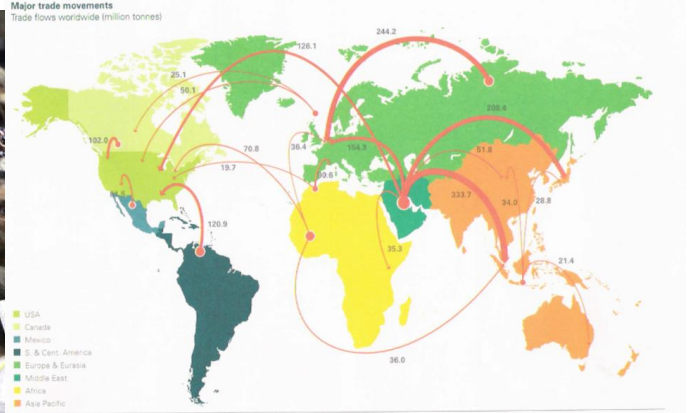
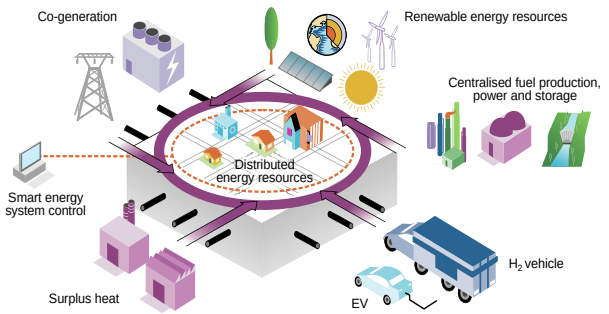
비정상시계열모형
(Non-stationary Time Series Model)





1. 비정상시계열모형

- **시계열 분석 : 자기 과거 값과의 관계가 높은 자료를 대상으로 하는 분석**
  즉, Autocorrelation이 높은 자료가 분석 대상
- 분석의 목표 : 분석 대상 시계열 자료의 DGM(Data Generating Mechanism)을 밝히는 것
  (시계열자료에 있는 Autocorrelation(Serial Correlation) 정보를 알아내는 것)

- **시계열 분석 모형들은 개발되어 사용되어온 역사의 순서에 따라**
  다음과 같이 1~4단계로 구분

- 1단계 : 시계열 분해분석 (Decomposition Model)
- 2단계 : 이동평균법과 지수평활법 (Moving Average and Smoothing Model)
- 3단계 : ARIMA 모형 (Box-Jenkins ARIMA Model)
- 4단계 : 비정상시계열 모형 (Non-stationary Time Series Model)

1. 비정상시계열모형

전통적인 세계관

- **TREND (추세요인)**
- **CYCLICAL (순환요인)**
- **SEASONAL (계절요인)**
- **Irregular component (불규칙 요인)**

1980년대~현재의 새로운 세계관 (Nelson & Plosser(1982))

- **IRREGULAR 가 진짜 !!!**
- **Irregular component의 분해가 중요**

2. The Box-Jenkins (ARIMA) Methodology

- **AR (Auto regressive)**

  : Effect of present and past values of dependent variable (Y)

$$Y_t = a_1 Y_{t-1} + e_t \rightarrow AR(1)$$

$$Y_t = a_1 Y_{t-1} + a_2 Y_{t-2} + \cdots + a_p Y_{t-p} + e_t \rightarrow AR(p)$$

- **MA (Moving Average)**

  : Effect of present and past values of error term (e)

$$Y_t = \beta_1 e_{t-1} + e_t \rightarrow MA(1)$$

$$Y_t = \beta_1 e_{t-1} + \cdots \beta_q e_{t-q} + e_t \rightarrow MA(q)$$

- **ARMA**

$$Y_t = a_1 Y_{t-1} + a_2 Y_{t-2} + \cdots + a_p Y_{t-p} + \beta_1 e_{t-1} + \cdots \beta_q e_{t-q} + e_t \rightarrow ARMA(p,q)$$

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TRENDS AND RANDOM WALKS IN MACROECONMIC TIME SERIES

Some Evidence and Implications

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This paper investigates whether macroeconomic time series are better characterized as stationary fluctuations around a deterministic trend or as non-stationary processes that have no tendency to return to a deterministic path. Using long historical time series for the U.S. we are unable to reject the hypothesis that these series are non-stationary stochastic processes with no tendency to return to a trend line. Based on these findings and an unobserved components model for output that decomposes fluctuations into a secular or growth component and a cyclical component we infer that shocks to the former, which we associate with real disturbances, contribute substantially to the variation in observed output. We conclude that macroeconomic models that focus on monetary disturbances as a source of purely transitory fluctuations may never be successful in explaining a large fraction of output variation and that stochastic variation due to real factors is an essential element of any model of macroeconomic fluctuations.

Table 2

Sample autocorrelations of the natural logs of annual data.[a]

Series	Period	Sample autocorrelations T	r_1	r_2	r_3	r_4	r_5	r_6
Random walk[b]		100	0.95	0.90	0.85	0.81	0.76	0.70
Time aggregated[b] random walk		100	0.96	0.91	0.86	0.82	0.77	0.73
Real GNP	1909–1970	62	0.95	0.90	0.84	0.79	0.74	0.69
Nominal GNP	1909–1970	62	0.95	0.89	0.83	0.77	0.72	0.67
Real per capita GNP	1909–1970	62	0.95	0.88	0.81	0.75	0.70	0.65
Industrial production	1860–1970	111	0.97	0.94	0.90	0.87	0.84	0.81
Employment	1890–1970	81	0.96	0.91	0.86	0.81	0.76	0.71
Unemployment rate	1890–1970	81	0.75	0.47	0.32	0.17	0.04	−0.01
GNP deflator	1889–1970	82	0.96	0.93	0.89	0.84	0.80	0.76
Consumer prices	1860–1970	111	0.96	0.92	0.87	0.84	0.81	0.77
Wages	1900–1970	71	0.96	0.91	0.86	0.82	0.77	0.73
Real wages	1900–1970	71	0.96	0.92	0.88	0.84	0.80	0.75
Money stock	1889–1970	82	0.96	0.92	0.89	0.85	0.81	0.77
Velocity	1869–1970	102	0.96	0.92	0.88	0.85	0.81	0.79
Bond yield	1900–1970	71	0.84	0.72	0.60	0.52	0.46	0.40
Common stock prices	1871–1970	100	0.96	0.90	0.85	0.79	0.75	0.71

[a]The natural logs of all the data are used except for the bond yield. T is the sample size and r_i is the ith order autocorrelation coefficient. The large sample standard error under the null hypothesis of no autocorrelation is $T^{-\frac{1}{2}}$ or roughly 0.11 for series of the length considered here.
[b]Computed by the authors from the approximation due to Wichern (1973).

2. The Box-Jenkins (ARIMA) Methodology

- **I (Integrated)**
  : AR 모델에서 Y의 과거 항의 계수가 '1'이 되는 경우

$$Y_t = a_1 Y_{t-1} + e_t \rightarrow AR(1)$$ **에서 $a_1 = 1$ 인 경우**

- **Error terms들의 집합이 변화를 좌지우지**
  : Random Walk (with drift)
- **과거 기억을 영원히 기억, 구조적인 변화**
  : Permanent Memory / Structural Shift
- **현재의 확률분포가 유지된다고 할 수 없음**
  : 예측치의 오류 가능성 높음 / Non-Stationary time series

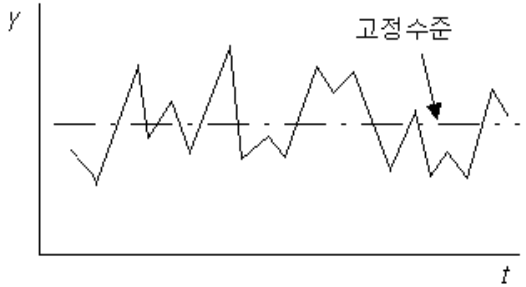
3. 정상시계열 / 비정상시계열

- **정상(Stationary) 시계열이란?**
  - 조건 : Mean of the process is constant over time
    Variance is finite and constant over time
    Covariance depends only on the distance
    between time points and not on time itself.
  - 특성 : mean reverting (평균으로의 복귀)이 빠르다.
    data가 주로 short memory로 이루어져 있다.
    forecast의 신뢰도가 장기간 지속된다.

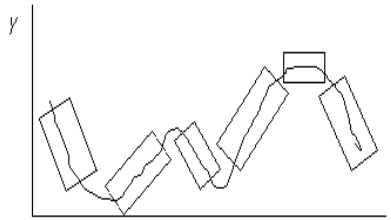
- **비정상(Non-Stationary) 시계열이란?**
  - I (1) 인 시계열 : 매우 심한 auto-correltation 문제 발생

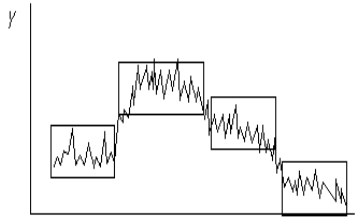
3. 정상시계열 / 비정상시계열

- **정상 시계열**



- **비정상 시계열**





4. 비정상시계열모형의 분석

- 비정상시계열을 정상시계열로 만들기 !
  - 차분 ($\Delta Y_t = Y_t - Y_{t-1}$)
  - 계절차분 : 계절성이 있는 시계열의 경우 ($\Delta Y_t = Y_t - Y_{t-12}$)
  - 로그변환 : 분산이 증가하는 시계열의 경우

4. 비정상시계열모형의 분석

비정상시계열의 재 구조화 – 새로운 'Trend' 의 정의

- **Trend - Stationary (TS)**

  : Stationary TS + Trend : Deterministic Trend

- **Difference - Stationary (DS)**

  : Non-stationary TS : Stochastic Trend

- **TS/DS 연계형 : Difference - Stationary with Trend**

  : Non-stationary TS + Deterministic Trend

  $Y_t = a + b \cdot Y_{t-1} + c \cdot T$