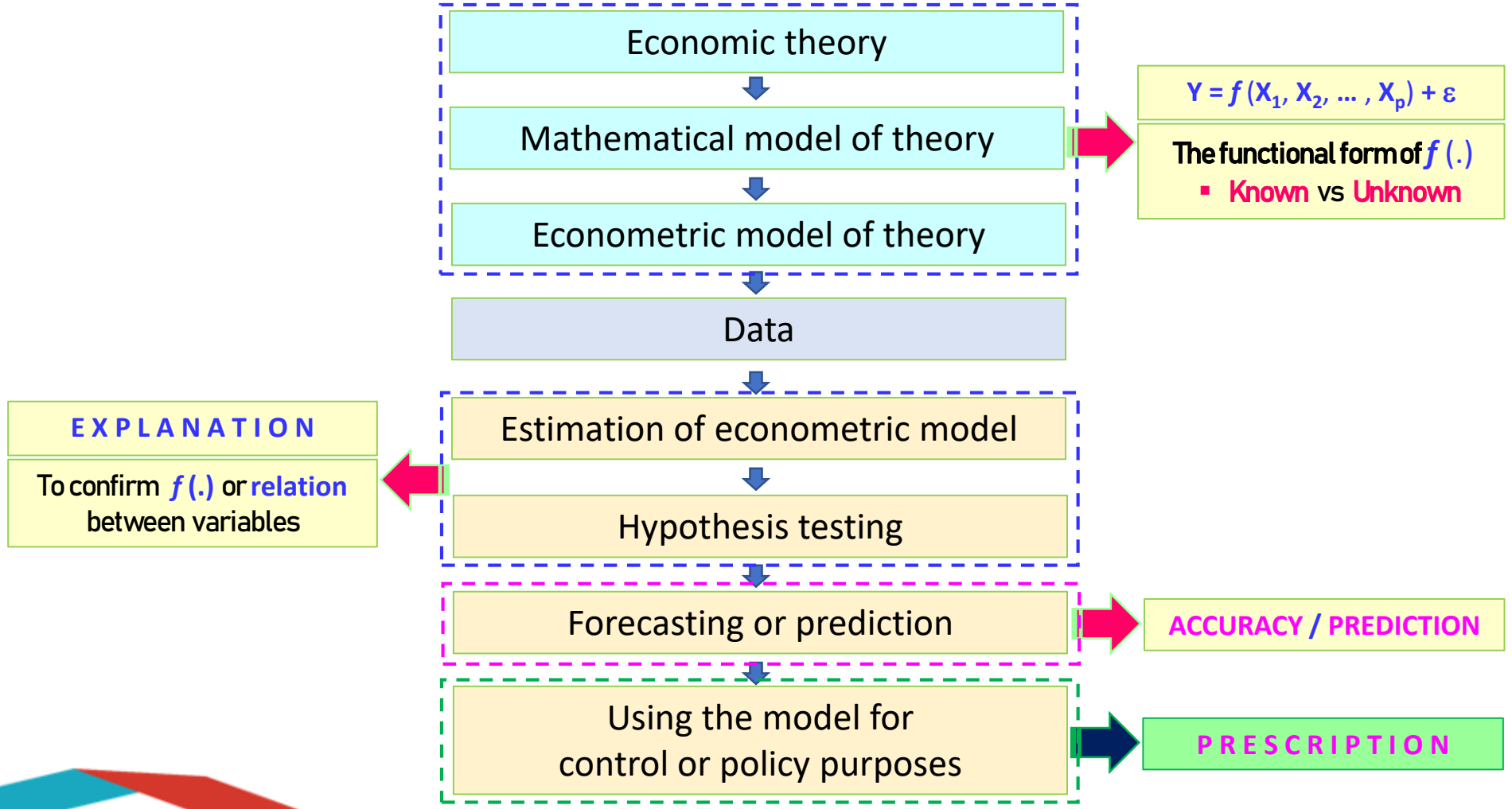
Econometrics Modeling

Source: Gujarati (2004)



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Selecting Forecasting Methods

Sales-forecasting methods used by firms

	Regularly used (percentage)		Regularly used (percentage)
Expert opinions		**Extrapolation**	
Internal		Naïve	30.6
Sales force	44.8	Moving average	20.9
Executives	37.3	Rate of change (percentage)	19.4
External		Rate of change (units)	15.7
Industry survey	14.9	Exponential smoothing	11.2
Analogies		Regression against time	6.0
Leading indicators	18.7	Box-Jenkins	3.7
Econometric			
Multiple regression	12.7		
Econometric methods	11.9		

Qualitative methods

Quantitative methods

Quantitative methods

Source: J.S. Armstrong, "*Principles of Forecasting*"

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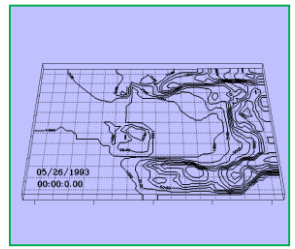
Quantitative Forecasting Methods

Approach:

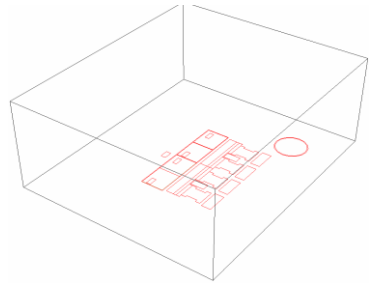
- **Causal** Approach

$$Y_t = f(X_{1t}, X_{2t}, \dots, X_{6t}) + \varepsilon_t$$



- **Time Series** Approach

$$Y_t = f(Y_{t-1}, Y_{t-2}, \dots, Y_{t-k}) + \varepsilon_t$$



- **Variable**: **Univariate** vs **Multivariate**
- **Technique**: **Classical Models** vs **Machine Learning**

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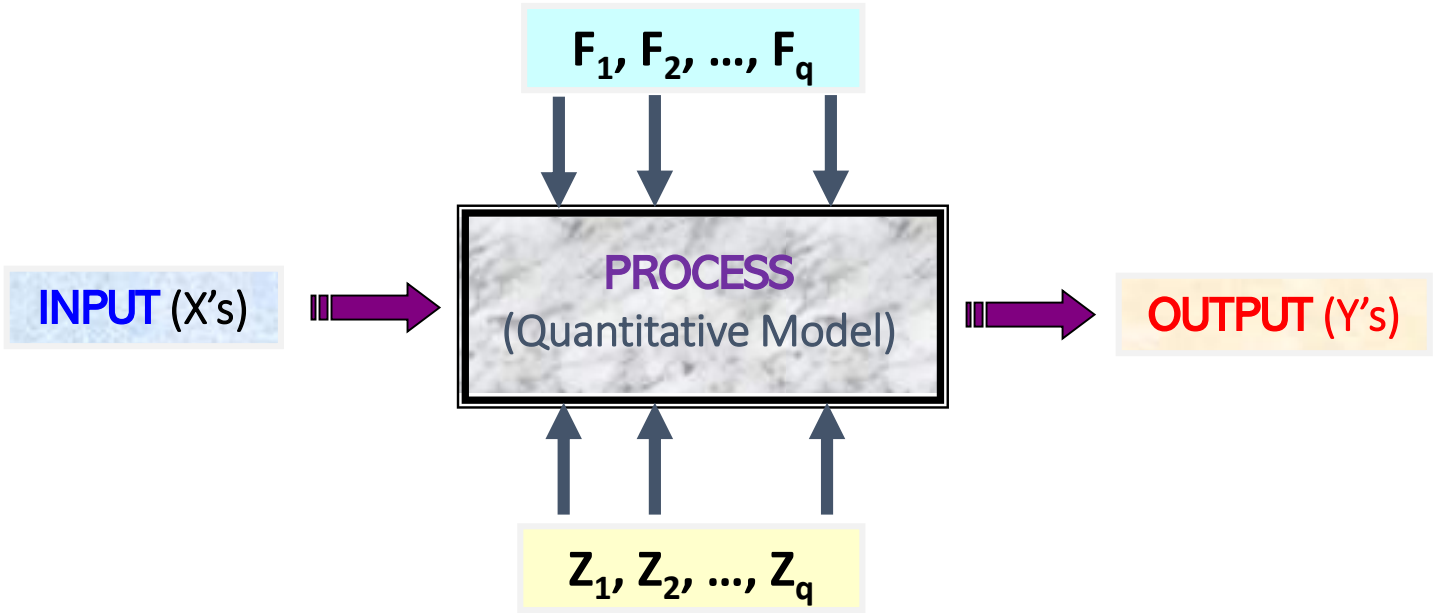
Data Analytics for Sales Forecasting

Controllable Factors

Different **regions** have different demography, social structures, and cultures.



The number of **sales** in a certain company.

Uncontrollable Factors

Adalah mudah untuk membuat prediksi dengan metode kuantitatif, tetapi tidak mudah untuk bisa membuat eksplanasi yang valid dan reliable tentang angka-angka prediksi itu, khususnya tentang jaminan asumsi/skenario yang digunakan adalah benar dimasa yang akan datang.

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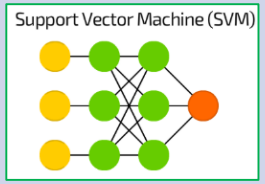
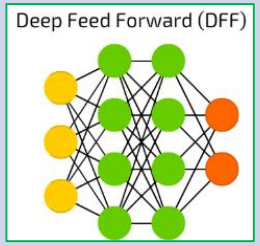
Quantitative Forecasting Methods

Approach	Variable	Technique	Methods
Causal 	Univariate	Classical models	**Multiple Regression**, MARS, …
		Machine Learning	**NN**, **SVR**, ANFIS, **Deep Learning**, …
		Hybrid	**Regression & NN**, …
	Multivariate	Classical models	Multivariate Linear Regression (MLR), …
		Machine Learning	Multi output NN, Deep Learning, …
		Hybrid	MLR & Multi output NN, …
Time Series 	Univariate	Classical models	Time Series Regression (TSR), **ARIMA**, …
		Machine Learning	**NN**, **SVR**, ANFIS, **Deep Learning**, …
		Hybrid	**ARIMA & NN**, **ARIMA & Deep Learning**, …
	Multivariate	Classical models	VARIMA, GSTAR, …
		Machine Learning	Multi output NN, Deep Learning, …
		Hybrid	VARIMA & NN, GSTAR & NN, …

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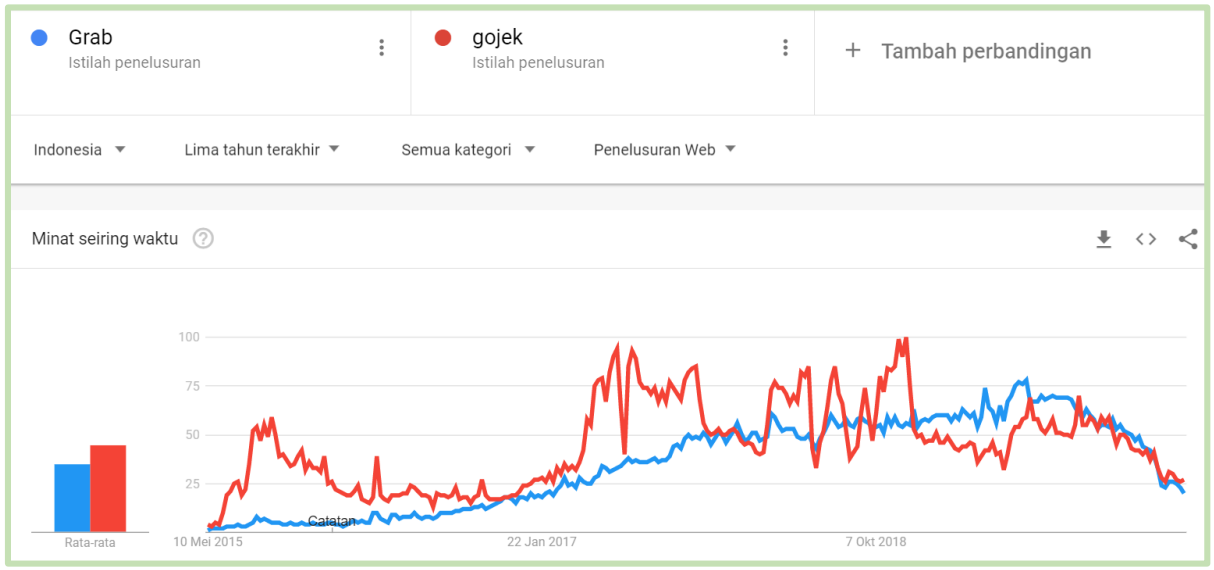
Time Series PATTERN

- General time series "pattern"
  - Stationer
  - Trend
  - Seasonal
  - Cyclic
  - Calendar Variation



Source: https://trends.google.com/trends/?geo=US

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Trend & Cyclic Pattern

INDONESIA

IDX Composite
IDX: COMPOSITE

+ Follow

4,608.79 −21.34 (0.46%) ↓
May 6, 15:15 GMT+7 · Disclaimer

1 day | 5 days | 1 month | 6 months | YTD | 1 year | 5 years | Max

Open	4,630.13	Low	4,597.75
High	4,647.52		

UNITED STATES

Dow Jones Industrial Average
INDEXDJX: .DJI

+ Follow

23,664.64 −218.45 (0.91%) ↓
May 6, 17:10 EDT · Disclaimer

1 day | 5 days | 1 month | 6 months | YTD | 1 year | 5 years | Max

Open	23,978.88	Low	23,661.14
High	24,054.59		

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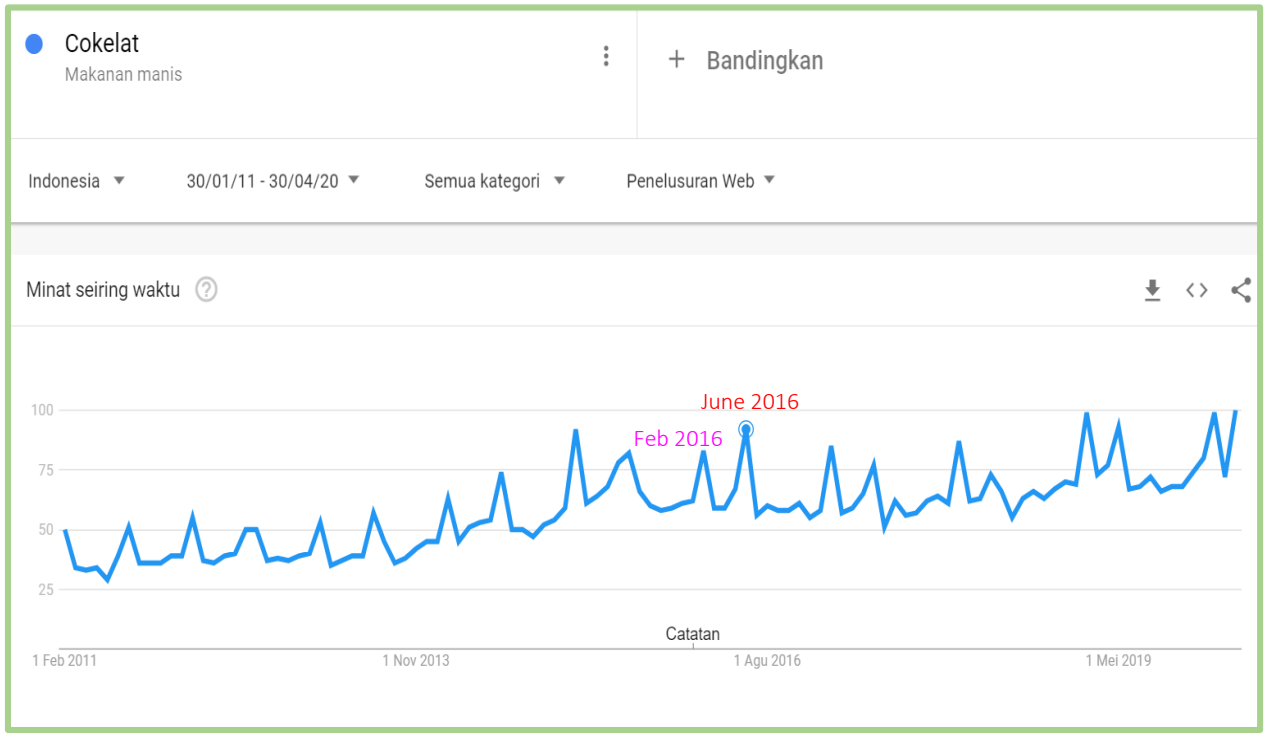
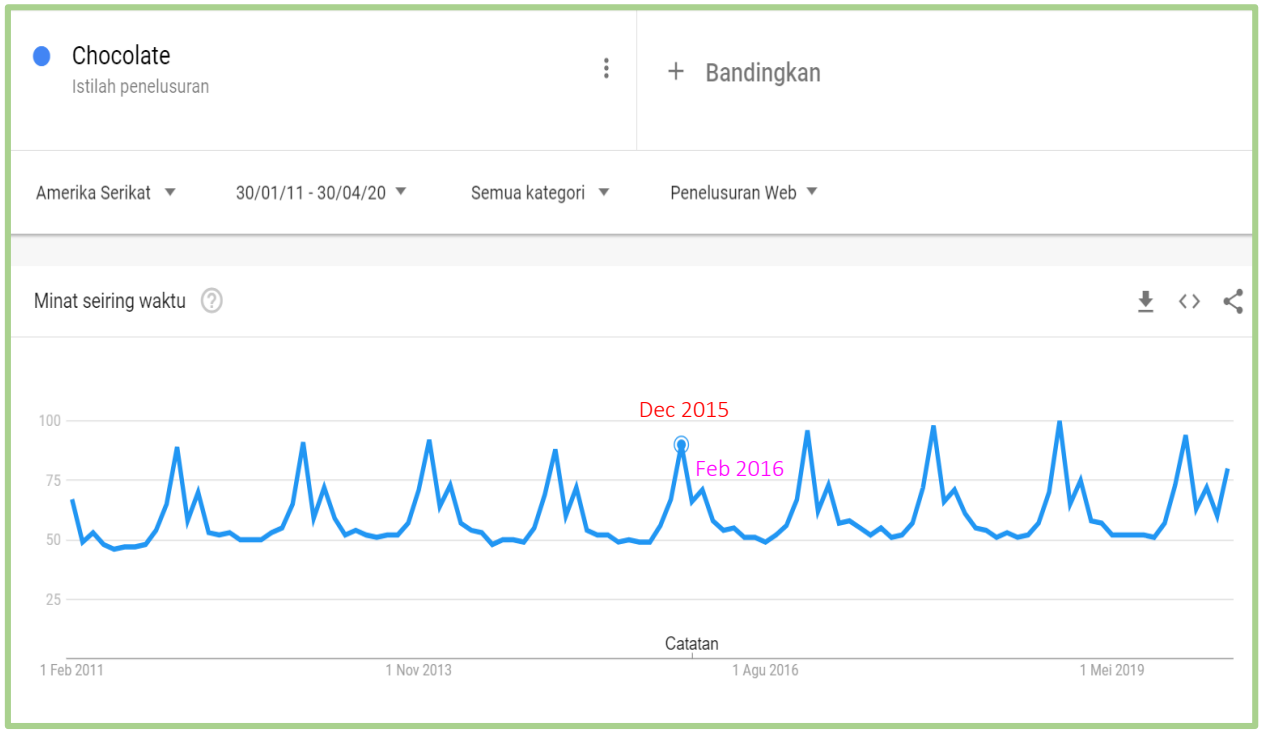
Seasonal & Calendar Variation Pattern

INDONESIA



Seasonal & Calendar Variation Pattern

UNITED STATES



Seasonal Pattern

Source: https://trends.google.com/trends/?geo=US

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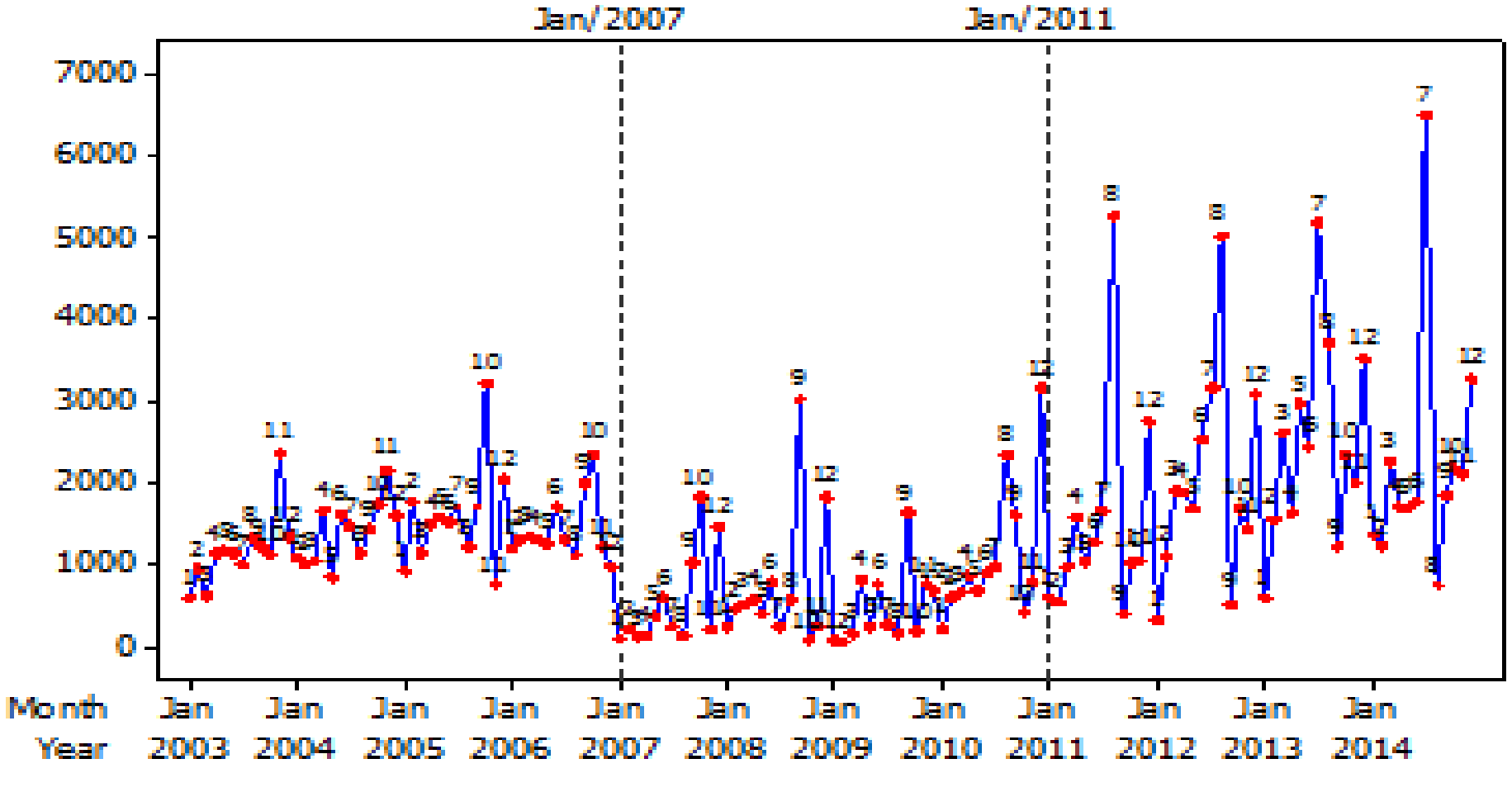
Outflow Data in Indonesia



Indonesian Currency

Indonesian Currency

Seasonal & Calendar Variation Pattern

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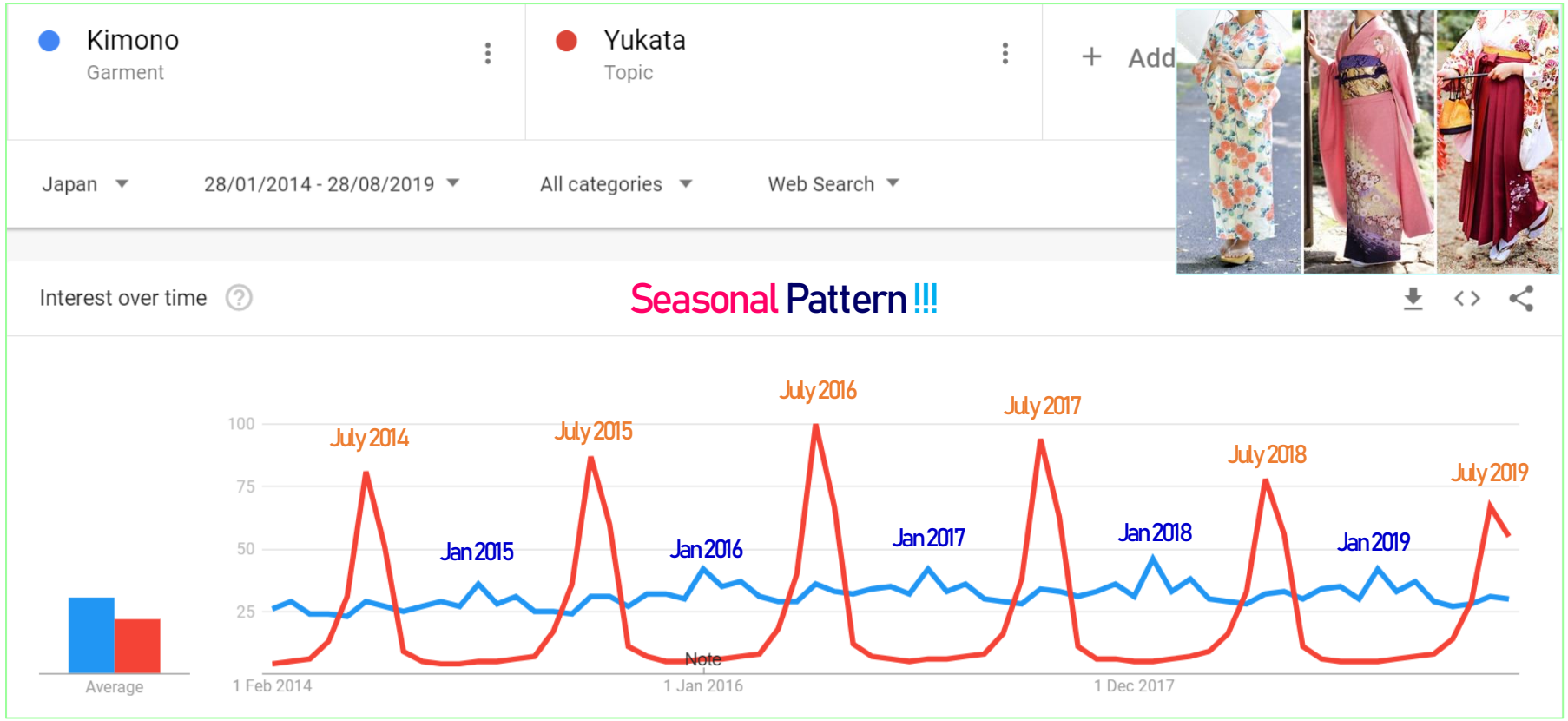
Seasonal or Calendar Variation Pattern

https://trends.google.com/trends/explore?date=2014-01-28%202019-08-28&geo=JP&q=%2Fm%2F049kc,%2Fm%2F01332v



The Gregorian calendar is a solar calendar system.

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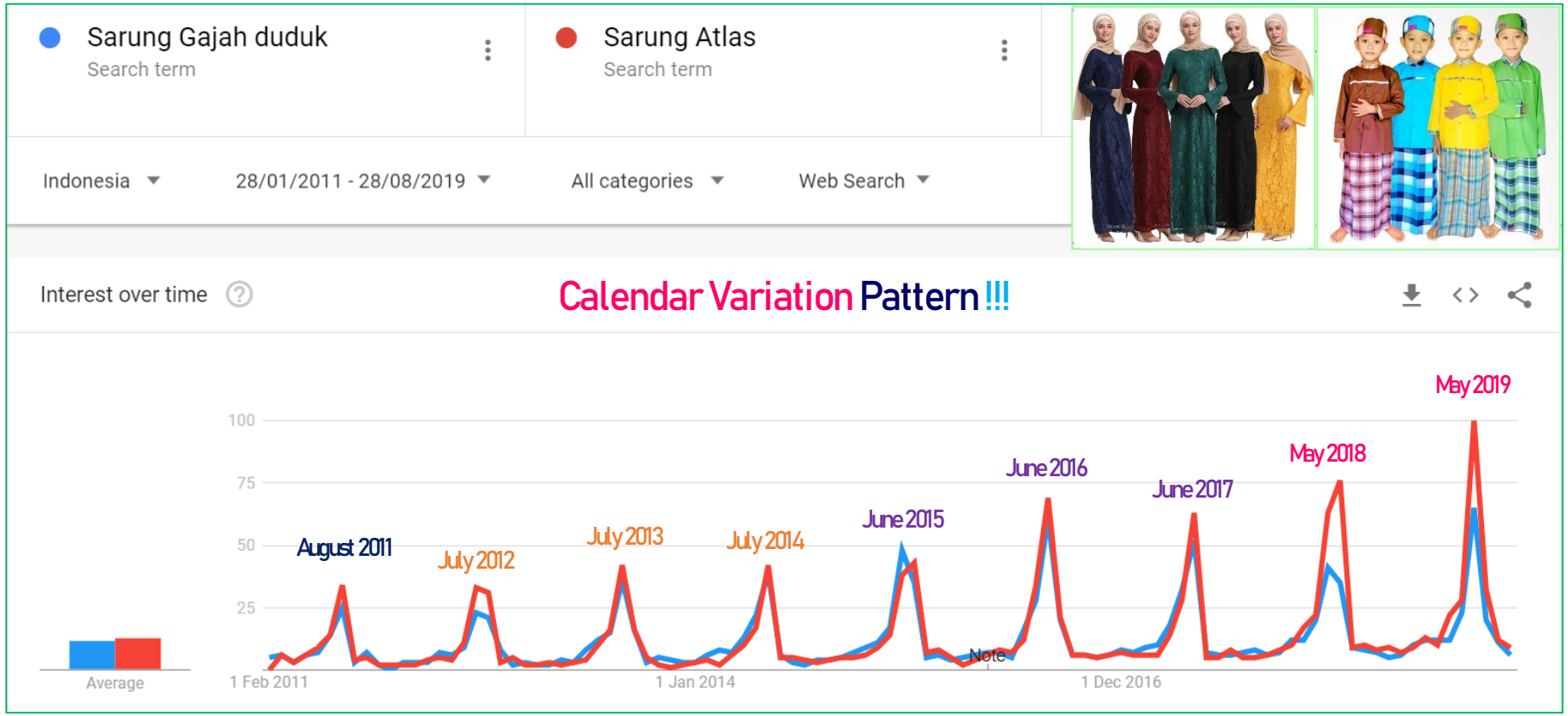
Seasonal or Calendar Variation Pattern

https://trends.google.com/trends/explore?date=2011-01-28%202019-08-28&geo=ID&q=Sarung%20Gajah%20duduk,Sarung%20Atlas



The Lunar calendar is a calendar based upon the monthly cycles of the Moon's phases.

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25 years of time series forecasting

De Gooijer & Hyndman (International Journal of Forecasting, 2006)

- 25 years of time series forecasting
  - Introduction
  - Exponential smoothing
    - Preamble
    - Variations
    - State space models
    - Method selection
    - Robustness
    - Prediction intervals
    - Parameter space and model properties
  - ARIMA models
    - Preamble
    - Univariate
    - Transfer function
    - Multivariate
  - Seasonality
  - State space and structural models and the Kalman filter

1980 ↓ 2005

- Nonlinear models ✓
  - Preamble
  - Regime-switching models
  - Functional-coefficient model
  - Neural nets ✓
  - Deterministic versus stochastic dynamics
  - Miscellaneous
- Long memory models
- ARCH/GARCH models
- Count data forecasting
- Forecast evaluation and accuracy measures
- Combining ✓
- Prediction intervals and densities
- A look to the future
- Acknowledgments
- References

❖ Spatial-Temporal
❖ Linear-Nonlinear
❖ Calendar Variation-Seasonality-Trend

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SOME REMARKS

☞ *The M3-Competition*: results, conclusions and implications

(1) Statistically sophisticated or complex methods do not necessarily provide more accurate forecasts than simpler ones.

(2) The relative ranking of the performance of the various methods varies according to the accuracy measure being used.

(3) The accuracy when various methods are being combined outperforms, on average, the individual methods being combined and does very well in comparison to other methods.

(4) The accuracy of the various methods depends upon the length of the forecasting horizon involved.

Makridakis & Hibon (International Journal of Forecasting, 2000)

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What should we be prepared for the future?

"The best way to predict the future is to create it"

Peter Ferdinand Drucker

19 November 1909 – 11 November 2005, An Austrian Born Management Consultant, Educator and Author, University of Frankfurt

Sources : Six Tools for Common Cause Variability Reduction for Pharmaceutical QA/QC and Manufacturing, Lynn Torbeck, Torbeck and Assoc.

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References

1. Hanke, J.E. and Reitsch, A.G. (1995, 2005, 2008)
   Business Forecasting, 5th, 7th and 9th edition, Prentice Hall.
2. Armstrong, J.S. (2002)
   Principles of Forecasting: A Handbook for Researchers and Practicioners, Kluwer Academic Publisher.
3. De Gooijer, J.G. and Hyndman, R.J. (2006)
   25 years of time series forecasting, International Journal of Forecasting, 22, 443-473.
4. Makridakis, S., Spiliotis, E., Assimakopoulos, V. (2020)
   The M4 Competition: 100,000 time series and 61 forecasting methods, International Journal of Forecasting, 36 (1), 54-74.
5. https://trends.google.com/trends/?geo=US

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