Risk Management and Decision Analysis

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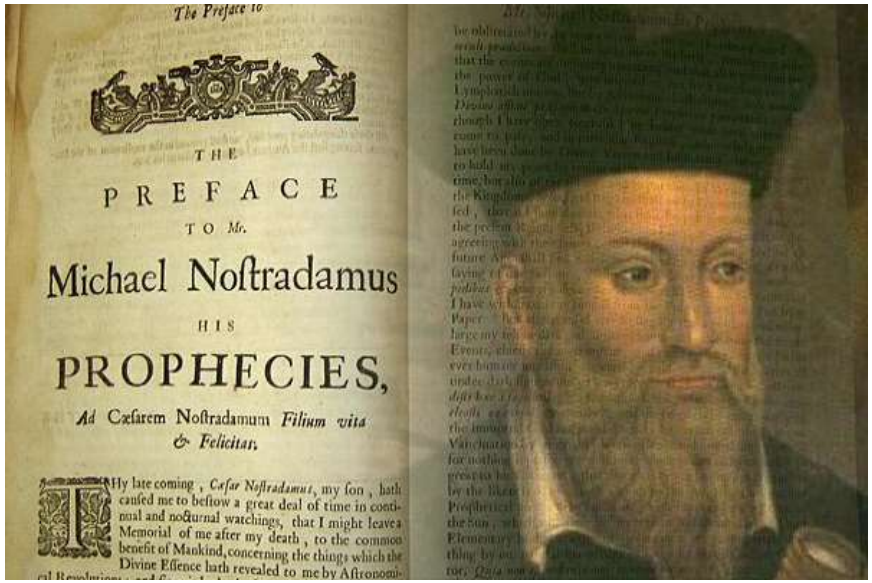
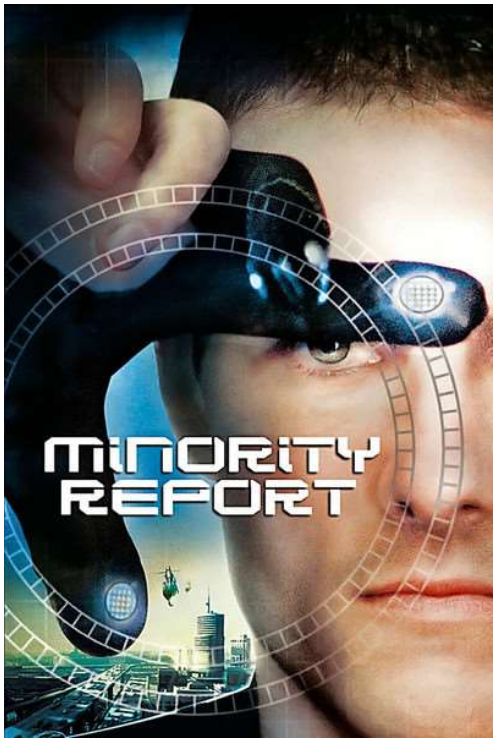
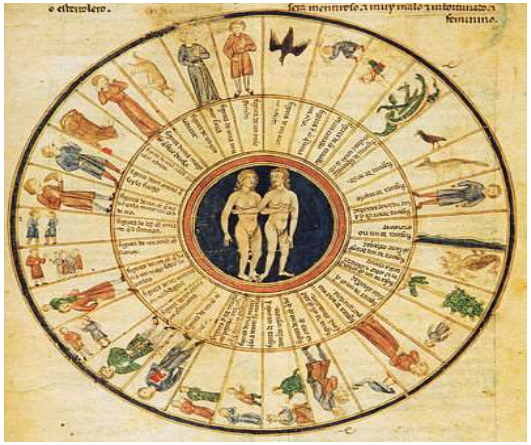
PART I

Prediction Method

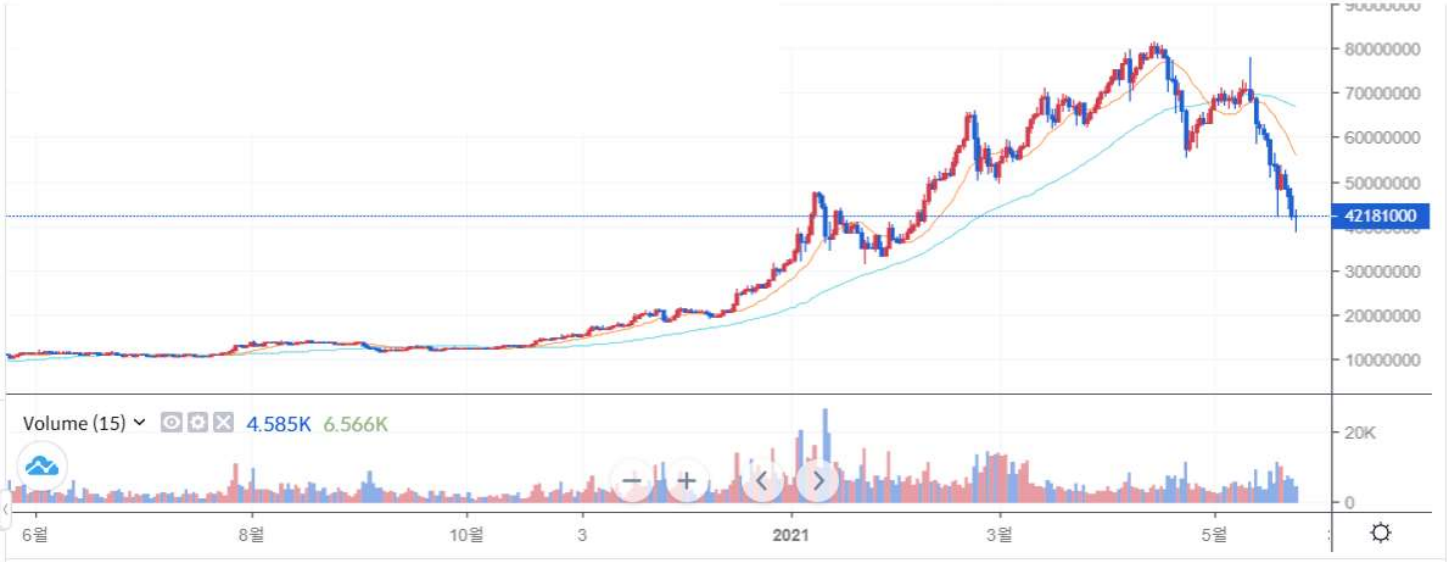
Prediction? Superpower?







Prediction? Superpower?



What is Prediction (Forecasting)?

- **Forecasting & Prediction**
  - Forecasting is the process of making predictions of the future based on past and present data and most commonly by analysis of trends.
  - Prediction is a similar, but more general term.
  - Risk and uncertainty are central to forecasting and prediction.

Hyndman, R.J. and Athanasopoulos, G. (2013) Forecasting: principles and practice. OTexts: Melbourne, Australia.

Prediction Methods

- **Qualitative methods**
  - Qualitative forecasting techniques are subjective, based on the opinion and judgment of consumers, experts.
  - They are appropriate when past data are not available.
  - Examples: Delphi method, Scenario building, Statistical surveys, etc.

- **Quantitative methods**
  - Quantitative forecasting models are used to forecast future data as a function of past data.
  - They are appropriate to use when past numerical data is available and when it is reasonable to assume that some of the patterns in the data are expected to continue into the future.

Hyndman, R.J. and Athanasopoulos, G. (2013) Forecasting: principles and practice. OTexts: Melbourne, Australia.

Prediction Methods - Quantitative methods

- **Average approach**: all future values are equal to the mean of the past data.
- **Naïve approach**: forecasts are produced that are equal to the last observed value.
- **Drift method**: the amount of change over time (called the drift) is set to be the average change seen in the historical data.

- **Time series methods**
  - Time series methods use historical data as the basis of estimating future outcomes.
  - Autoregressive(과거값으로 회귀분석, 자기상관성), Moving average(과거 예측오차로 예측모델 생성), Weighted moving average, Exponential smoothing, Autoregressive moving average (ARMA), Autoregressive integrated moving average (ARIMA), etc.
- **Causal methods**
  - Causal methods try to identify the underlying factors that might influence the variable that is being forecast.
  - Regression analysis, Parametric or non-parametric techniques, etc.
- **Artificial intelligence methods / Simulation / Probabilistic forecasting**

Hyndman, R.J. and Athanasopoulos, G. (2013) Forecasting: principles and practice. OTexts: Melbourne, Australia.

Regression Analysis

- The earliest form of regression was the method of least squares, which was published by Legendre in 1805, and by Gauss in 1809.
- The term "regression" was coined by Francis Galton in the nineteenth century to describe a biological phenomenon.
  - ‘co-relation’
- Galton’s work was later extended by Udny Yule and Karl Pearson to a more general statistical context
  - ‘correlation coefficient’ → R
- Regression analysis is widely used for prediction and forecasting, where its use has substantial overlap with the field of machine learning.

* Galton, F. (1877). “Typical laws of heredity.” *Proceedings of the Royal Institution of Great Britain*, 8, 282-301.
** Pearson, K. (1896). “Mathematical contributions to the theory of evolution III: Regression, heredity, and panmixia.” *Philosophical Transactions of the Royal Society*, A, 187, 253-318.

Simple Linear Regression (SLR)

- $Y = \beta_0 + \beta_1 X + e$

  where, Y : dependent variable (actual value)
  X : Independent variable
  e : residual
  β_0, β_1 : parameter

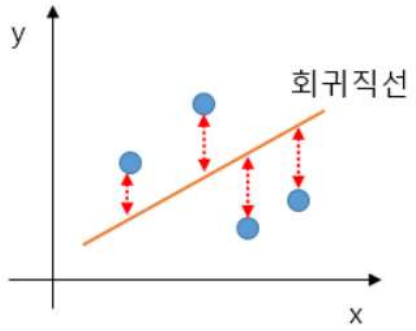
- $Y = \hat{Y} + e$ or $\hat{Y} = Y - e$

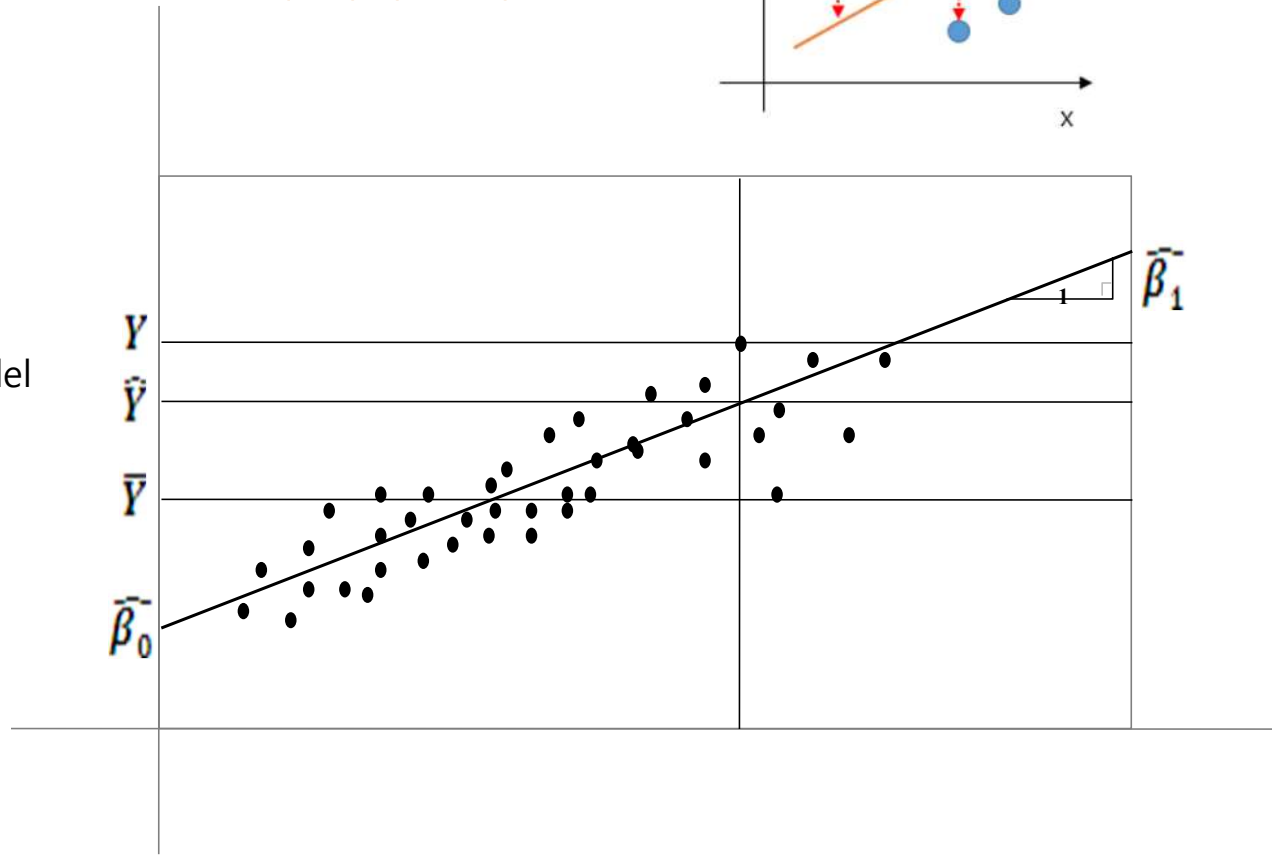
  → estimated Y by the model

- $\hat{Y} = \beta_0 + \beta_1 X$: Final form of SLR model

  → Regression coefficient

Residual(잔차, 실측값-예측값 간의 차이)의 제곱의 합이 최소가 되는 공식을 도출





Q = 전체 데이터의 편차들을 제곱하여 합한 값

Q_e = 전체 데이터의 잔차들을 제곱하여 합한 값

$$R^2 = \frac{Q - Q_e}{Q}$$

Weisberg, S. (1985). *Applied Linear Regression*. John Wiley & Sons, Inc. 2nd Ed.

AR, MR

AR모델

- 예측하고자 하는 특정 변수의 과거 관측값의 선형결합으로 해당 변수의 미래값 예측
- 과거 p개 관측값의 선형결합으로 예측하는 모델을 p차 AR모델이라고 하며 AR(p)로 표현

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \varepsilon_t$$

여기에서, c는 상수, ϕ_p는 가중치, ε_t는 오차

MA모델

- 예측오차를 이용하여 미래의 값 예측
- 과거 q개 예측오차의 선형결합으로 예측하는 모델을 q차 MA모델이라고 하며 MA(q)로 표현

$$y_t = c + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t$$

여기에서, c는 상수, θ_q는 가중치, ε_t는 오차

ARMA, ARIMA

ARMA모델과 ARIMA모델

- ARMA(p, q)모델
  - AR(p)모델과 MA(q)모델을 결합하여 ARMA(p, q)모델 도출
  - 시계열의 각 값을 과거 p개 관측값과 q개 오차를 이용하여 예측

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t$$

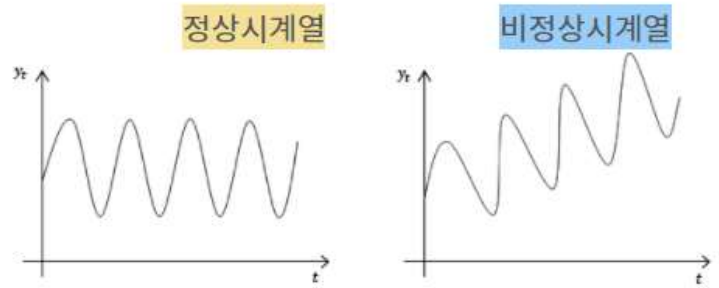
- ARIMA(p, d, q)모델
  - ARMA모델에 차분 과정 추가
  - 시계열 데이터를 d회 차분하고 결과값은 과거 p개 관측값과 q개 오차에 의해 예측되는 모델
  - 결과값은 비차분화(un-differenced) 과정을 거쳐 최종 예측값으로 변환

차분(differencing): 연이은 관측값들의 차이를 계산
→ 평균의 정상화

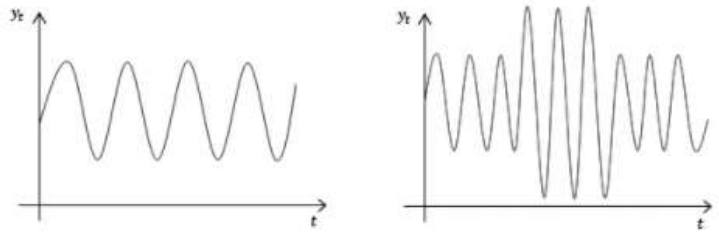
정상성(stationarity) vs 비정상성

정상성

- 뚜렷한 추세가 없다. 시계열의 평균이 시간 축에 평행하다.
- 시계열의 변동이 시간의 흐름에 따라 일정하다. 시간이 지나도 분산이 일정하다.

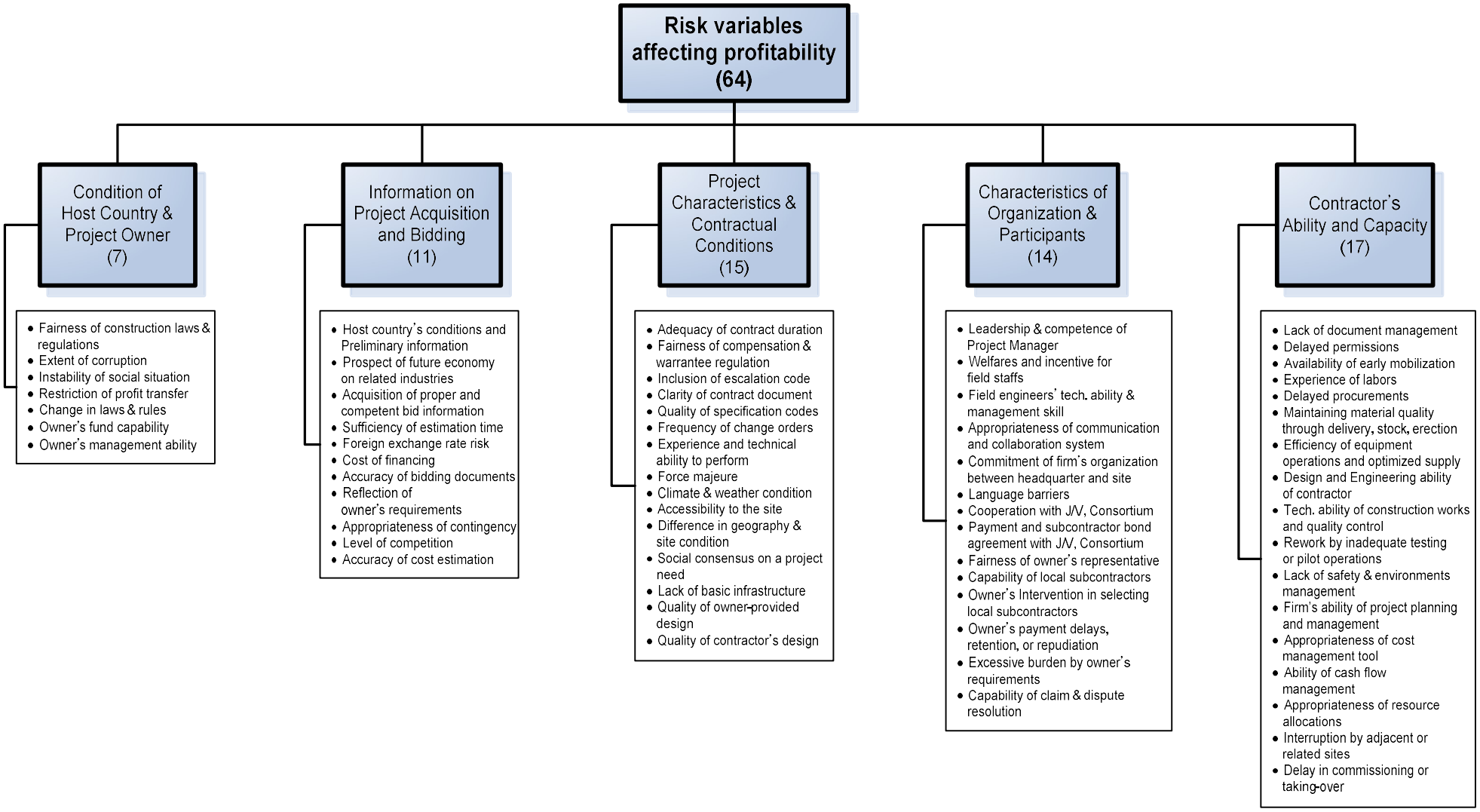


평균이 시간에 따라 일정한 경우(좌)와 변하는 경우(우)



분산이 시간에 따라 일정한 경우(좌)와 변하는 경우(우)

Risk Factors Affecting Performance



Han, S. H., Kim, D. Y., and Kim, H. (2007). "Predicting Profit Performance for Selecting Candidate International Construction Projects." *Journal of Construction Engineering and Management*, 133(6), 425-436.

Profit Prediction Model : Factor Analysis

- **Factor analysis(요인분석) was performed to compress risk factors to the relevant groups that have a high correlation each other**
- **14 group factors were drawn as a valid sub-dimensional representation of the initial sources of 64 risk factors**

F1 Contractor's ability & experience	F6 Country environments	F11 Commitment of J/V or consortium
F2 Project condition – resource delivery, labor skill, etc.	F7 Project information in early stage of a project	F12 Contract condition & management
F3 Project environments	F8 Quality of design	F13 Quality of bid information
F4 Attitude & ability of owner & A/E	F9 Quality of cost management	F14 Conflict resolution system
F5 Commitment of organization – PM competency, etc.	F10 Quality of estimation	

Han, S. H., Kim, D. Y., and Kim, H. (2007). "Predicting Profit Performance for Selecting Candidate International Construction Projects." *Journal of Construction Engineering and Management*, 133(6), 425-436.

Profit Prediction Model : Regression Analysis

- **Model summary**

독립변수 수와 데이터의 수를 고려한 R2
(R2는 독립변수의 수가 증가하면 커짐)

종속변수의 자기상관성 평가
0(양의 자기상관)-2(없음)-4(음의 자기상관)

Model	R	R square	Adjusted R square	Std. deviation of presumption(추정값)	Durbin-Watson
8	0.843	**0.652**	0.508	1.308	1.805

- **Coefficients of multiple regression analysis**

단위와 분포의 평균이 변수마다 다르기 때문에 이를 비교해보기 위해 변환한 수치

Composition (Group Factors)	Unstandardized coefficient (비표준화계수)		Standardized coefficient (표준화계수)	T (B/표준편차)	Significance
	B	Standard error	beta		
Constant	4.670	0.138		33.873	0.000
F10 Quality of estimation	0.619	0.139	0.332	4.467	0.000
F7 Project information in early stage of a project	0.527	0.139	0.283	3.800	0.000
F4 Attitude and ability of owner & A/E	0.506	0.139	0.271	3.647	0.000
F12 Contract condition and management	0.499	0.139	0.267	3.596	0.001
F2 Project condition – resource delivery, labor skill, etc	0.477	0.139	0.256	3.440	0.001
F5 Commitment of organization	0.470	0.139	0.252	3.393	0.001

$$\textit{Profit Performance} = 4.670 + 0.619\times F10 + 0.527\times F7 + 0.506\times F4 + 0.499\times F12 + 0.477\times F2 + 0.470\times F5 + 0.402\times F1 + 0.379\times F8$$

Han, S. H., Kim, D. Y., and Kim, H. (2007). "Predicting Profit Performance for Selecting Candidate International Construction Projects." *Journal of Construction Engineering and Management*, 133(6), 425-436.

표준편차 감소 → t값 증가 → 유의미(독립-종속변수간 상관도 높음)

Failure of the Gaussian Hypothesis

- **Structural Factors of Current World Environment**
  - From ***large-scale*** to ***off-scale***
  - From ***complexity*** to the ***unreadable***
  - From ***tightly-coupled*** to ***total interdependence***
  - From ***high speed*** to ***instantaneity***
  - From ***uncertainty*** to ***ignorance***

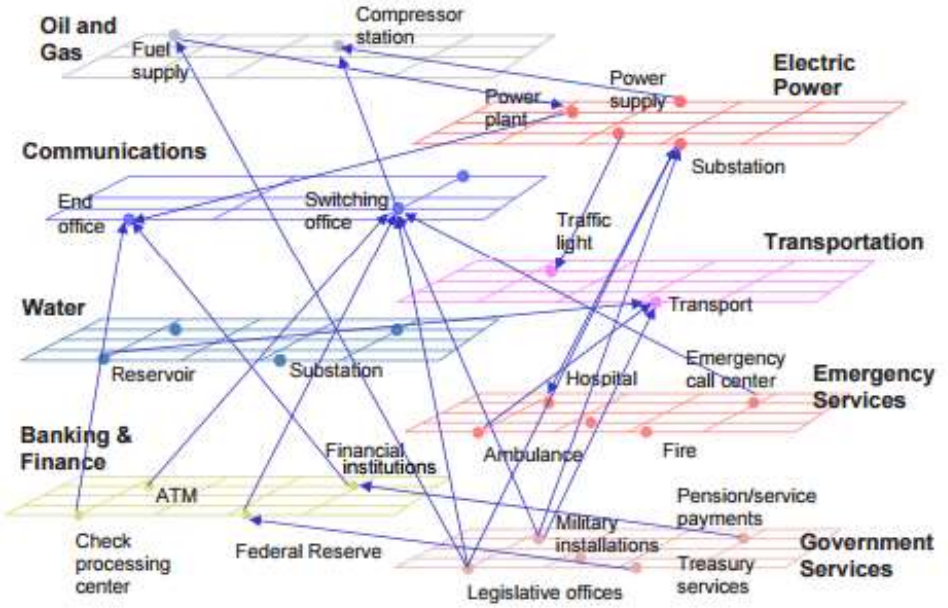
Topper B., and Lagadec, P. (2013). "Fractal Crisis – A New Path for Crisis Theory and Management." *Journal of Contingencies and Crisis Management*, Vol. 21, No. 1, pp. 4-16.

Failure of the Gaussian Hypothesis

OECD Reviews of Risk Management Policies

Future Global Shocks

IMPROVING RISK GOVERNANCE

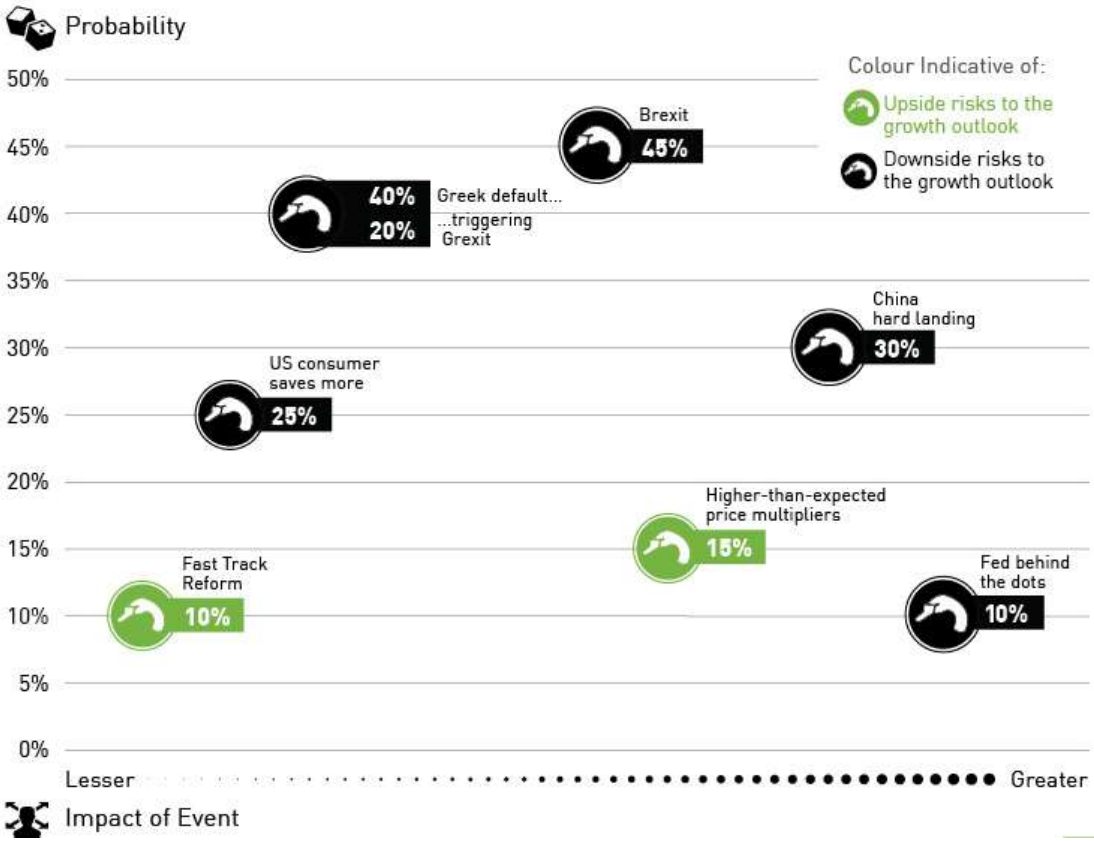


Source: The National Association of Regulatory Utility Commissioners (2005), "Utility and network interdependencies: What state regulators need to know", *Technical Assistance Brief on Critical Infrastructure Protection*.

OECD (2011). *Future Global Shocks: Improving Risk Governance*, OECD Reviews of Risk Management Policies, OECD Publishing.

Failure of the Gaussian Hypothesis

Hard landing: 고성장을 해오던 경기가 갑자기 침체기로 돌아서면서 투자가 위축되고 소득은 줄어들고 주가는 폭락하는 현상



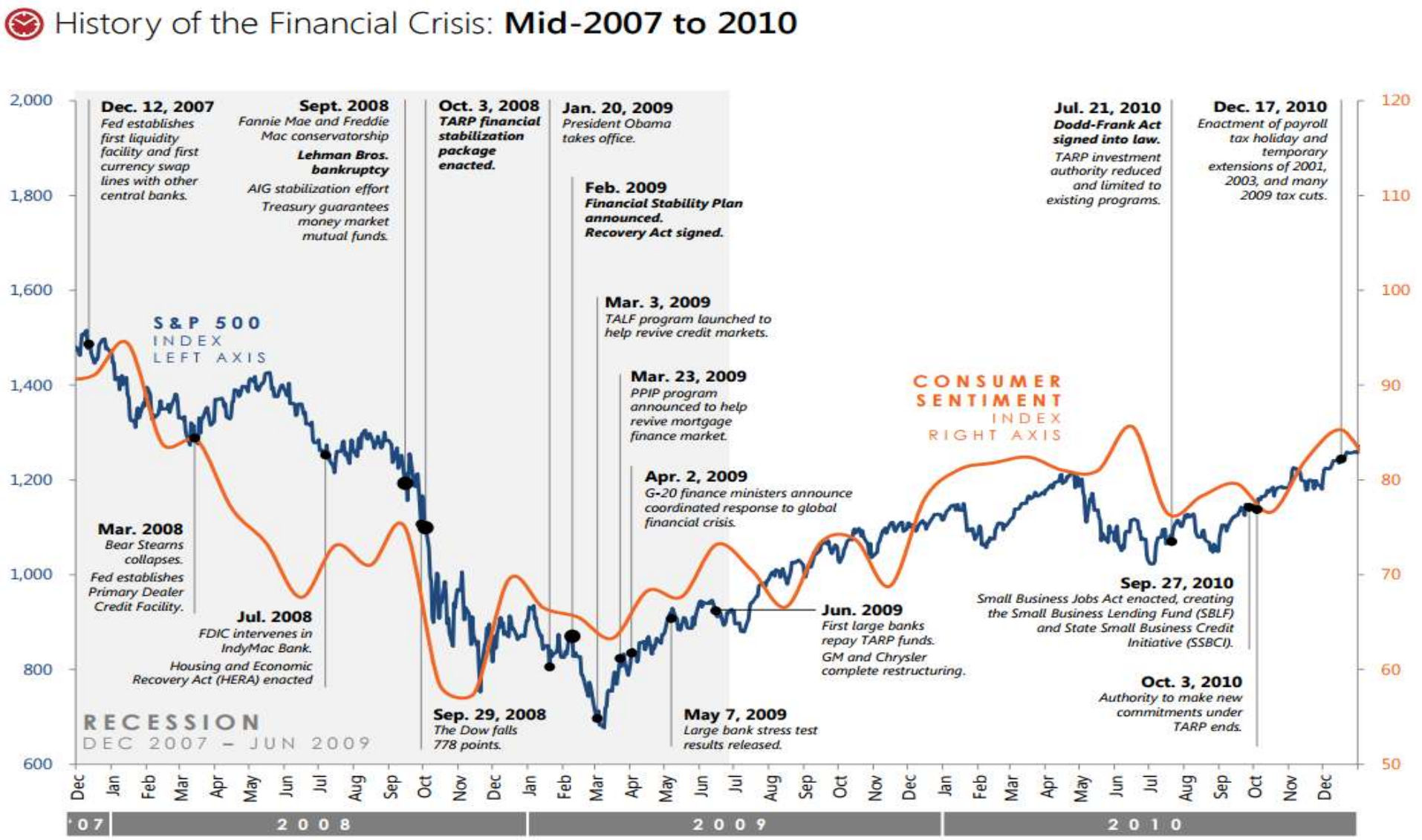
대부분의 사람은 백조라고 하면 당연히 흰색의 백조를 생각하고, 검은색의 백조가 있으리라고는 상상하지 못했습니다. 실제로 1697년 호주 서부에서 검은색의 백조가 발견될 때까지 검은 백조는 세상에 존재하지 않는 것으로 알려져 있었습니다. 그때까지 사람들이 보았던 모든 백조가 흰색이어서 검은 백조가 있을 수 있다는 사실을 아예 생각조차 할 수 없었기 때문입니다. 하지만 검은 백조를 실제로 발견한 순간부터 그 믿음은 잘못된 것으로 되어 버렸습니다.

그래서 전혀 예상할 수 없었던 일이 실제로 나타나는 경우를 블랙스완이라고 부르게 됐습니다. 이 용어는 그동안 철학·사회학·심리학 등에서 오랫동안 사용되어 왔지만, 금융에서 관심을 갖게 된 것은 나심 탈레브라는 학자가 2007년에 '블랙스완'이란 책을 발간한 이후부터입니다. 탈레브는 그 책에서 블랙스완의 세 가지 특징을 다음과 같이 설명하고 있습니다.

첫째, 대부분 사람들의 기대를 넘어서 예외적으로 일어나는 사건이라는 것입니다. 과거의 경험으로 볼 때 일어나지 않을 것으로 보이는 경우라는 것입니다. 둘째, 일단 발생하면 엄청난 변화를 초래할 만큼 충격적이라는 점입니다. 이는 특정 기업이나 개인의 문제가 아니라 전체 시장의 변화를 수반하는 것이라 할 수 있습니다. 셋째, 일단 블랙스완이 발생한 이후에는 사람들이 사전에 예측할 수 있었다고 받아들인다는 점입니다. 이는 블랙스완을 예상하는 것이 완전히 불가능한 것은 아니지만 소수의 의견으로 무시되는 경우가 있음을 의미합니다.

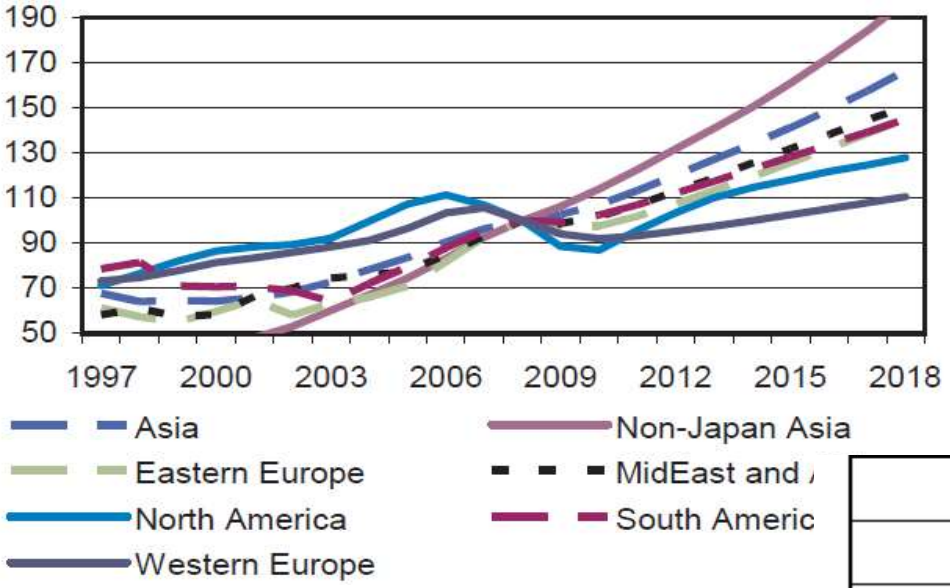
Visual Capitalist (2015). *Black Swans on the Horizon*, June 12, 2015

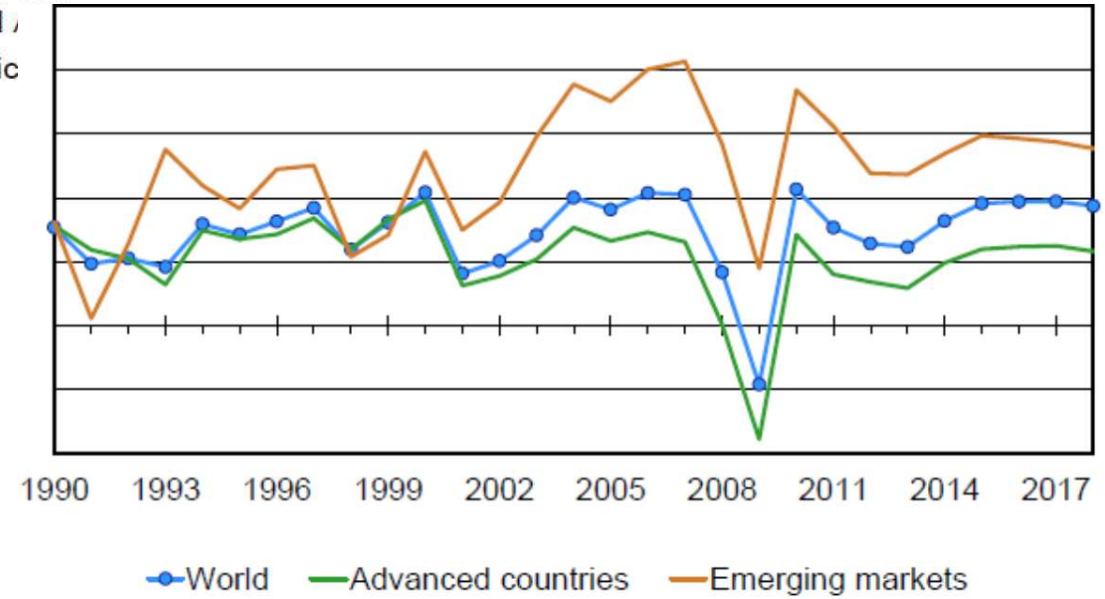
Failure of the Gaussian Hypothesis



U.S. Dept. of the Treasury (2013). *The Financial Crisis Five Years Later: Response, Reform, and Progress*

Failure of the Gaussian Hypothesis





Global Insight (2009, 2014). *Global Construction GDP Growth Trend*

https://hbr.org/2009/10/the-six-mistakes-executives-make-in-risk-management

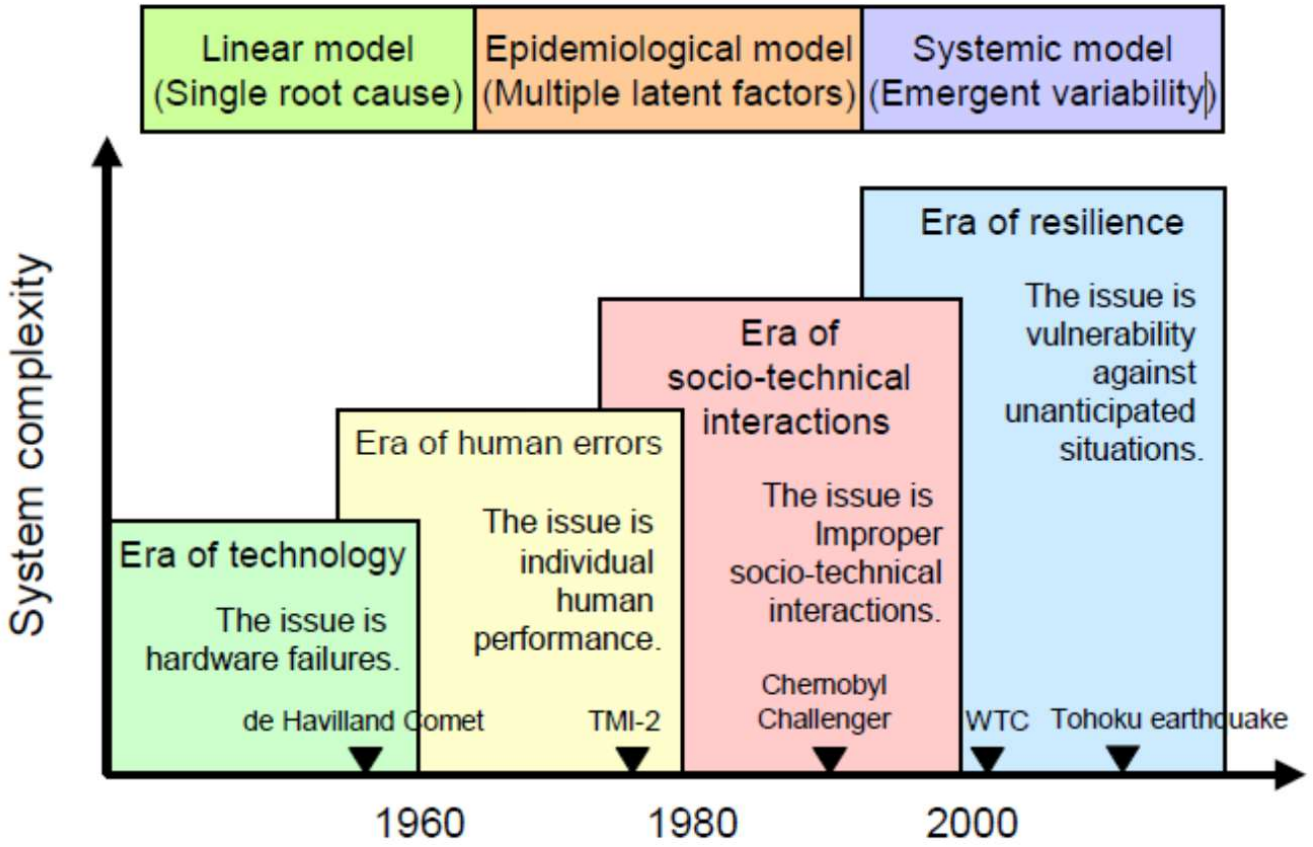
Failure of the Gaussian Hypothesis

- **Six mistakes executives make in risk management**
  - We think we can manage risk by predicting extreme events.
  - We are convinced that studying the past will help us manage risk.
  - We don't listen to advice about what we shouldn't do.
  - We assume that risk can be measured by standard deviation.
  - We don't appreciate that what's mathematically equivalent isn't psychologically so.
  - We are taught that efficiency and maximizing shareholder value don't tolerate redundancy.

Taleb, N. N., Goldstein, D. G., and Spitznagel, M. W. (2009). "The Six Mistakes Executives Make in Risk Management." *Harvard Business Review*, October 2009.

Modeling Trend

- **Changing Focus**



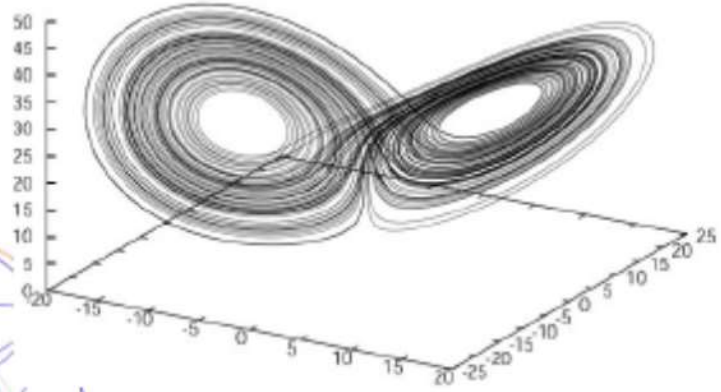
Topper B., and Lagadec, P. (2013). "Fractal Crisis – A New Path for Crisis Theory and Management." *Journal of Contingencies and Crisis Management*, Vol. 21, No. 1, pp. 4-16.

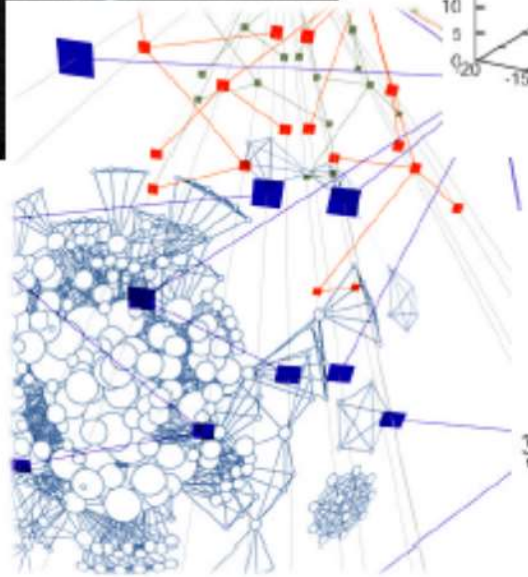
Complex System Approach

창발현상: 하위 구성요소에 없는 특성이나 행동이
상위구조에 자발적으로 돌연히 출현하는 현상

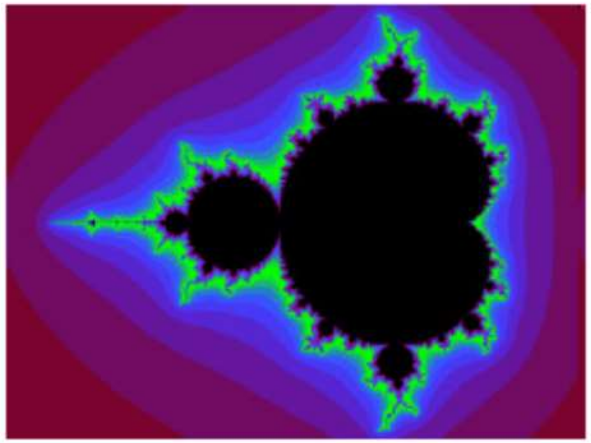
Emergent phenomena

Chaos

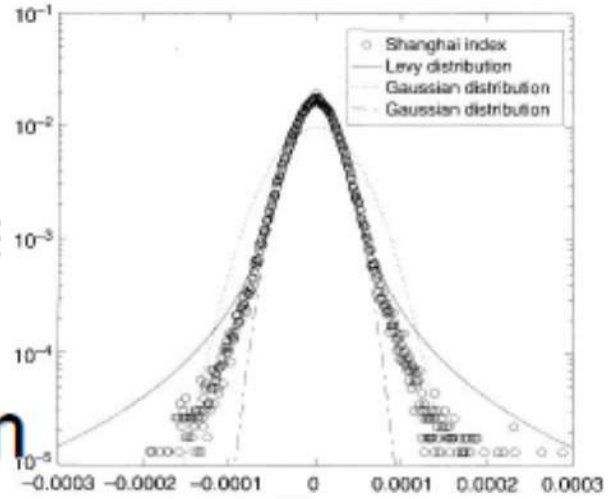




Network system



Fractal



Stylized fact 정형화된 사실

Fractal Theory

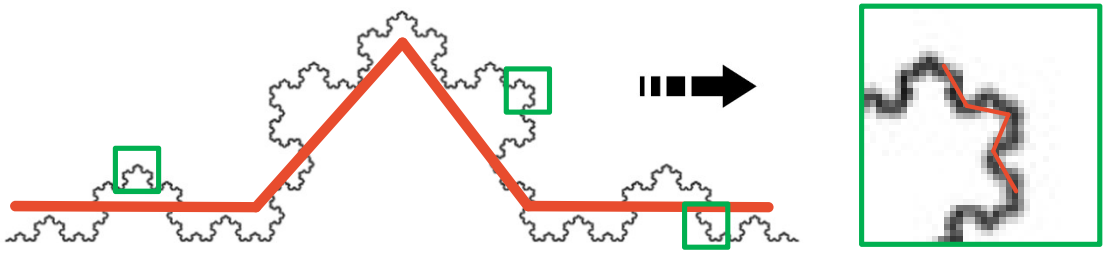
- **Fractal**
  - The term "fractal" was first used by mathematician Benoît Mandelbrot in 1975. Mandelbrot based it on the Latin *frāctus* meaning "broken" or "fractured", and used it to extend the concept of theoretical fractional dimensions to geometric patterns in nature.
  - A fractal is a mathematical set that exhibits a repeating pattern displayed at every scale.
  - Fractals are different from other geometric figures because of the way in which they scale. (Euclidean vs. Fractal geometry)
  - Characteristics: Local randomness and Global determinism, Fractal dimension, Self-similarity, Recursiveness

Peters, E. E. (1994). *Fractal Market Analysis.* John Wiley & Sons, Inc.

Fractal Theory

- **Fractal**

Characteristic	Description
Self-similarity(자기유사성)	The tendency of an object to be similar to parts of itself
Recursiveness(반복성)	The parts of an object appear in the entire area



Peters, E. E. (1994). *Fractal Market Analysis*. John Wiley & Sons, Inc.

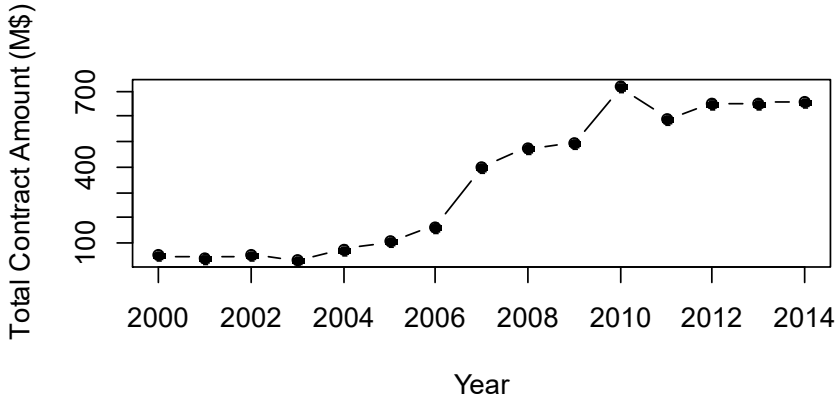
PART II

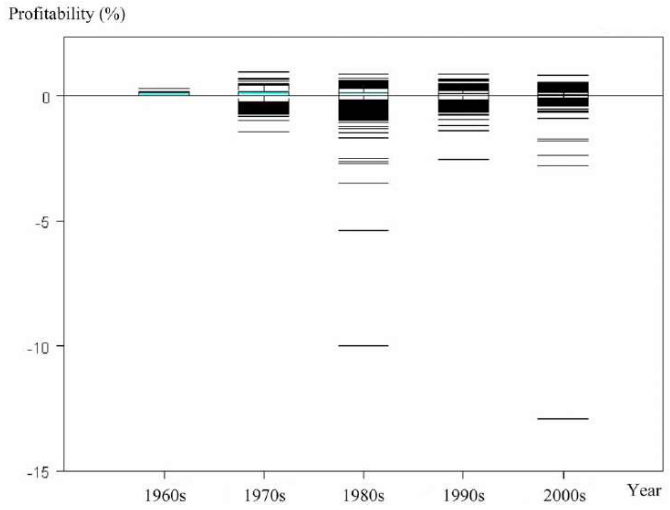
Mega-Shock Early Warning System for the International Construction Market

1.1 Research Background (1/2)

Failure in the Global Construction Market

- Risk management became an important part of the global construction market (Griffis and Christodoulou 2000; Han et al. 2007; Kim et al. 2008; Kim et al. 2013)
- The total contract amount of Korean construction companies in the global market are generally increasing for about 10 years, however, **the number of extreme failure cases are also increasing** (Kim et al. 2007; ICAK 2015)





Sudden Change of Market

- Many researches revealed the various causes of failure in the global construction market (Akintoye et al. 1998; Griffis and Christodoulou 2000; Han et al. 2007; Kim et al. 2008; Kim et al. 2009)
- Recent studies said that the shock derived from **sudden change of market** is one of the most influential causes (Han et al. 2007; Kim et al. 2009; Hwang 2011)

1.2 Problem Statement & Research Objective

Problem Statement

- The prediction result of conventional models depend on the past observations

Regression approach → Limited to predict the sudden change → Difficulty in risk mgmt

Assumption of trends and distribution of historical data

Research Objective

To develop an early warning system against a sudden change of the global construction market

- To understand the market better using Fractal analysis
- To improve the results of conventional approaches on prediction of a sudden change by introducing the Fractal analysis

1.3 Research Scope

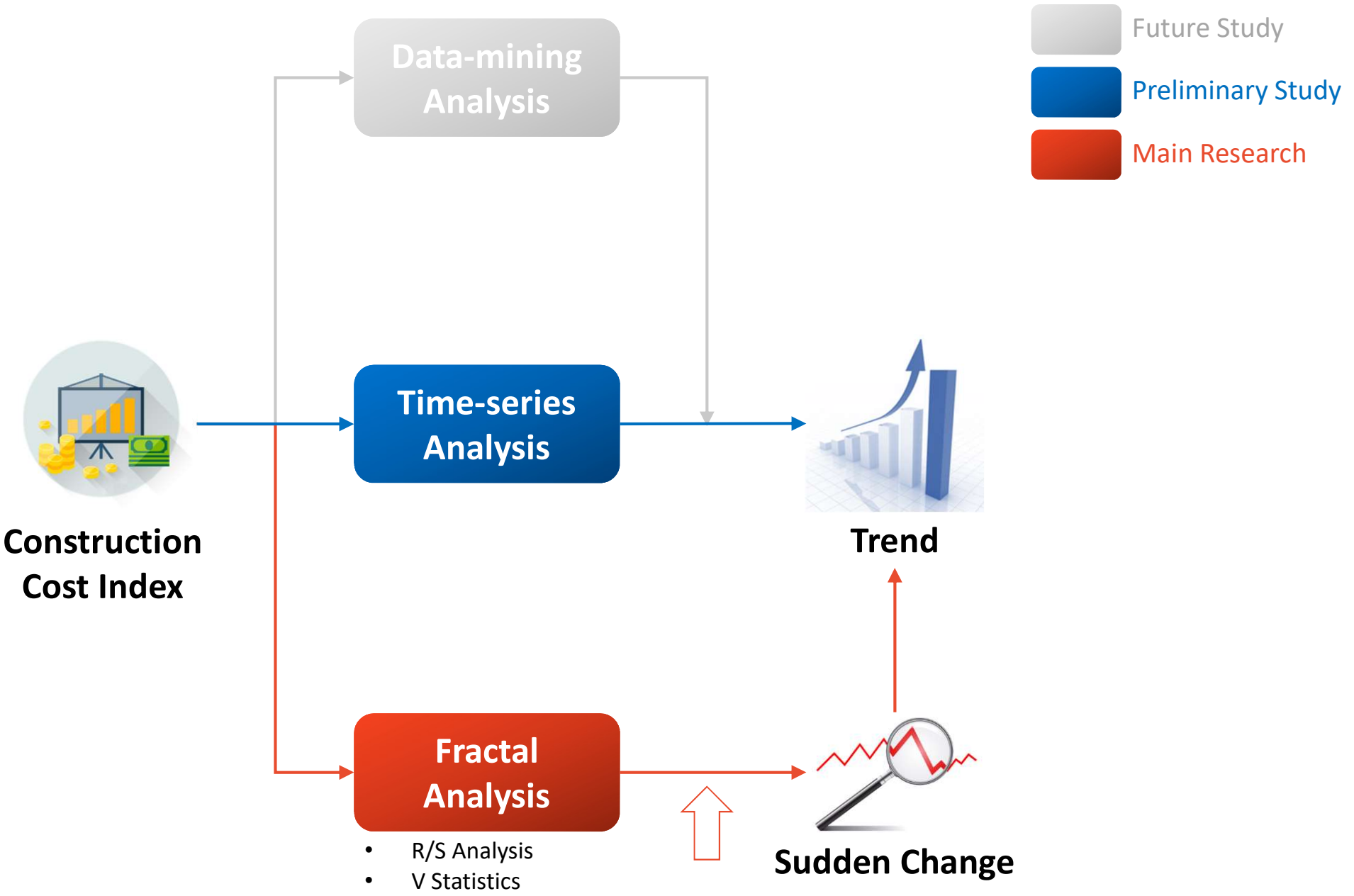
Target of Analysis

CCI

- Construction Cost Index (from Engineering News Record; ENR)
- Used for cost estimation, bid preparation, and investment planning on the global construction market (Williams 1994; Kim et al. 2008; Hwang 2011; Lesniak 2013; Jiang et al. 2013; Shahandashti and Ashuri 2013)
- 1990 JAN ~ 2016 AUG (320 records)

Elements	Description
Labor Rate	200 hours of common labor at the 20-city average of common labor rates
Steel Price	25 cwt (100 pounds) of standard structural steel shapes at the mill price prior to 1996 and the fabricated 20-city price from 1996
Cement Price	1.128 tons of Portland cement at the 20-city price
Lumber Price	1,088 board-ft of 2 x 4 lumber at the 20-city price

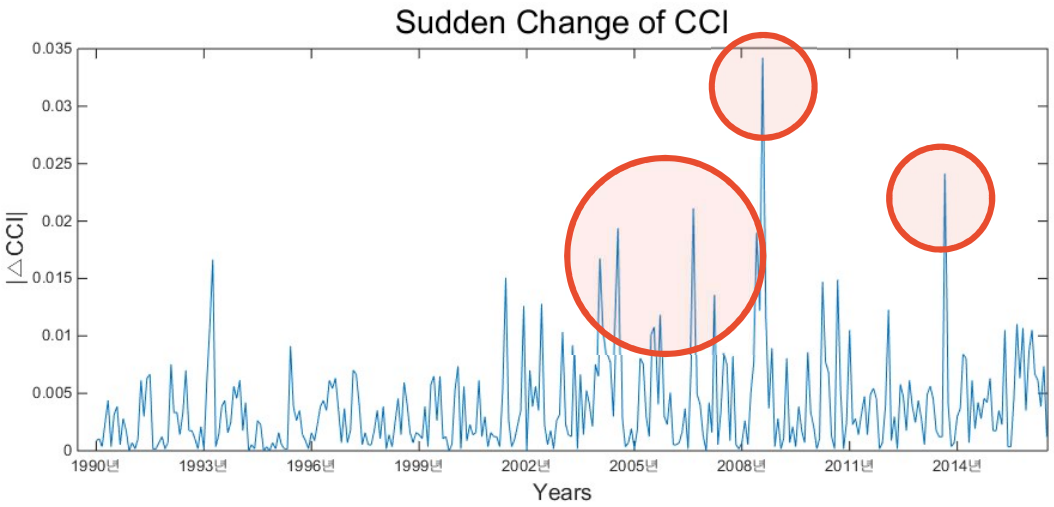
2.1 Research Framework



2.2 Preliminary Study (1/5)

Sudden Change of Market

- **Relatively big change**(전 구간과의 차이) **in Construction Cost Index (CCI)** – *2% 차이*
  - 2004 FEB
  - 2004 AUG
  - 2006 SEP
  - 2008 JUN
  - 2008 AUG
  - 2013 SEP



2.2 Preliminary Study (2/5)

Time-series Analysis (1/2)

Objective

- To predict sudden change of market based on conventional time-series model
  - Autoregressive(AR): 자신의 과거값을 변수로 하는 회귀분석(자기상관성)
  - Autoregressive-Integrated-Moving Average(ARIMA): 비정상적 시계열 자료 분석 방법, 과거 데이터 + 예측오차
  - Vector Error Correction Model(VECM): 다변량시계열 분석, 여러 데이터를 하나의 벡터로 묶어서 분석

Validation

Training Set: At least 5 yrs & Increased by 1 mth / Testing Set: 1 yr

- Compare Mean Absolute Percentage Error(MAPE) while increasing the size of training set
  →Examine whether the model is proper to predict the sudden change of market

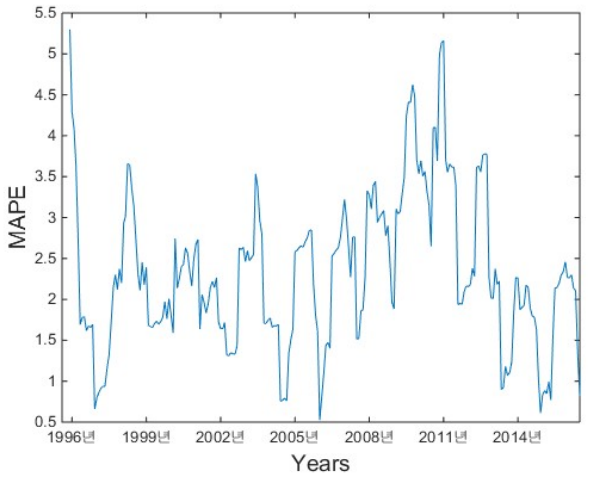
Training Set	1990 JAN – 1994 DEC
Testing Set	1995 JAN – 1995 DEC
Training Set	1990 JAN – 1995 JAN
Testing Set	1995 FEB – 1996 JAN
⋮	
Training Set	1990 JAN – 2015 AUG
Testing Set	2015 SEP – 2016 AUG

$MAPE_{(1)}$

$MAPE_{(2)}$

⋮

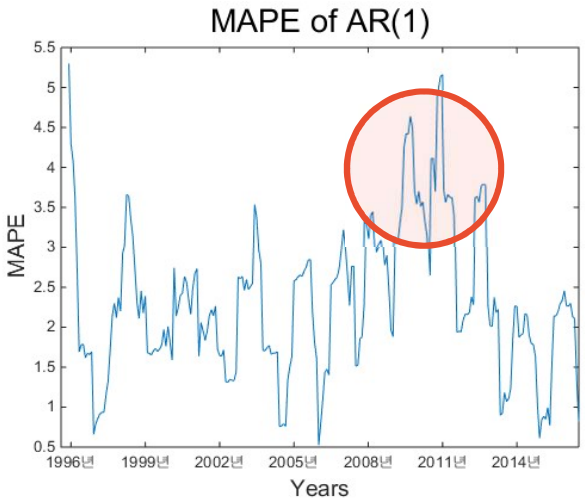
$MAPE_{(n)}$



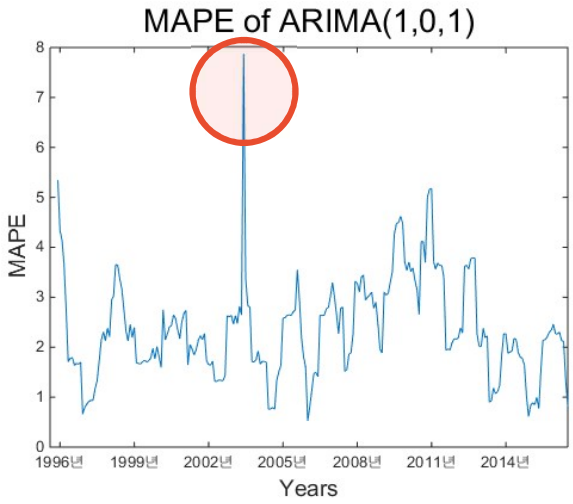
2.2 Preliminary Study (3/5)

Time-series Analysis (2/2)

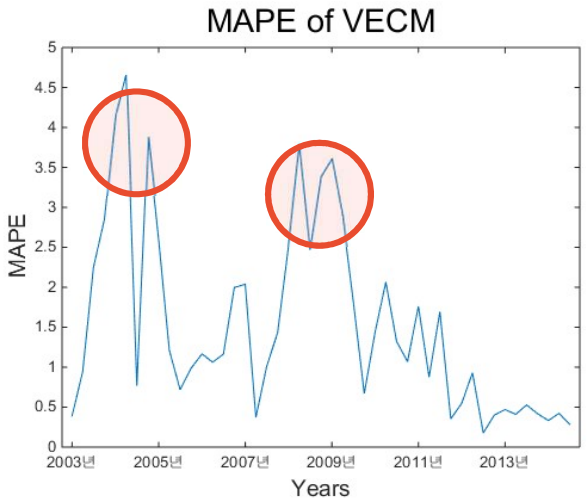
Results of Preliminary Study



Average: 2.33%



Average: 2.36%



Average: 1.54%

Conclusion

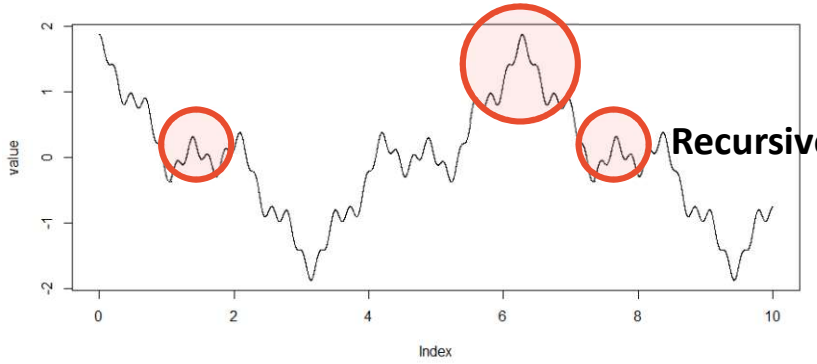
- The conventional time-series models are appropriate to prediction of **overall trend** (MAPE ≒ 2%)
- However, MAPE becomes large around 2004, 2006, 2008, when the **sudden change** occurred

2.2 Preliminary Study (5/5)

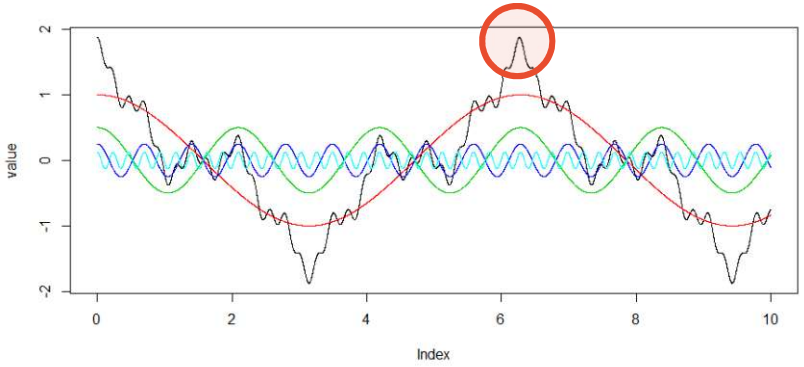
Fractal Analysis on Time-series

Estimation of cycles in time-series that derives fractal characteristics of the system

Self-similarity



Sudden Change



시계열은 여러 개의 작은 cycle로 구성됨
Cycle의 피크가 겹치는 부분에서 Sudden Change 발생

2.3 Model Development (1/2)

Rescaled Range(R/S) Analysis

Terminology

- Scale: The number of records in one segment (Non-overlapping)
- Rescaled Range: Fluctuation of range at certain scale

  "If scale changes, the average of range also changes → Rescaled range"

Logic (Peters 1994; Kumar and Manchanda 2009; Yin et al. 2013; Abdulhadi et al. 2015)

- Normalization → Cumulated Sum → Range → Rescaling

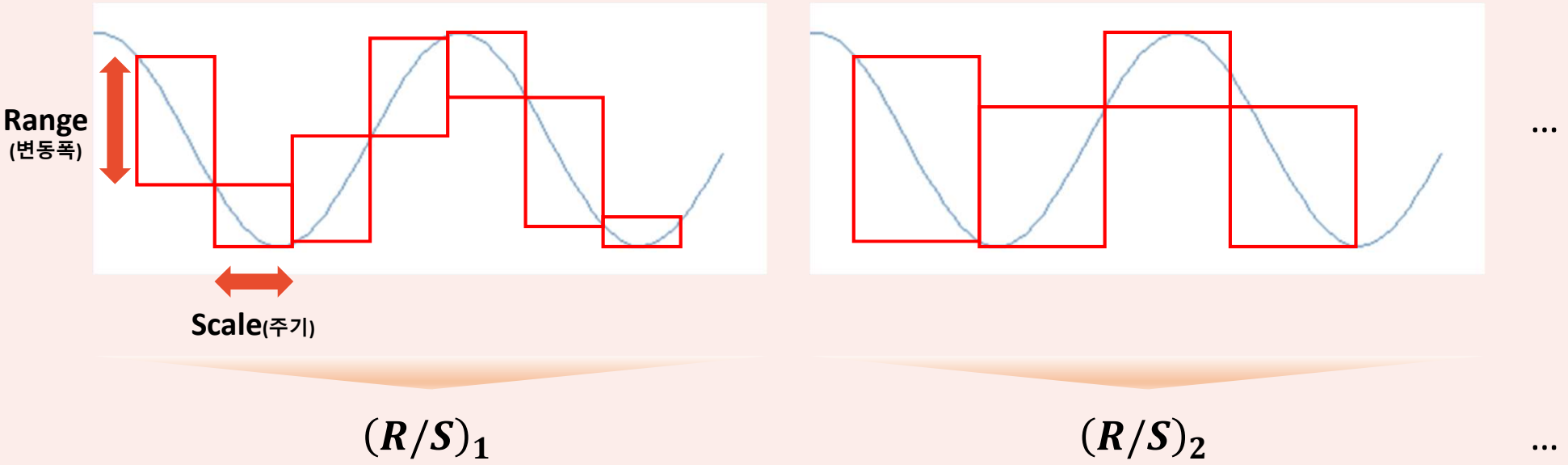
x = Differenced data

$$Z_r = x_r - \bar{x} \ (\mathrm{r} = 1, \dots, \mathrm{n})$$

$$Y_i = \sum_{r=1}^{i} Z_r \ (i = 1, \dots, n)$$

$$R_n = \max(Y_1, \dots, Y_n) - \min(Y_1, \dots, Y_n)$$

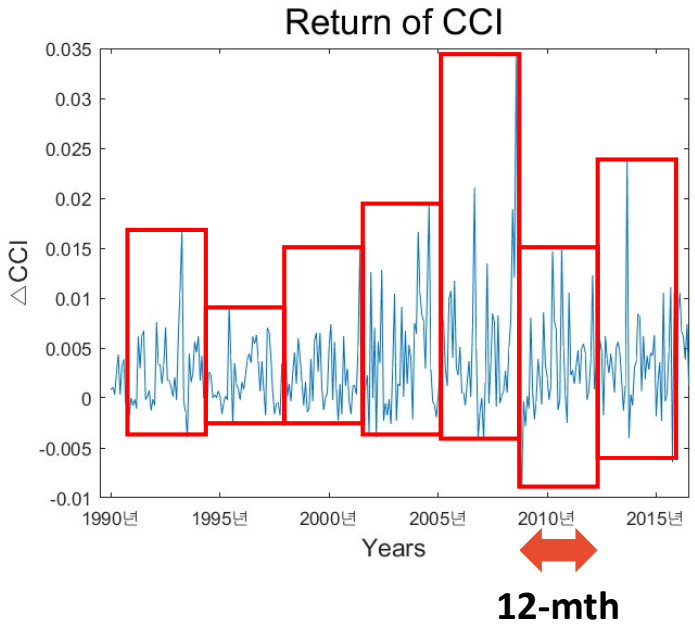
$$(R/S)_n = R_n/S_n$$



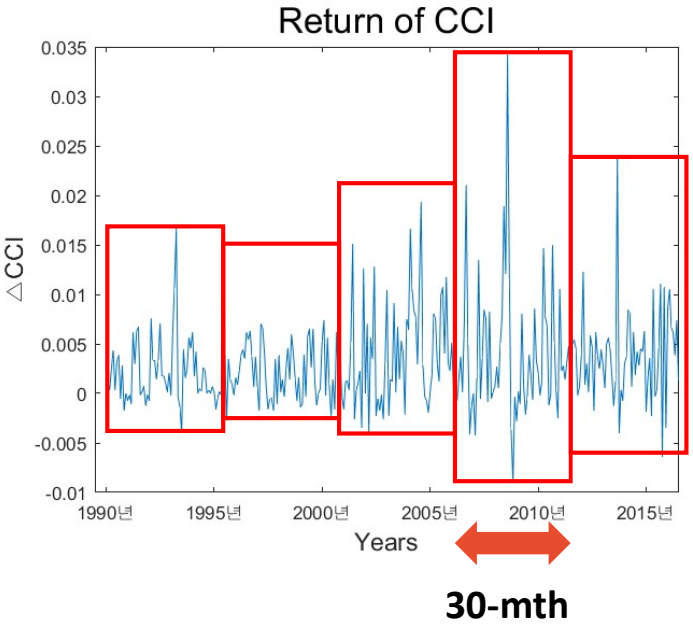
3.1 Result

Result of R/S Analysis

- 정상성을 찾아야 예측을 할 수 있음
- R/S 분석은 데이터를 Scale로 묶어, 비정상적 데이터를 max-min Range로 차분하여 정상성을 띄는 Scale을 찾아냄
- 12, 30, 75개월로 묶었을 때 각 박스끼리 평균과 분산이 일정한 정상성이 확인됨
- 이러한 스케일이 다양하다는 점이 자기유사성을 설명함



12-mth



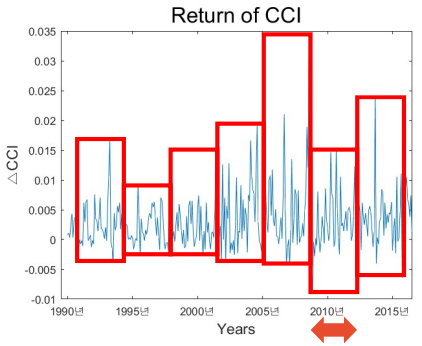
30-mth

2.3 Model Development (2/2)

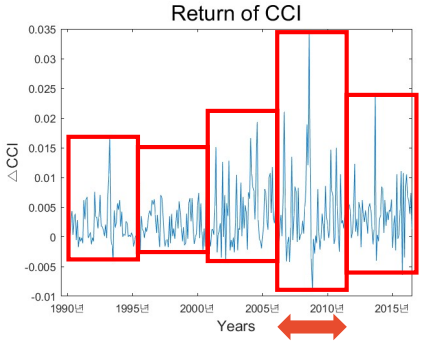
V Statistics (Peters 1994)

$$V_n = (R/S)_n/\sqrt{n}$$

Scale이 커질수록 V Statistics는 증가하나 정상성을 띄는 12, 30, 75개월에서는 일정기간 "정상성 " 을 띄기 때문에 진폭의 변화가 없음

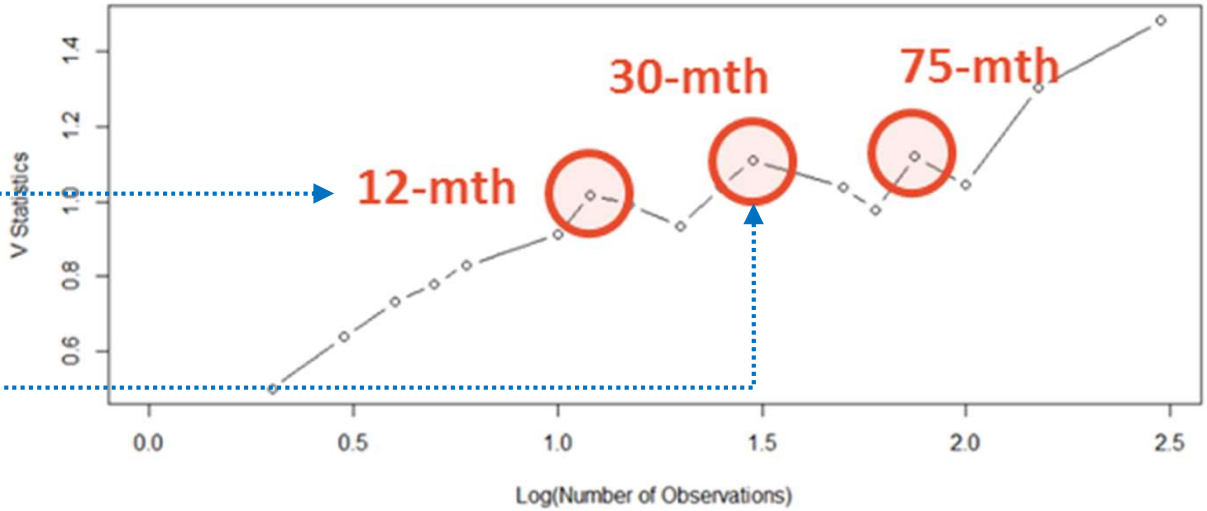


12-mth



30-mth

⋮



Number of Observation: Scale 내 데이터 수

3.2 Verification & Validation (1/2)

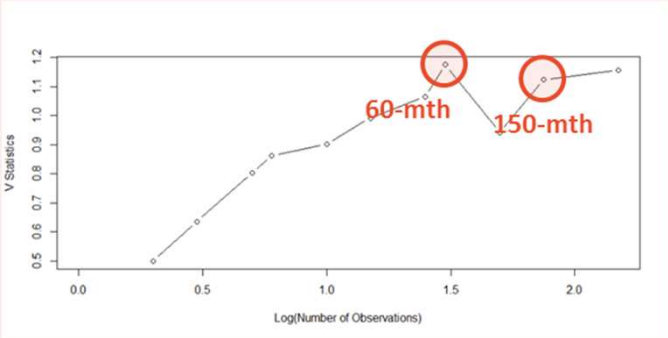
Verification with Other Time Lags

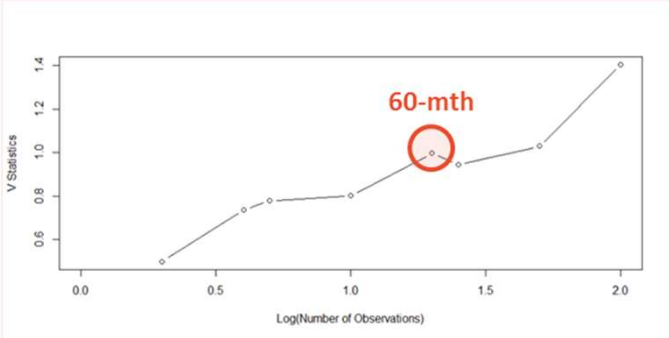
시계열데이터의 시차를 바꿔가며 같은 분석을 수행

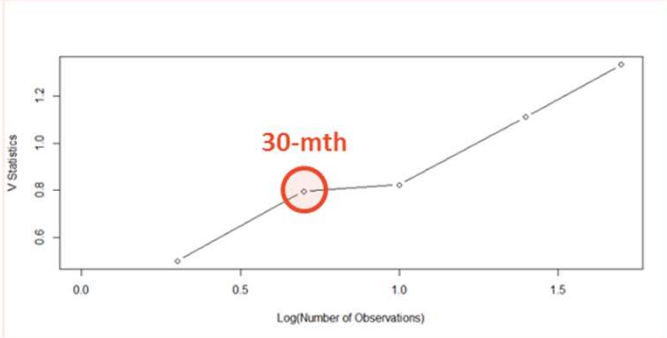
- Estimate the cycles of **CCI returns in different time lags** to verify the result of R/S Analysis

Result

Time Lag	Cycle Length	Derived From
2-mth	60-mth	Cycle of 30-mth
2-mth	150-mth	Cycle of 30, 75-mth
3-mth	60-mth	Cycle of 12, 30-mth
6-mth	30-mth	Cycle of 30-mth







3.2 Verification & Validation (2/2)

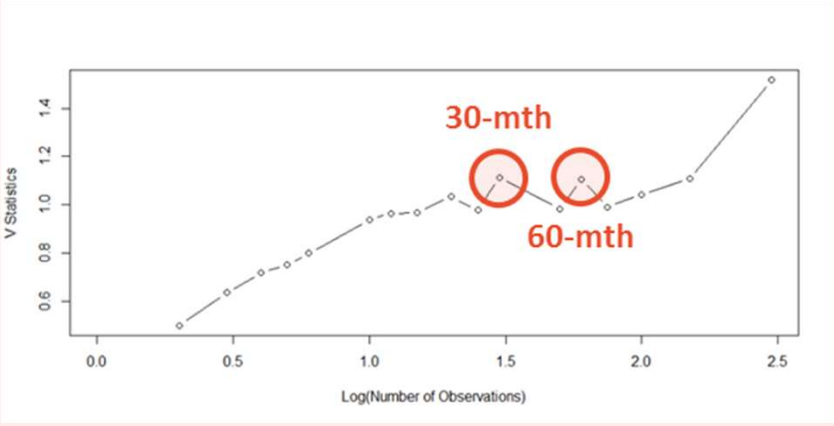
Validation with Other Market Factor – *1-mth Return of Crude Oil Price (COP)*

Concept

- Compare the result with other market factor (COP) that is **known for highly correlated with CCI**

Result

Time Lag	Cycle Length	Derived From
1-mth	30-mth	Cycle of 30-mth
1-mth	60-mth	Cycle of 30-mth

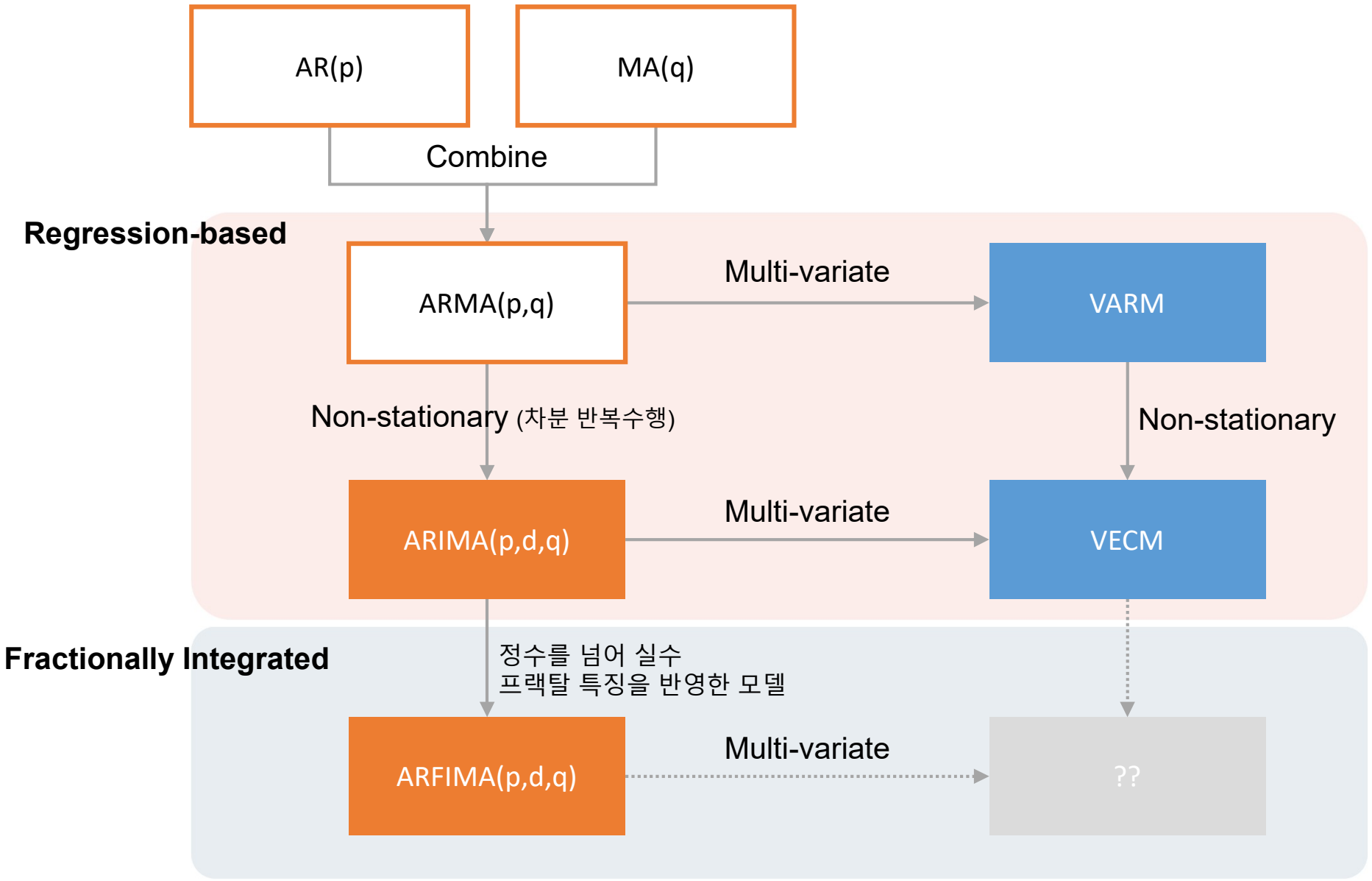


3.3 Summary & Contribution

Summary

- The number of **extreme failure** cases are continuously arising because of the **sudden change** in market
- Conventional approaches analyzing the market usually assume the existence of **trend of historical data**
  → Limited to predict a sudden change
- To overcome the limitations, this research introduced a **cycle estimation model** of the global construction market using Fractal analysis

Alternative Approach



ARFIMA (Fractionally Integrated)

Model Identification

- R/S Analysis → H>0 → ARFIMA!!
- Stability Test on H
  - Calculate H in different starting point of training set → Average

$$\left\{1-\sum_{i=1}^{p}\phi_i B^i\right\} * (1-B)^d * X_t = \{1+\sum_{j=1}^{q}\theta_j B^j\} * \varepsilon_t$$

H: Hurst Exponent
n값에 따른 (R/S)n값을 그래프로 그렸을 때 기울기

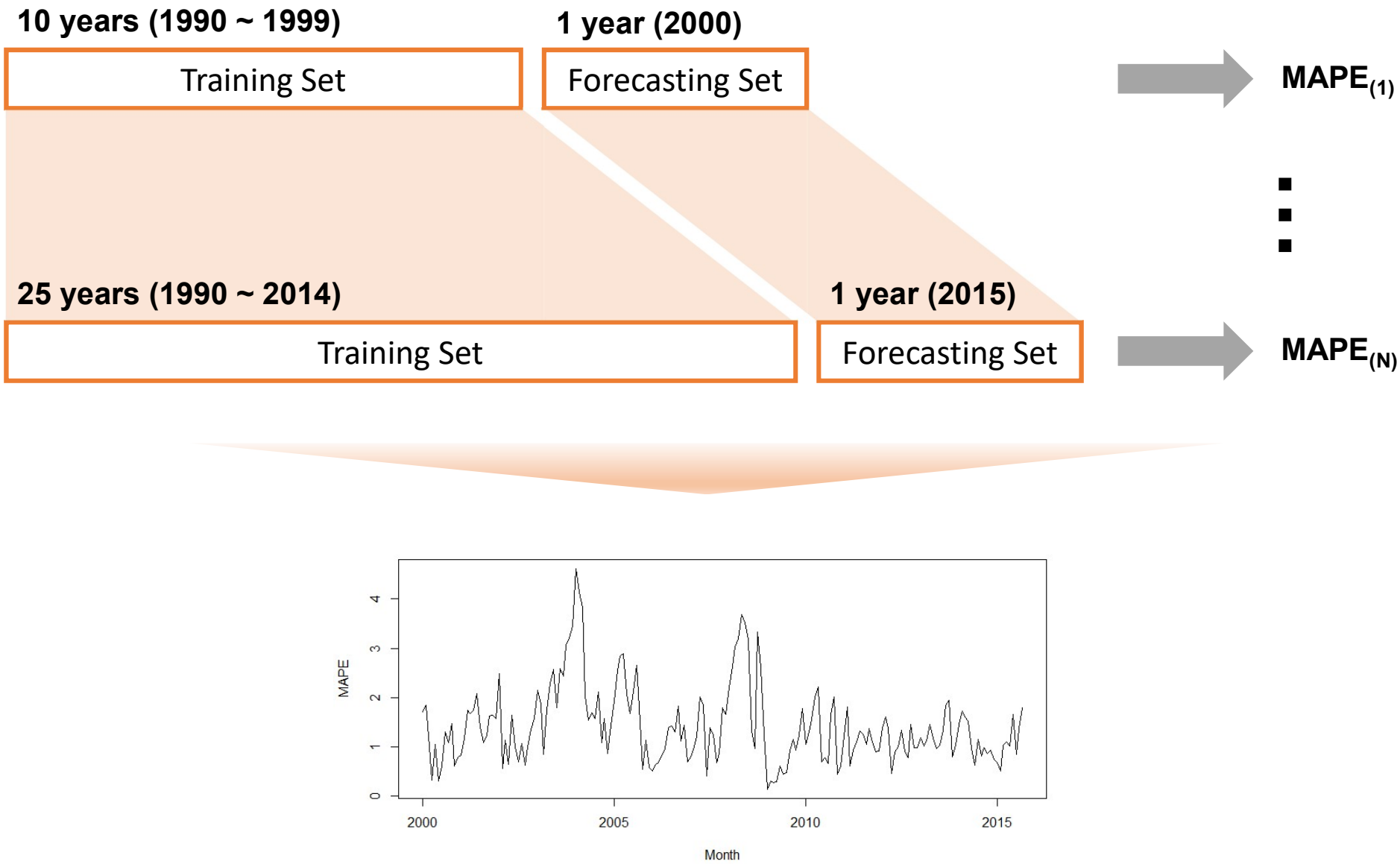
H가 양수이면(scale에 따라 range가 계속 커진다면) 데이터가 프랙탈의 특성을 가진다고 봄

즉, H>0 → 프랙탈 특성 존재 → ARFIMA 예측
아니면 ARIMA 예측

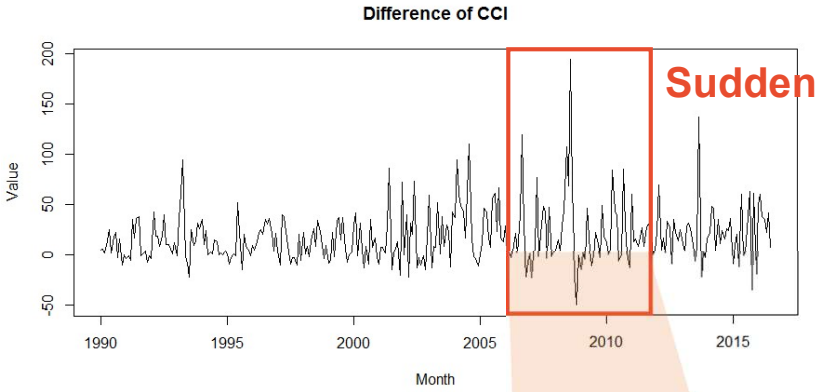
Model Estimation

- AR order (p) & MA order (q) – Same with ARIMA
- Hurst Exponent → Fractional Order (d)
  - d is a real number (doesn't have to be an integer)

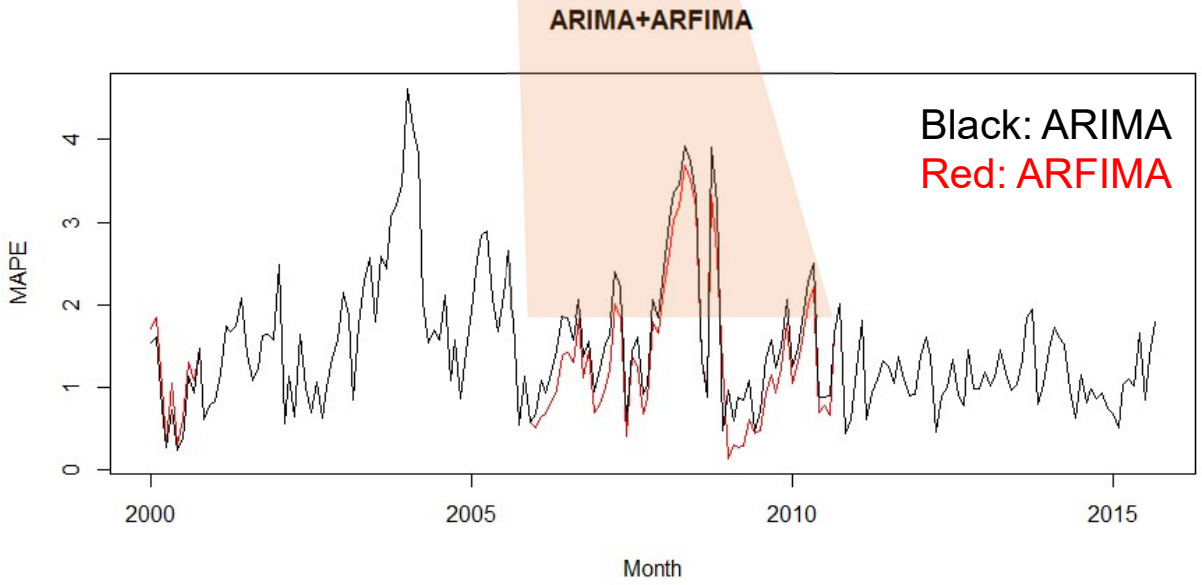
Validation Idea



Results



Sudden Change (2006.01 ~ 2010.08)



Forecasting Ahead = 12 months (1 year)

	MAPE @Total	MAPE @Sudden Change
ARIMA	1.49	**1.67**
ARIMA+ARFIMA	1.42	**1.38**

Results – Different Forecasting Ahead (1/2)

Forecasting Ahead (mth)	MAPE @Total (ARIMA)	MAPE @Total (ARIMA+ARFIMA)	MAPE @Sudden Change (ARIMA)	MAPE @Sudden Change (ARFIMA)
1	0.31	0.31	0.33	0.32
2	0.41	0.41	0.46	0.44
3	0.52	0.51	0.59	0.55
4	0.63	0.61	0.71	0.66
5	0.74	0.72	0.82	0.75
6	0.85	0.82	0.93	0.84
7	0.95	0.91	1.03	0.92
8	1.05	1.01	1.13	1.00
9	1.16	1.11	1.23	1.08
10	1.27	1.21	1.34	1.17
11	1.38	1.31	1.45	1.25
12	1.49	1.42	1.55	1.33
13	1.61	1.52	1.66	1.42
14	1.72	1.63	1.77	1.50
15	1.85	1.75	1.88	1.59
16	1.96	1.85	1.99	1.68
17	2.09	1.97	2.10	1.77
18	2.21	2.08	2.22	1.86

* Sudden Change: JAN 2006 ~ AUG 2010

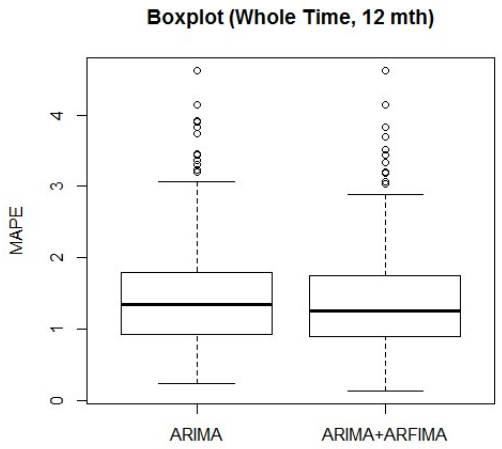
Results – Different Forecasting Ahead (2/2)

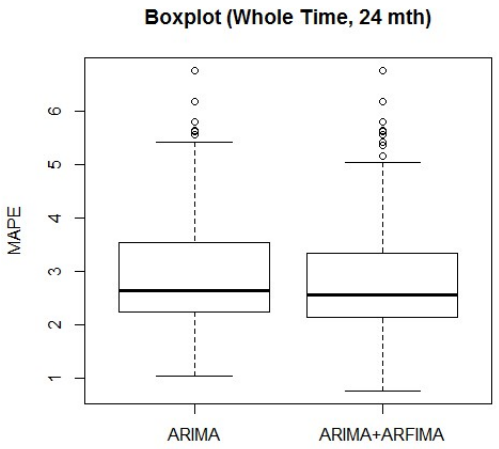
Forecasting Ahead (mth)	MAPE @Total (ARIMA)	MAPE @Total (ARIMA+ARFIMA)	MAPE @Sudden Change (ARIMA)	MAPE @Sudden Change (ARFIMA)
19	2.33	2.20	2.33	1.95
20	2.46	2.31	2.44	2.04
21	2.59	2.43	2.55	2.13
22	2.71	2.55	2.67	2.22
23	2.84	2.67	2.78	2.31
24	2.97	2.78	2.90	2.40
25	3.09	2.90	3.01	2.49
26	3.22	3.02	3.12	2.58
27	3.35	3.14	3.24	2.67
28	3.48	3.26	3.35	2.76
29	3.61	3.38	3.46	2.85
30	3.74	3.50	3.58	2.94
31	3.86	3.61	3.69	3.04
32	3.99	3.73	3.80	3.13
33	4.12	3.85	3.92	3.22
34	4.25	3.97	4.03	3.30
35	4.39	4.09	4.14	3.39
36	4.51	4.21	4.24	3.48

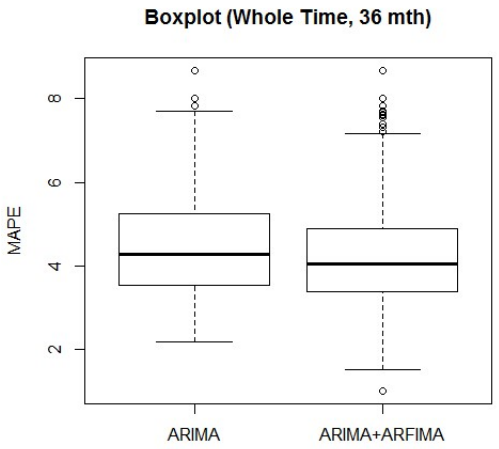
* Sudden Change: JAN 2006 ~ AUG 2010

Box Plot (Forecasting Ahead = 1,2,3 year)

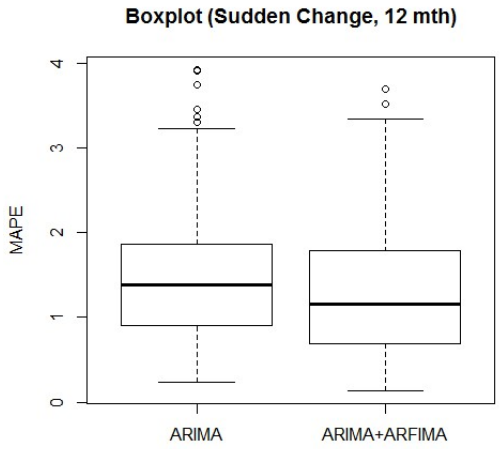
Box Plot (Whole Time)

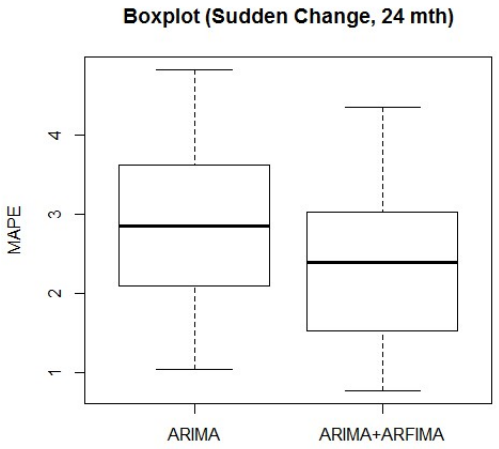


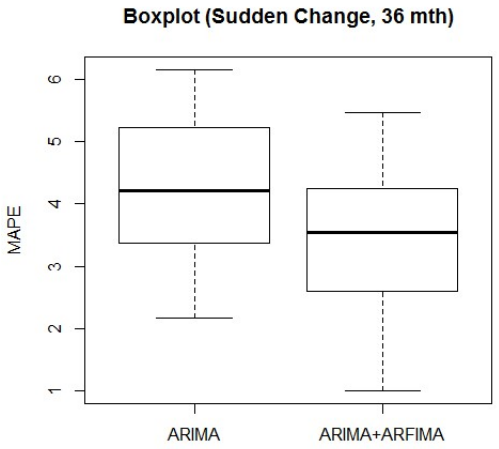




Box Plot (Sudden Change)

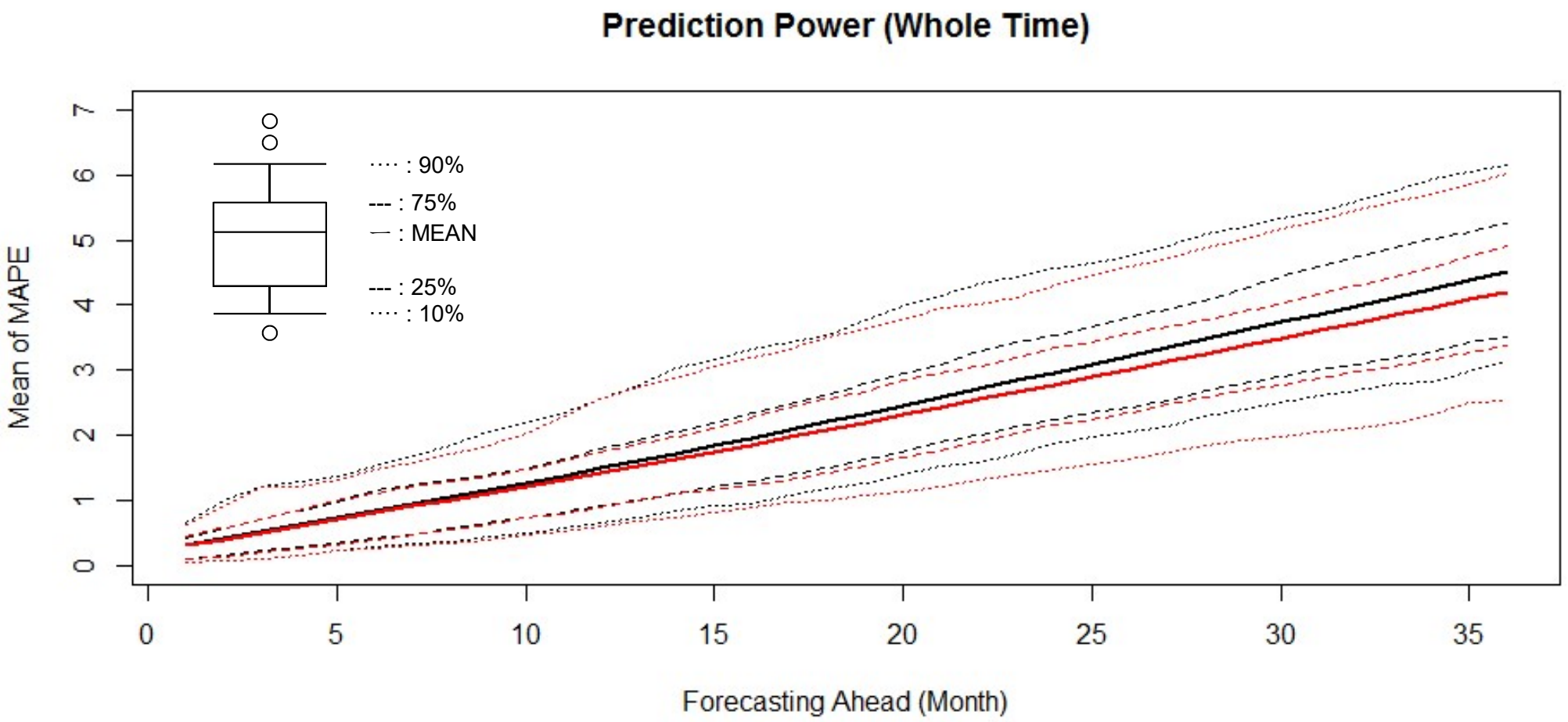




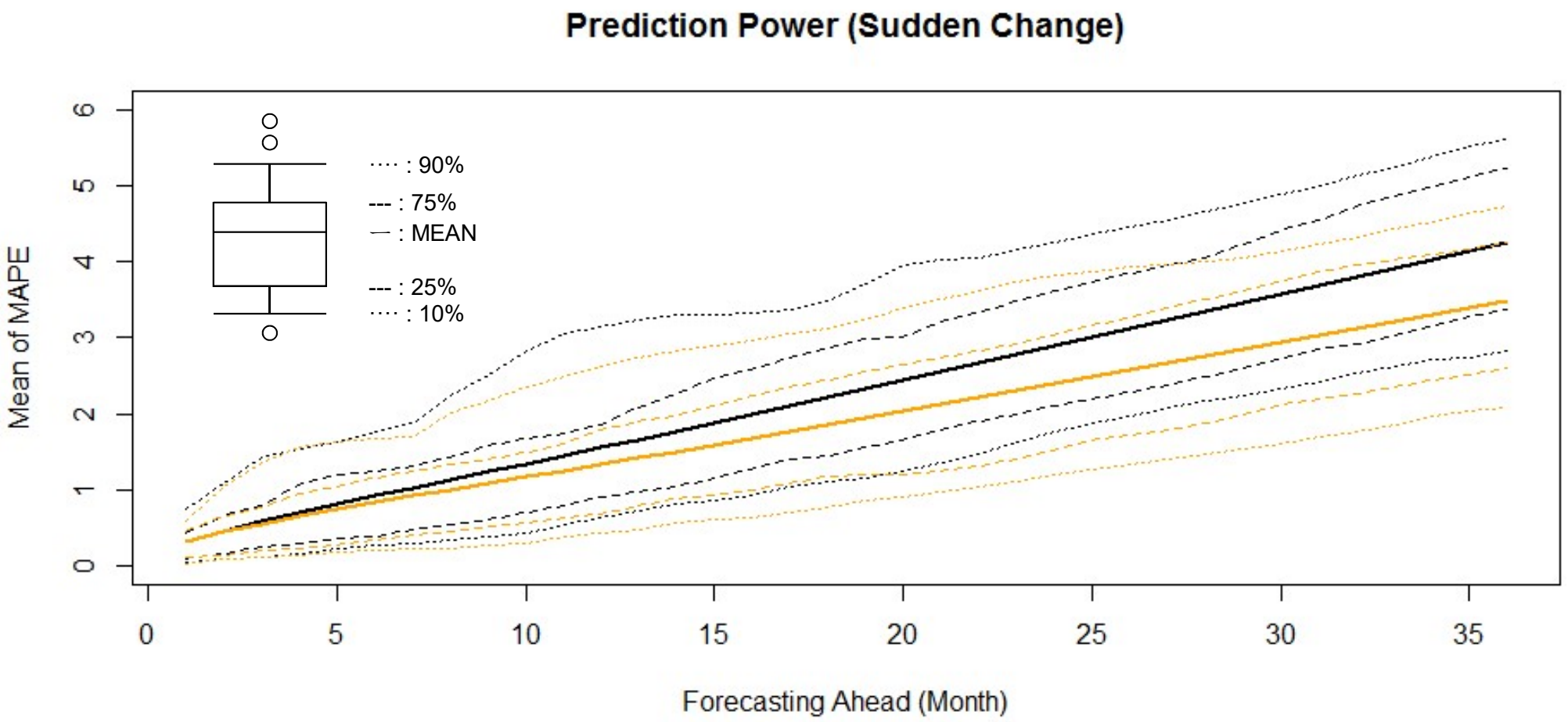


* Sudden Change: JAN 2006 ~ AUG 2010

Box Plot – Continuously (Whole Time)



Box Plot – Continuously (Sudden Change)



* Sudden Change: JAN 2006 ~ AUG 2010

PART III

Risk Communication

Communication

The single biggest problem with communication is the illusion that it has been taken place. (의사소통의 단 하나, 가장 큰 문제는 서로 의사소통이 잘 되었다고 착각하는 것이다)

George Bernard Shaw

- Communication (from Latin commūnicāre, meaning "to share") is the act of conveying intended meanings from one entity or group to another through the use of mutually understood signs and semiotic rules

- Imperfect science, reliant on a common appreciation of the meaning, implication and tone of language being used.

Bulgin, A. (2011). *Risk Communication in the 21st Century Extended Enterprise*.

Types of Communication

- Non-verbal
- Verbal
- Written communication
- Business
- Political
- Family
- Interpersonal

Bulgin, A. (2011). *Risk Communication in the 21st Century Extended Enterprise*.

What is Risk Communication?

- **Risk Communication**
  - Risk communication is an essential sub-set of any corporate communication policy.
  - Exchange or sharing of information about risk (UK Risk Mgmt. Standard, AIRMIC, 2002)
  - Continual and iterative processes that an organization conducts to provide, share or obtain information, and to engage in dialogue with stakeholders regarding the management of risk (ISO 31000 Risk Mgmt. Standard, 2009)
  - An interactive process of exchange of information and opinion on risk among risk assessors, risk managers and other interested parties (WHO)

Bulgin, A. (2011). *Risk Communication in the 21st Century Extended Enterprise*.

Importance of Risk Communication

- As enterprises have become more complex and diverse, the ability to ensure common linguistic understanding and interpretation has become increasingly difficult to achieve.
- The need for clarity of communication has become ever more paramount; without it, there is unlikely to be uniform purpose, shared systemic beliefs and ethics, or a means to achieve assurance for all stakeholders.
- The world is now swamped with information from both official and unofficial channels. This has made people both cynical and desensitized.

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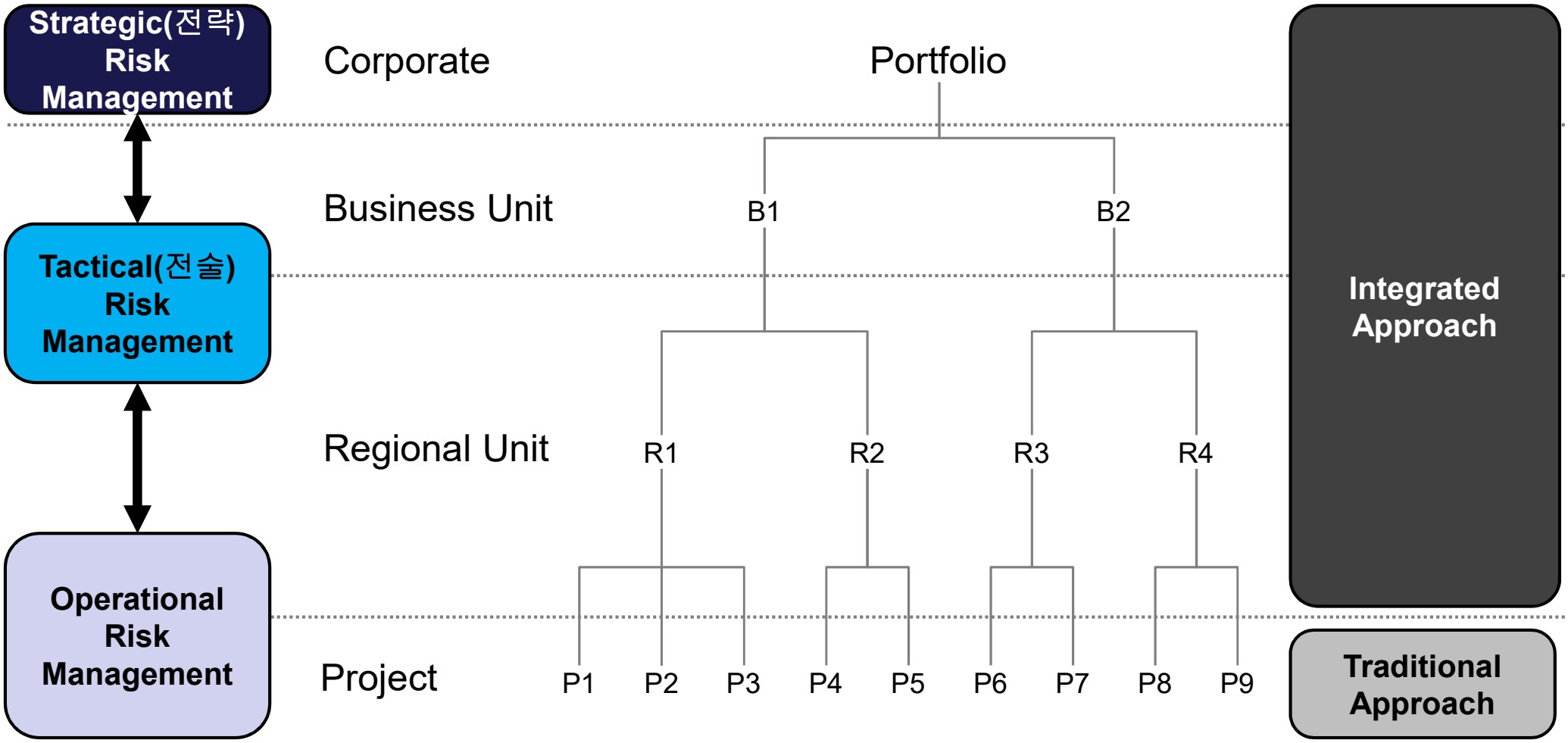
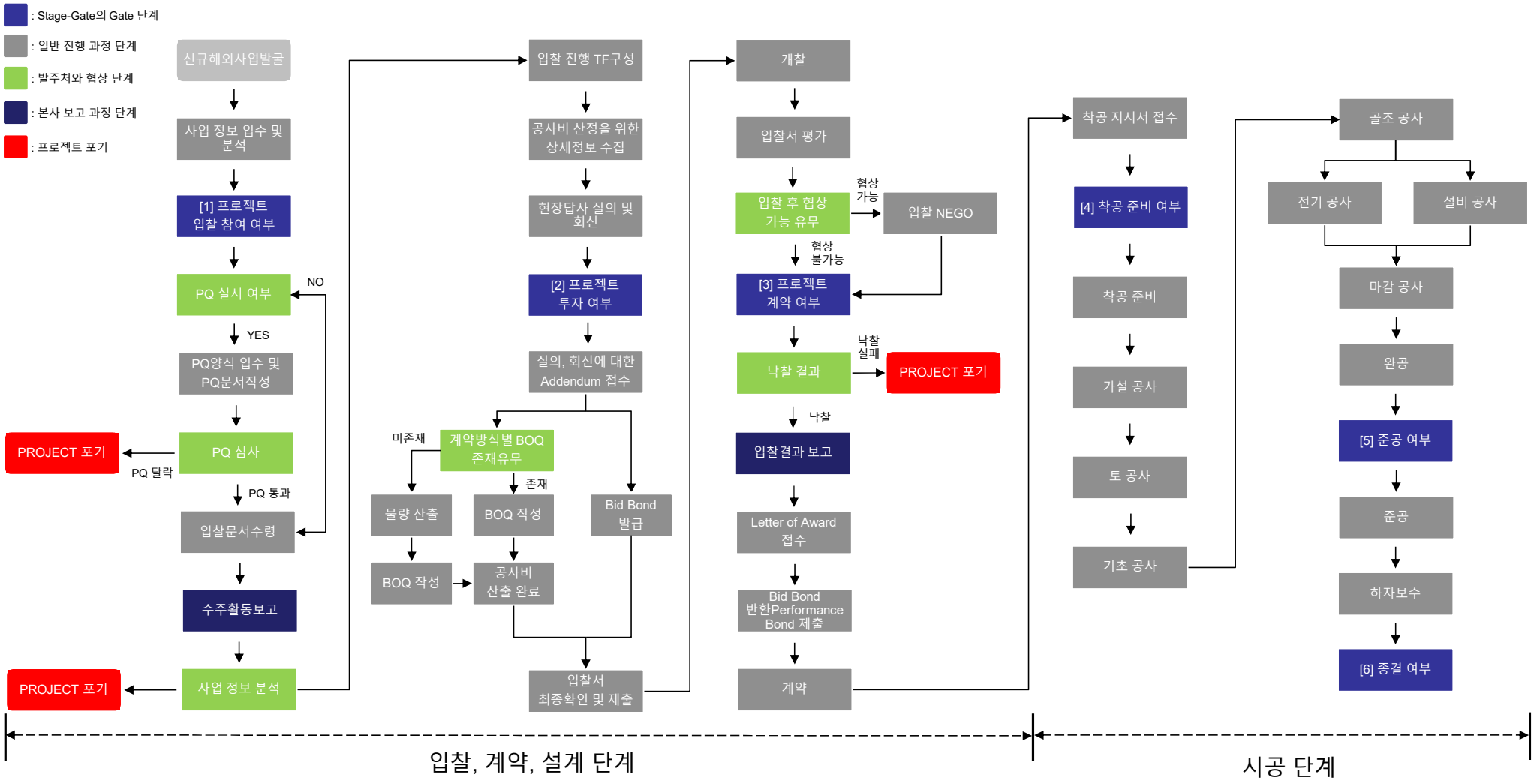
Importance of Risk Communication

Level of Risk Management

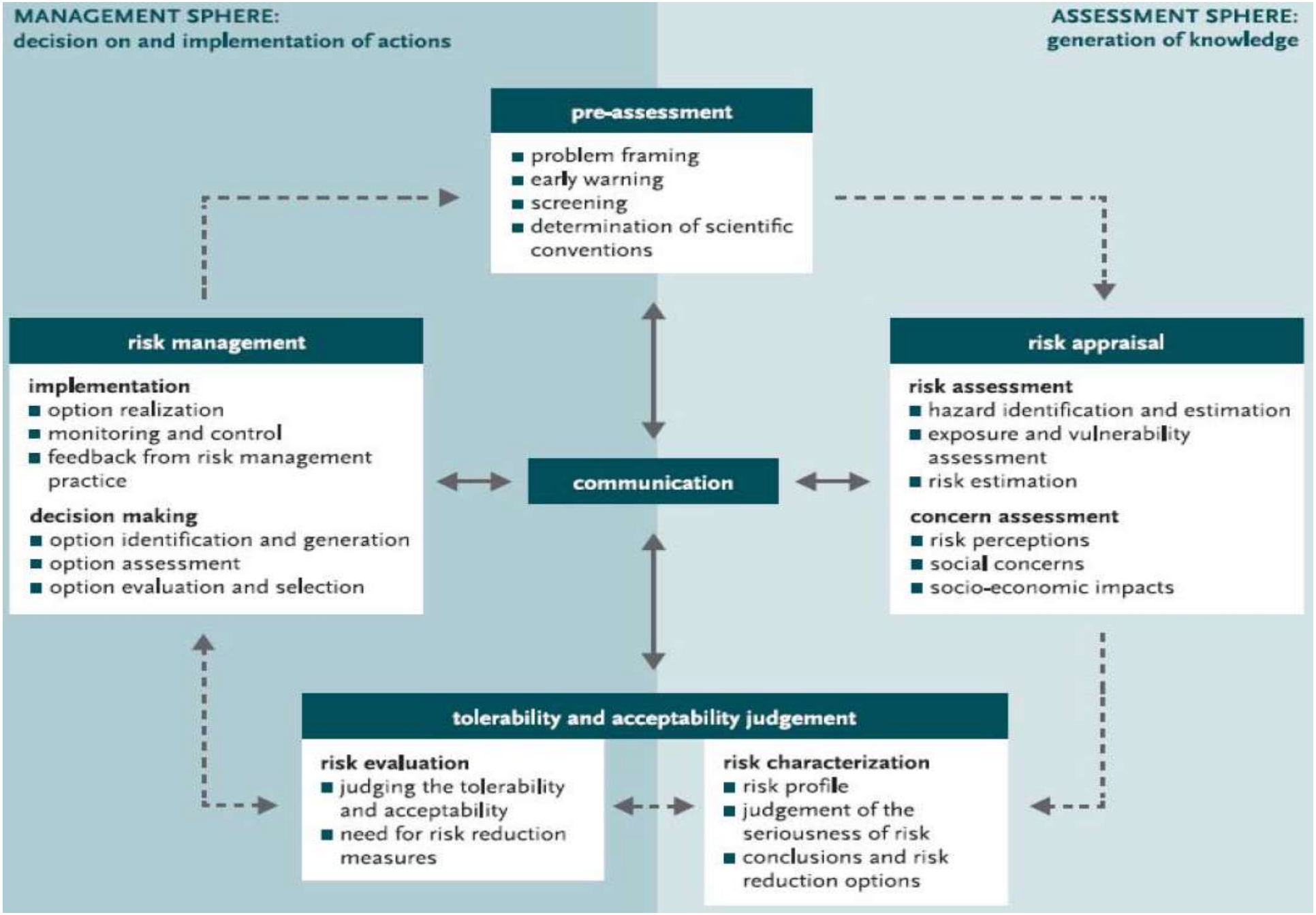


OO건설 해외 사업 Process Diagram



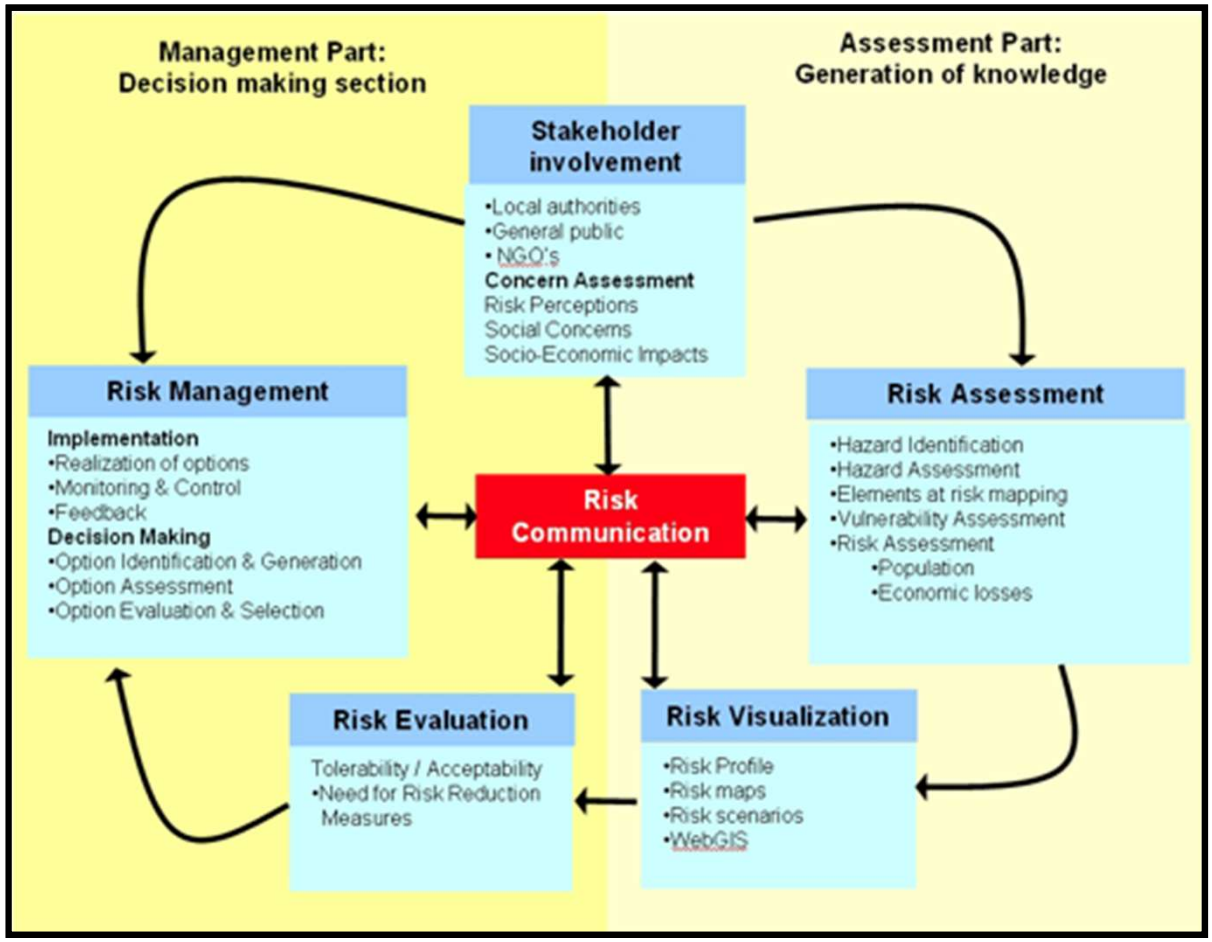
Basic elements of the risk governance framework

(Renn, 2008)



Risk Governance Framework

- The aim of Risk governance is to involve the various stakeholders within all aspects of risk management.
- Risk communication is central.



Source: The International Risk Governance Council Risk Governance Framework (IRGC) 2006

Risk Governance Framework

- A **stakeholder** is any individual or group:
  - with an interest in the success or failure of an organization/ project/ endeavor in delivering intended results.
  - affected by the outcome of the project.
  - might be called on to provide input, feedback, or authorization for the use case.
- **Beneficiary**: a stakeholder with an interest in the positive outcome of the project without actively participating

Risk Governance Framework

- **Risk information consumers (RC)**: refers to governmental and non-governmental institutions (national, regional, local) as well as to communities and individuals, who may require “information on risk” as an input to carry out their specific tasks.

- **Risk information providers (RP)**: governmental and non-governmental institutions (national, regional, local), who are requested to provide the required data inputs to carry through the decision making process concerning risk assessment (the technical aspects); this includes providers of basic data as well as providers of information on risk.

Risk Governance Framework

Stakeholder	Role	Explanation
Local Communities	RC	Local communities are supposed to be direct beneficiaries of risk management policies. They could be regarded as "information consumers" when they make use of participatory mechanisms to take part in the decision making process, and therefore would require to be informed about the topics under discussion (defining insurance policies, land use management plans, etc.) Communities can also take part in the risk assessment process as "information providers", especially when considering issues related to vulnerability assessment (risk perception, etc.)
Local authorities	RC	Local authorities are mostly using risk information for local decision making. They normally do not have the capacity to generate risk information on their own.
Governmental organizations - sectors	RC RP	Ministries use risk information in their planning processes, they main role is as "information consumers". However, in many cases, the different sectors make use of their own technical resources to produce risk assessment studies; in this case they are also "providers" of information.
National basic data producers	RP	For instance national bureau of statistics, topographic surveys. Though they produce "general purpose" information, they are relevant for the risk assessment process.
National thematic organizations	RP	For instance: meteorological, seismological, geological that, generally, should be considered and "information producers"
Disaster management organization	RP RC	A disaster management organization is both generating risk information, and is also using this information for early warning, preparedness planning and disaster prevention.
Private sector	RP RC	Consultants can be important source for specific data for hazard, vulnerability and risk assessment. A special case is also the insurance industry, which can be a RP as RC at the same time. Sometimes the entire process of hazard, vulnerability and risk assessment is done entirely by a consulting company. The private sector as a whole is also RC as beneficiary of disaster risk reduction
NGO	RC RP	NGO's often are actively involved in collecting relevant hazard and vulnerability data at community level. They can also be RC
Universities	RP	Universities can be active in generating hazard and risk information. They can sometimes have the main role in this process
International organizations	RP RC	International organization can bring in additional support for generating hazard and risk information (e.g. World Bank) They also require risk information for making sound investments.

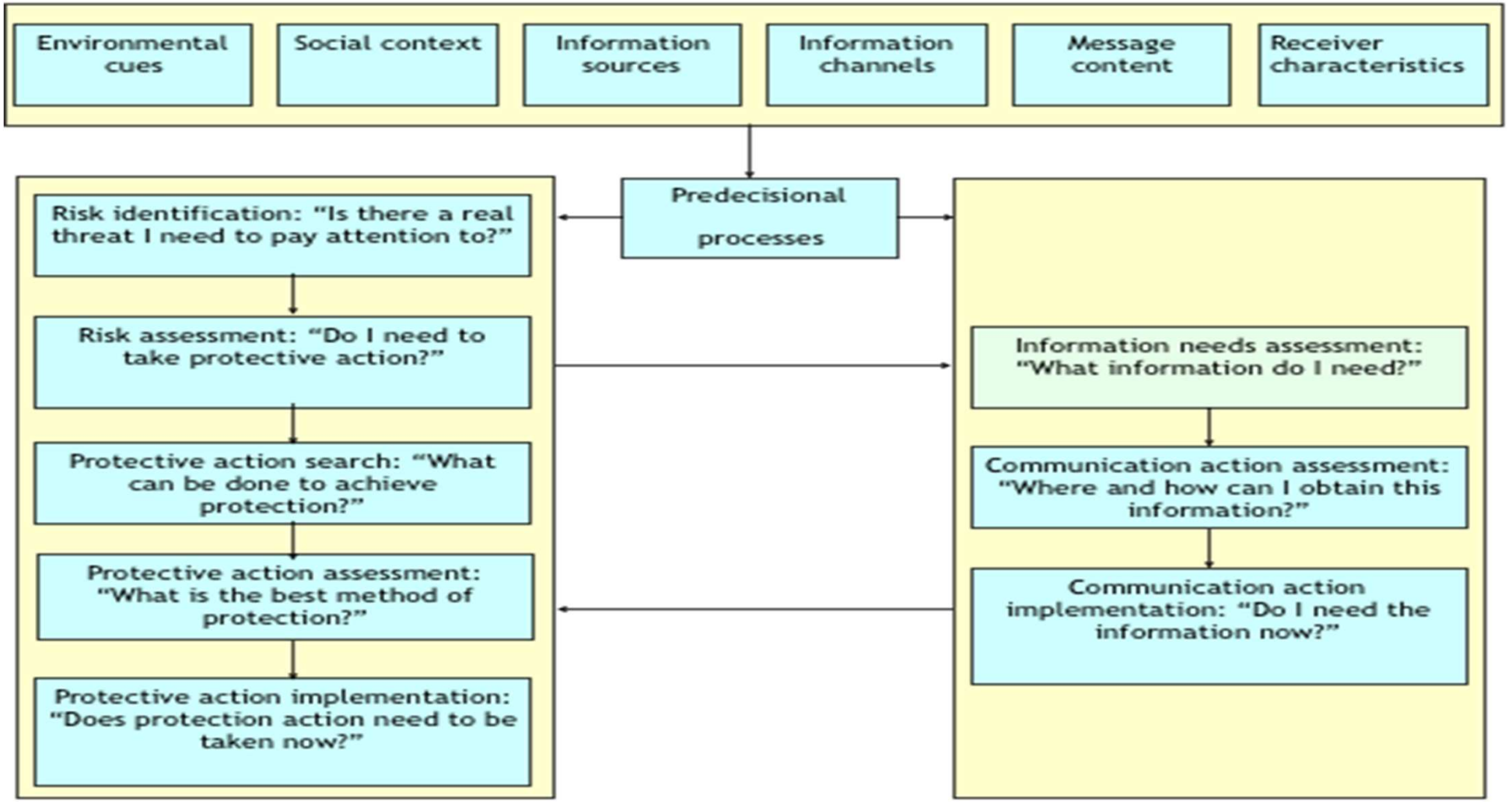
Risk Governance Framework

Risk Communication

- Risk communication is the interactive exchange of information about risks among risk assessors, managers, news media, interested groups and the general public.
  - who (Source)
  - says what (Message)
  - via what medium (Channel)
  - to whom (Receiver)
  - and directed at what kind of change (Effect)

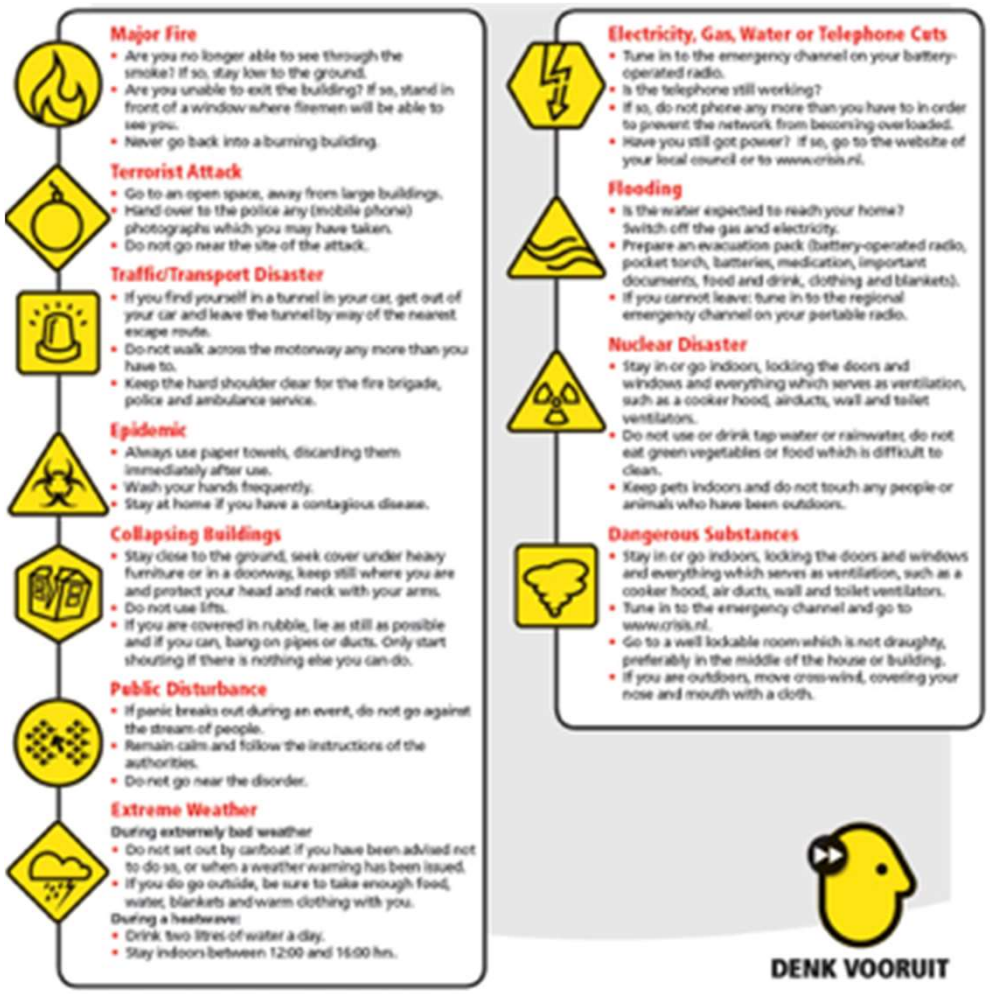
Risk Governance Framework

Risk Communication



Risk Governance Framework

Risk Communication



Major Fire
- Are you no longer able to see through the smoke? If so, stay low to the ground.
- Are you unable to exit the building? If so, stand in front of a window where firemen will be able to see you.
- Never go back into a burning building.

Terrorist Attack
- Go to an open space, away from large buildings.
- Hand over to the police any (mobile phone) photographs which you may have taken.
- Do not go near the site of the attack.

Traffic/Transport Disaster
- If you find yourself in a tunnel in your car, get out of your car and leave the tunnel by way of the nearest escape route.
- Do not walk across the motorway any more than you have to.
- Keep the hard shoulder clear for the fire brigade, police and ambulance service.

Epidemic
- Always use paper towels, discarding them immediately after use.
- Wash your hands frequently.
- Stay at home if you have a contagious disease.

Collapsing Buildings
- Stay close to the ground, seek cover under heavy furniture or in a doorway, keep still where you are and protect your head and neck with your arms.
- Do not use lifts.
- If you are covered in rubble, lie as still as possible and if you can, bang on pipes or ducts. Only start shouting if there is nothing else you can do.

Public Disturbance
- If panic breaks out during an event, do not go against the stream of people.
- Remain calm and follow the instructions of the authorities.
- Do not go near the disorder.

Extreme Weather

During extremely bad weather
- Do not set out by canboat if you have been advised not to do so, or when a weather warning has been issued.
- If you do go outside, be sure to take enough food, water, blankets and warm clothing with you.

During a heatwave:
- Drink two litres of water a day.
- Stay indoors between 12:00 and 16:00 hrs.

Electricity, Gas, Water or Telephone Cuts
- Tune in to the emergency channel on your battery-operated radio.
- Is the telephone still working?
- If so, do not phone any more than you have to in order to prevent the network from becoming overloaded.
- Have you still got power? If so, go to the website of your local council or to www.crisis.nl.

Flooding
- Is the water expected to reach your home? Switch off the gas and electricity.
- Prepare an evacuation pack (battery-operated radio, pocket torch, batteries, medication, important documents, food and drink, clothing and blankets).
- If you cannot leave: tune in to the regional emergency channel on your portable radio.

Nuclear Disaster
- Stay in or go indoors, locking the doors and windows and everything which serves as ventilation, such as a cooker hood, airducts, wall and toilet ventilators.
- Do not use or drink tap water or rainwater, do not eat green vegetables or food which is difficult to clean.
- Keep pets indoors and do not touch any people or animals who have been outdoors.

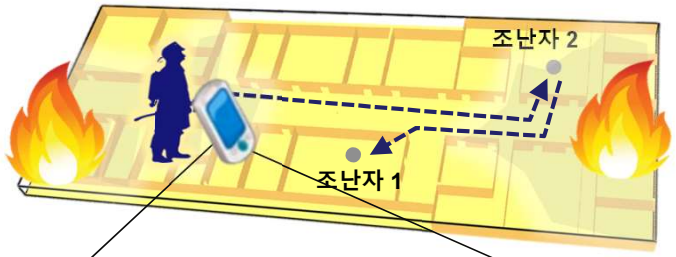
Dangerous Substances
- Stay in or go indoors, locking the doors and windows and everything which serves as ventilation, such as a cooker hood, air ducts, wall and toilet ventilators.
- Tune in to the emergency channel and go to www.crisis.nl.
- Go to a well lockable room which is not draughty, preferably in the middle of the house or building.
- If you are outdoors, move cross-wind, covering your nose and mouth with a cloth.

DENK VOORUIT

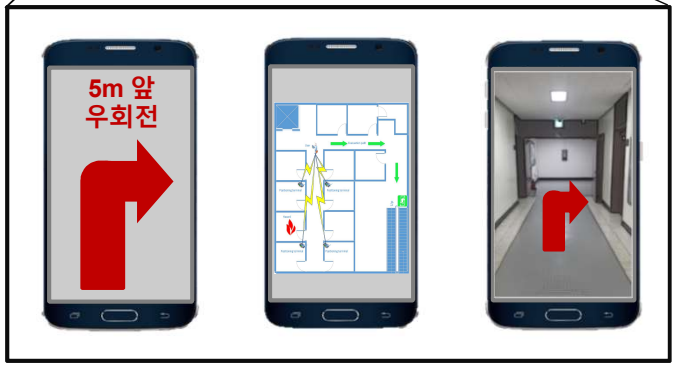
Risk Governance Framework

Risk Communication

구조대원의 최적 구조 경로 결정



효율적 구조/대피 경로 안내



Factors affecting Risk Communication

1. Risk Language

- Despite many attempts to define risk terminology, there is no universally recognized lexicon of risk either within or outside of the risk management profession.

- Misunderstanding can arise at the most fundamental level.

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Factors affecting Risk Communication

1. Risk Language

CATEGORY	NA	Likelihood of Occurrence (L) Very Low → Very High					Relative Impact (I) Negligible → Extreme					Baseline	Coordinate L, I	Comments
		1	2	3	4	5	A	B	C	D	E			
II.A BUSINESS PLAN														
II.A.1 Business case												E		
II.A.2 Economic model/ feasibility												D		
II.A.3 Economic incentives/ barriers												E		
II.A.4 Market/product												D		
II.A.5 Standards and practices												D		
II.A.6 Operations												D		
II.A.7 Tax and tariff												D		

Legend

Likelihood of Occurrence

NA = Not applicable to this project
1 = Very low probability and occurs in only exceptional circumstances (<10% chance)
2 = Low chance and unlikely to occur in most circumstances (10% chance <35%)
3 = Medium chance and will occur in most circumstances (35% chance <65%)
4 = High chance and will probably occur in most circumstances (65% chance <90%)
5 = Very high chance and almost certain and expected to occur (90% or greater chance of occurrence)

Relative Impact

A = Negligible and routine procedures sufficient to deal with the consequences
B = Minor and would threaten an element of the function
C = Moderate and would necessitate significant adjustment to the overall function
D = Significant and would threaten goals and objectives; requires close management
E = Extreme and would stop achievement of functional goals and objectives

CII (2003). *IPRA*

Factors affecting Risk Communication

1. Risk Language

[Survey by DSMC (1983)]

- Need for common language in uncertain (risky) situations
- 23 military experts interpreting various phrases
- How to reduce error and inconsistency in elicit uncertain information?

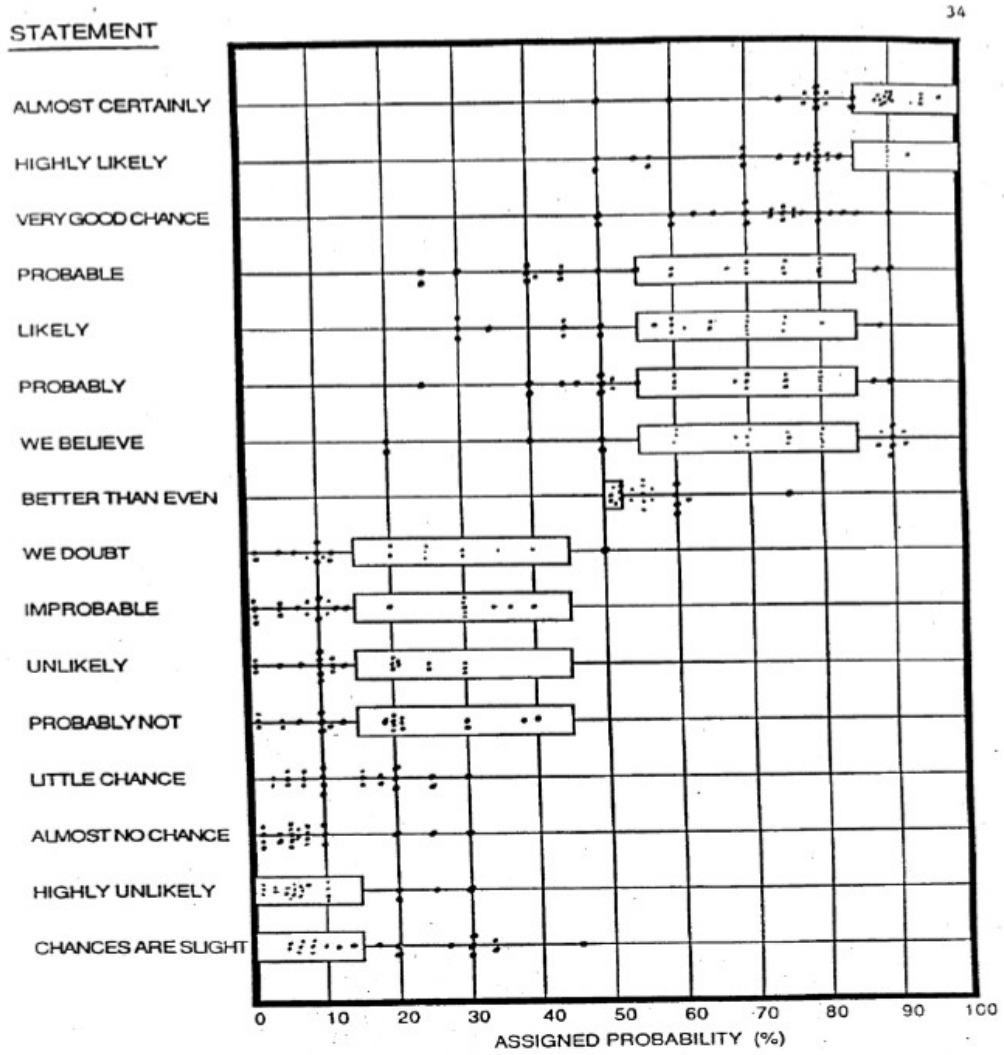
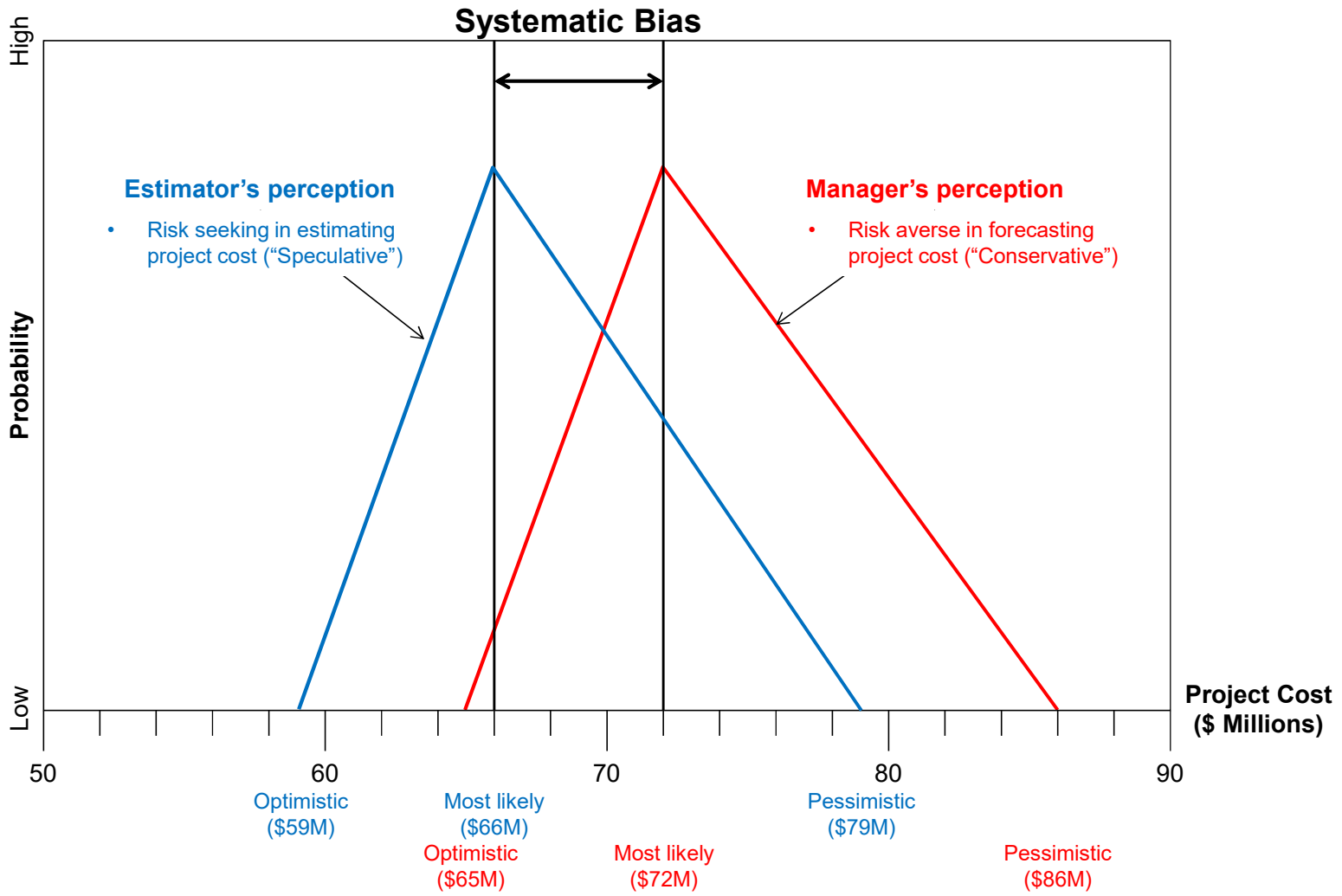


Figure III-IV: What Uncertainty Statements Mean To Different Readers
After Defense Systems Management College [1983]

* Defense Systems Management College (1983). “Risk Assessment Techniques, A Handbook for Program Management Personnel," Defense Systems Management College (Fort Belvoir), July.

Factors affecting Risk Communication

2. Risk Perception



Mak, S. and J. Raftery (1992). "Risk attitude and systematic bias in estimating and forecasting." *Construction Management & Economics*, 10(4): 303-320.

Barriers to Communication Effectiveness

- **Physical barriers**: Physical barriers are often due to the nature of the environment.
- **System design**: System design faults refer to problems with the structures or systems in place in an organization. Examples might include an organizational structure which is unclear and therefore makes it confusing to know whom to communicate with.
- **Attitudinal barriers**: Attitudinal barriers come about as a result of problems with staff in an organization.

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Barriers to Communication Effectiveness

- **Ambiguity of words/phrases**: Words sounding the same but having different meaning can convey a different meaning altogether.
- **Individual linguistic ability**: The use of jargon, difficult or inappropriate words in communication can prevent the recipients from understanding the message.
- **Physiological barriers**: These may result from individuals' personal discomfort, caused—for example—by ill health, poor eyesight or hearing difficulties.
- **Bypassing**: These happens when the communicators (sender and the receiver) do not attach the same symbolic meanings to their words.

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Barriers to Communication Effectiveness

- **Technological multi-tasking and absorbency**: With a rapid increase in technologically-driven communication in the past several decades, individuals are increasingly faced with condensed communication in the form of e-mail, text, and social updates.
- **Fear of being criticized**
- **Gender barriers**
- **Cultural distance**

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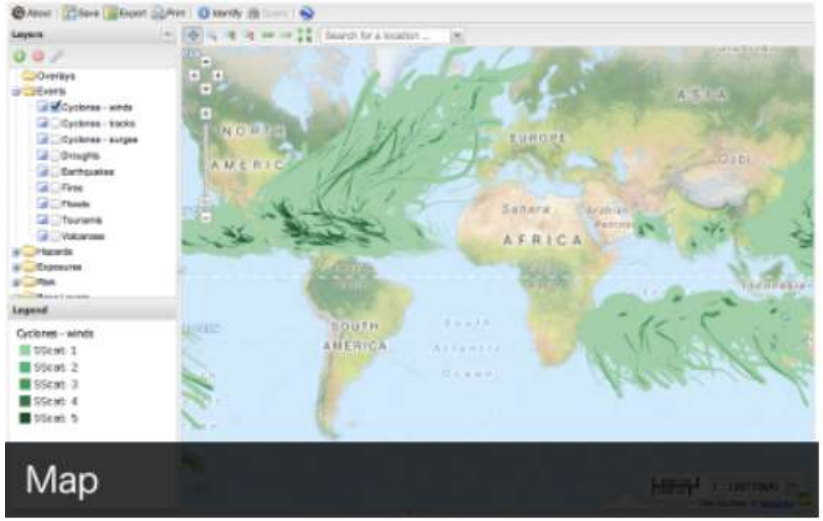
Risk Visualization

- **Statistical information** per administrative unit (country, province, municipality, or neighborhood)
- **Maps** which shows the spatial variation of risk over an area
- **WebGIS** applications that allow the user to combine different types of information, and display information such as:
- **Animations** showing the spatial and temporal distribution of hazards and risk
- **Infographic**

Risk Visualization



Risk Visualization

Ergo-CORE

The Ergo Open Source Consortium's base IT infrastructure, Ergo-CORE, consists of the MAEViz platform developed by the earthquake engineering community under the leadership of the University of Illinois at Urbana-Champaign, with extensions provided by EQvis, a European application for industrial risk by the IRIS Project). The Consortium's primary goal is to encourage and support the development of improvements and enhancements to Ergo-CORE, as well as development and extension of applications and models that are compatible with both the Ergo-CORE platform and one another, in order to provide for a valuable, robust environment for decision-makers and researchers concerned with hazard analysis, response, and prevention. Ergo-CORE will provide baseline data management, visualization and modeling, and analysis services, as well as user interface functions.

Currently, the Ergo project is focused on applications and tools supporting the earthquake engineering community. However, Ergo aims to broaden this focus to encompass other communities engaged in hazard risk assessment and response. While natural hazards such as earthquakes, volcanic eruptions, and severe weather and flooding will remain the major focus of application development, we anticipate similar applications in other critical areas, such as the health, utility, transportation, and supply sectors. Finally, we anticipate supporting the Ergo platform and its applications as planning tools for urban and regional development.

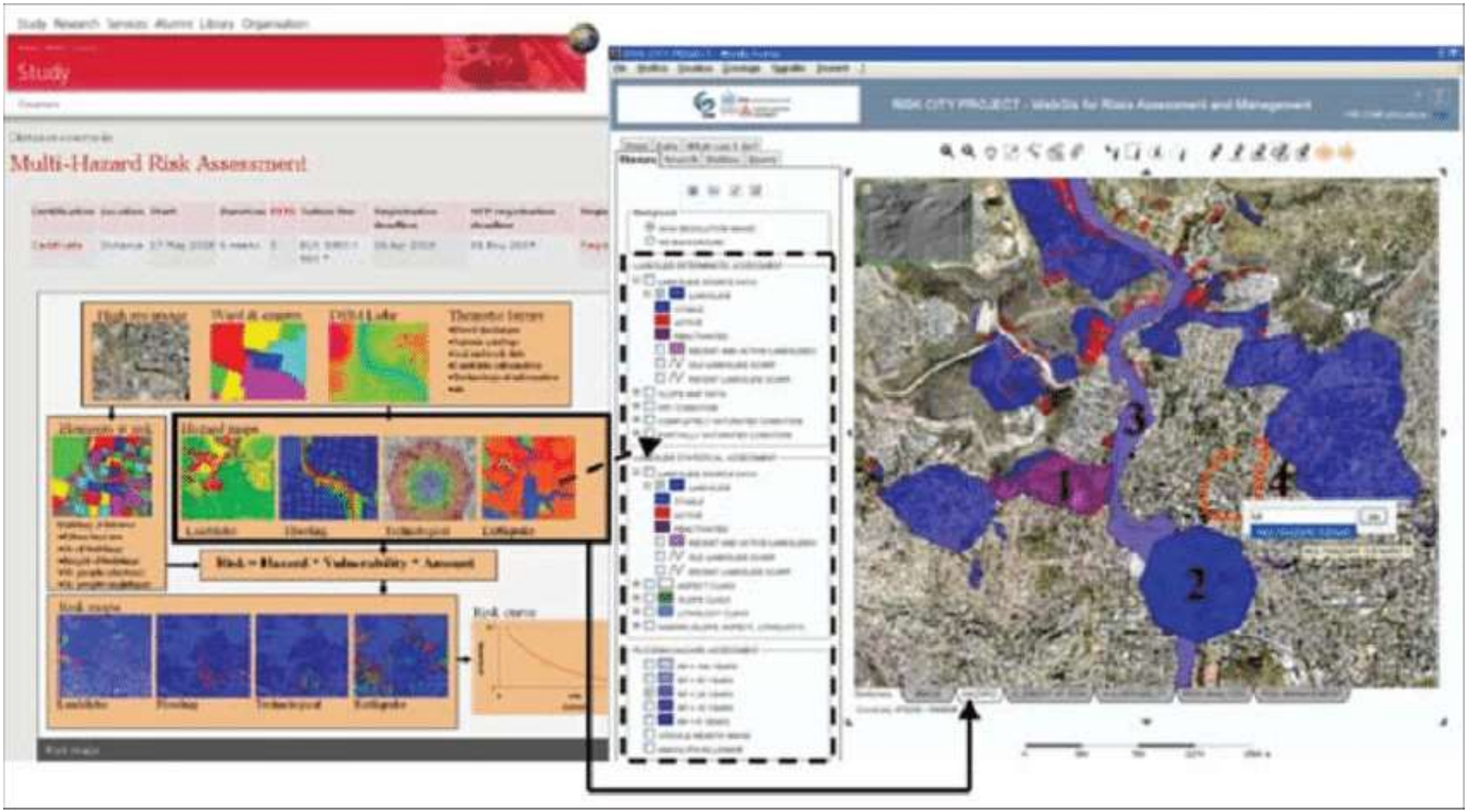
Ergo-EQ

The Ergo Open Source Consortium's co

Source: https://ergo.ncsa.illinois.edu

Risk Visualization

WebGIS: RiskCity

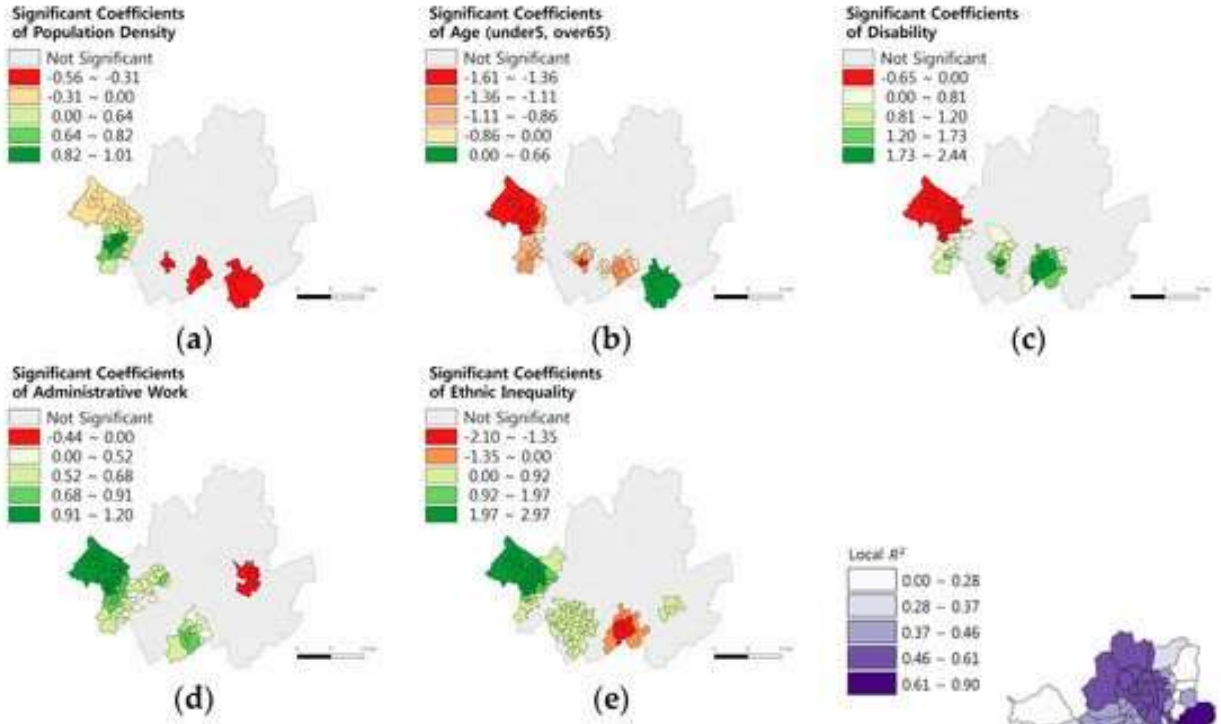


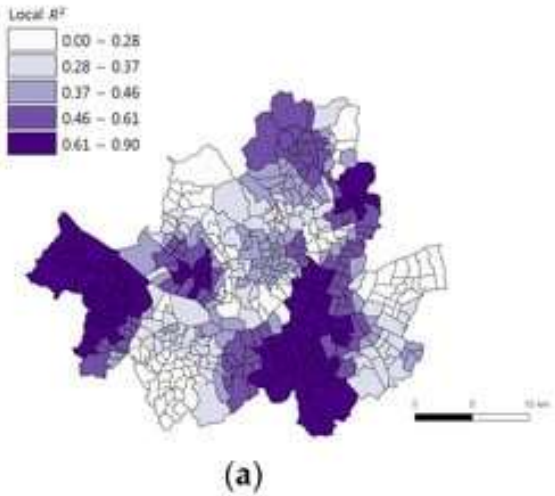
Risk Visualization

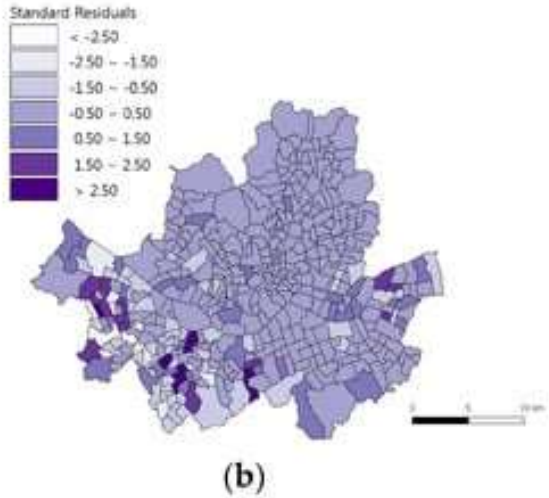
A Spatial Disaster Assessment Model of Social Resilience Based on Geographically Weighted Regression

by Hwikyung Chun [1], Seokho Chi [1,*] and Bon Gang Hwang [2]

[1] Department of Civil and Environmental Engineering, Seoul National University, Seoul 08826, Korea
[2] Department of Building, National University of Singapore, Singapore 117566, Singapore
* Author to whom correspondence should be addressed.







건설사고 위험성 통계

국토안전관리원

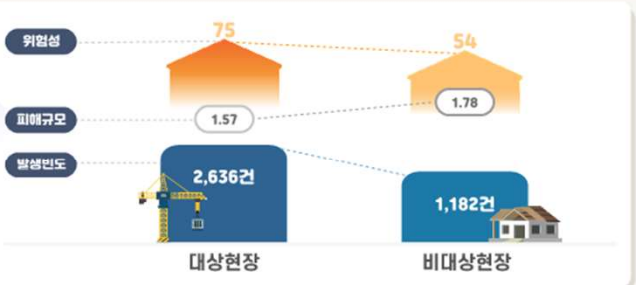
발주형태별 건설사고 위험성

건설사고접수현황 **3,830건** 대상

> 공공공사 대비 민간공사에서 발생빈도, 피해규모, 건설사고 위험성이 큼.

안전관리계획 수립대상 여부별 건설사고 위험성

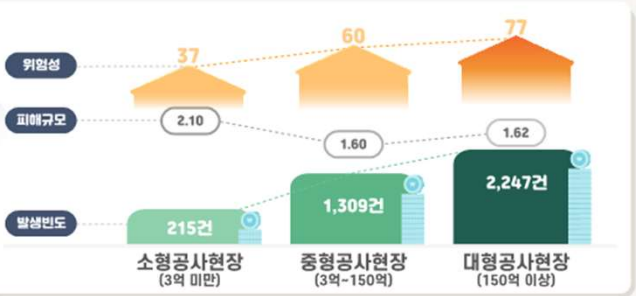
건설사고접수현황 **3,818건** 대상



> 발생빈도는 안전관리계획 수립 대상현장에서 높고, 피해규모는 비대상현장에서 큼. 이를 종합한 건설사고 위험성은 대상현장에서 큼.

공사규모(공사비)별 건설사고 위험성

건설사고접수현황 **3,771건** 대상



> 발생빈도는 대형공사현장(150억 이상)에서 높고, 피해규모는 소형공사현장(3억 미만)에서 큼. 이를 종합한 건설사고 위험성은 대형공사현장에서 가장 큼.

위험성 안전사고유형(15유형)별 위험성 평가점수의 총합에 근거하여 크기를 산정함
위험성 평가점수 산정방식:발생빈도 환산점수 X 피해규모 환산점수

피해규모 평균 사망/부상자 수 (=(사망자수X10+부상자수)/건설사고 발생건수)

발생빈도 건설사고 발생건수

국토안전관리원

공종별 건설사고 위험성

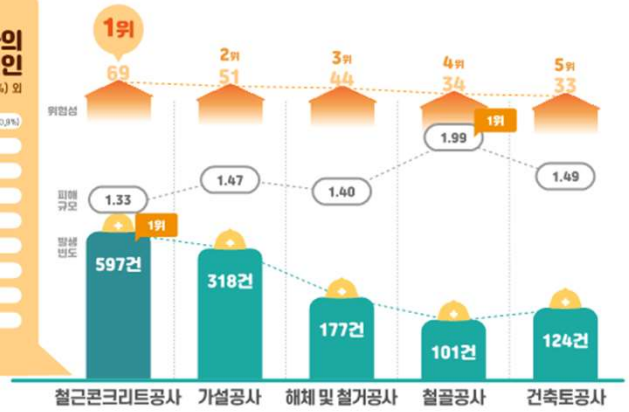
건축분야 위험공종 TOP5

건축분야 건설사고접수현황 1,690건 대상

건축 철근콘크리트공사의 구체적 사고원인

작업자 과실 337건(56.4%) 외

작업중 이동/충돌	65건(10.9%)
구조물등 그밖의 위험방치 및 미확인	17건(2.8%)
거푸집 긴결재/앵커 위치 및 해체	16건(2.7%)
작업순서 미흡	8건(1.3%)
작업신호 불량	7건(1.2%)
해체작업 방법 불량	6건(1.0%)
자재붕괴에 의한 파손	6건(1.0%)
거푸집 하단 미고정	5건(0.8%)
전도 예방조치 미흡	5건(0.8%)



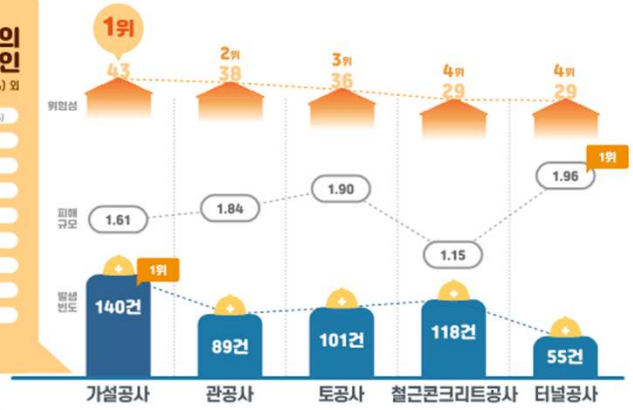
토목분야 위험공종 TOP5

토목분야 건설사고접수현황 736건 대상

토목 가설공사의 구체적 사고원인

작업자 과실 69건(49.3%) 외

작업중 이동/충돌	12건(8.6%)
해체작업 방법 불량	6건(3.6%)
작업신호 불량	5건(2.9%)
작업순서 미흡	5건(2.9%)
거푸집 긴결재/앵커 위치 및 해체	5건(2.9%)
흙막이가시설 설치시기	5건(2.9%)
굴착면 기울기	2건(1.4%)
지반상태 불량	2건(1.4%)
전도 예방조치 미흡	2건(1.4%)



조사기간 : 2020.07.31~2020.12.15
조사대상 : 2019.07.01~2020.07.15 건설사고접수현황
조사방법 : 건설공사 안전관리 종합정보망(CSI) DB활용

Q & A