TIME SERIES ANALYSIS

Forecasting

- The Jewish prophet Isaiah wrote in about 700 BC

Tell us what the future holds, so we may know that you are gods. (Isaiah 41:23)

- Popular prediction about computing:

Computers in the future may weigh no more than 1.5 tons. (Popular Mechanics, 1949)

Need for forecasting

- deciding whether to build another power generation plant in the next five years requires forecasts of future demand;
- scheduling staff in a call center next week requires forecasts of call volumes;
- stocking an inventory requires forecasts of stock requirements.

- The predictability of an event or a quantity depends on several factors including:
  - how well we understand the factors that contribute to it;
  - how much data is available;
  - whether the forecasts can affect the thing we are trying to forecast.

Terminologies

- Time series data
  - experimental data that have been observed at different points in time
- Examples:
  - daily stock market quotations
  - monthly unemployment figures
  - No. of COVID-19 cases observed over a period of time
  - BP measured over time

First Step – Plot the data

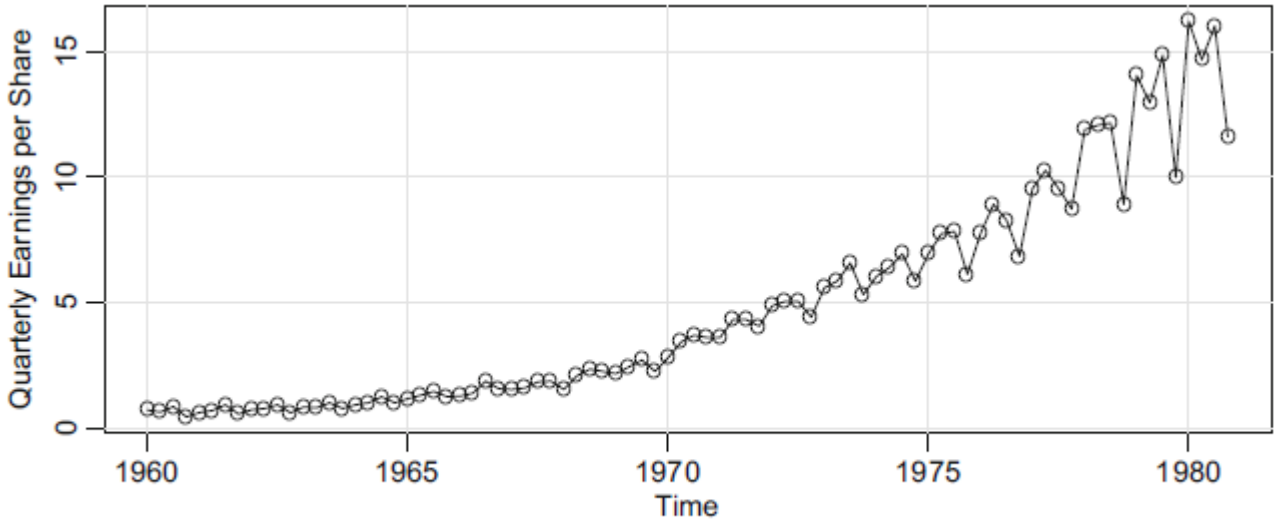


Fig. 1.1. Johnson & Johnson quarterly earnings per share, 84 quarters, 1960-I to 1980-IV

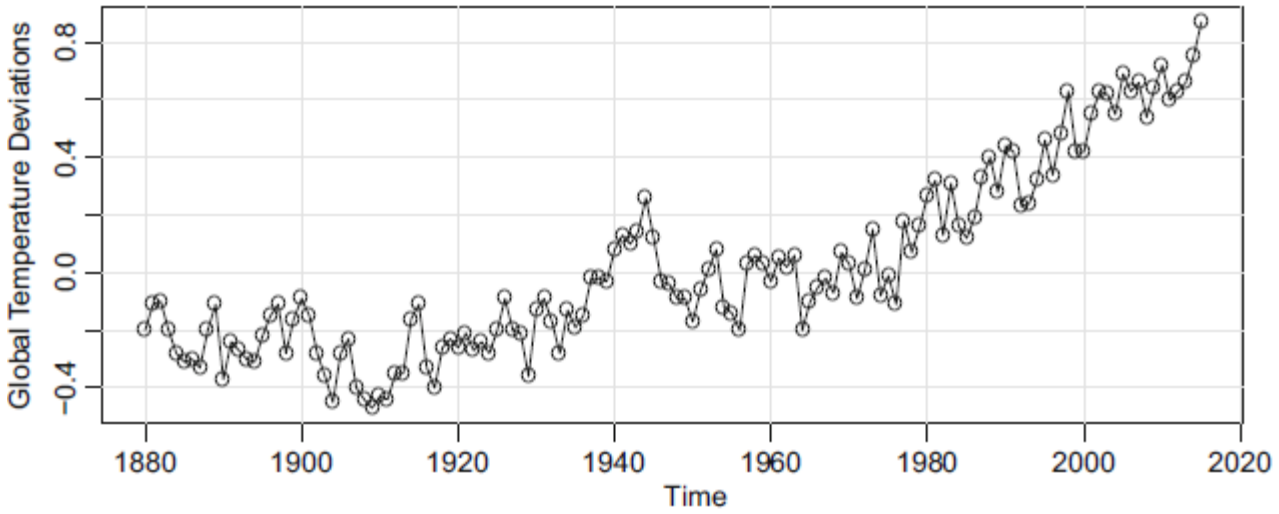
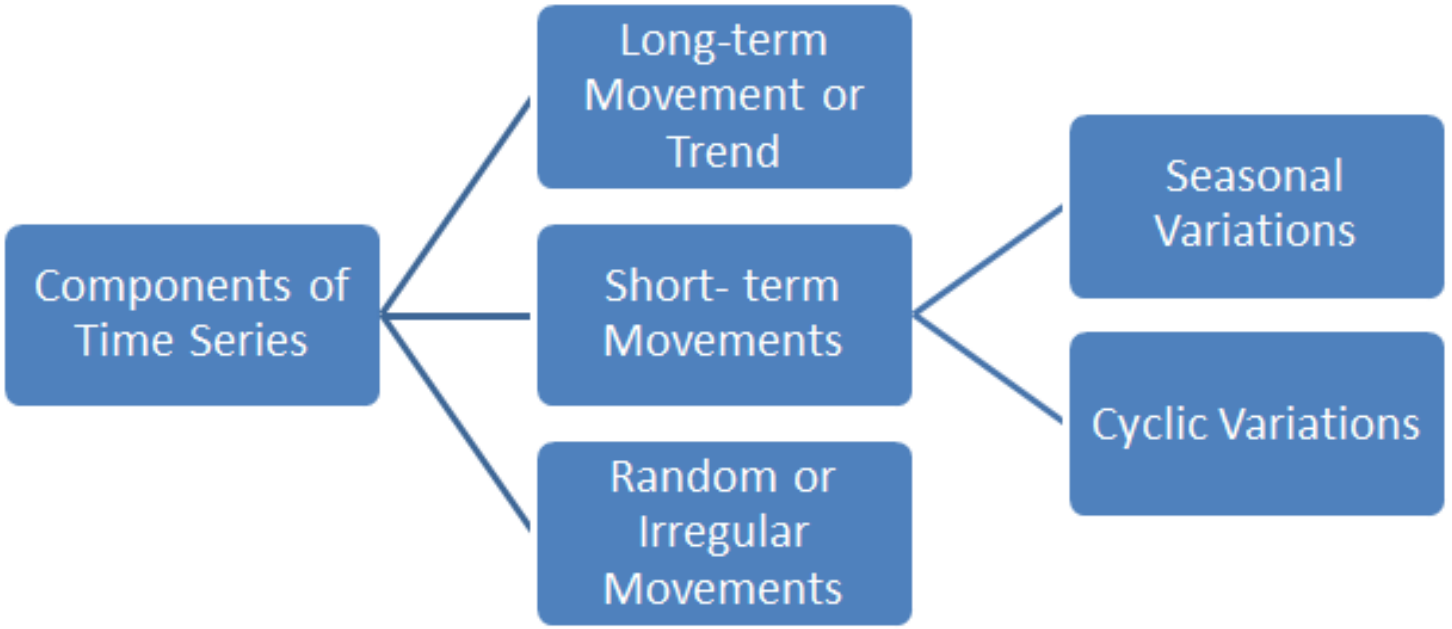


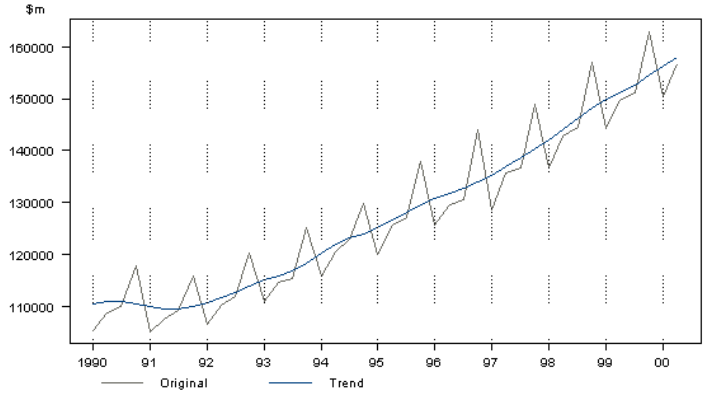
Fig. 1.2. Yearly average global temperature deviations (1880–2015) in degrees centigrade

Components of Time Series



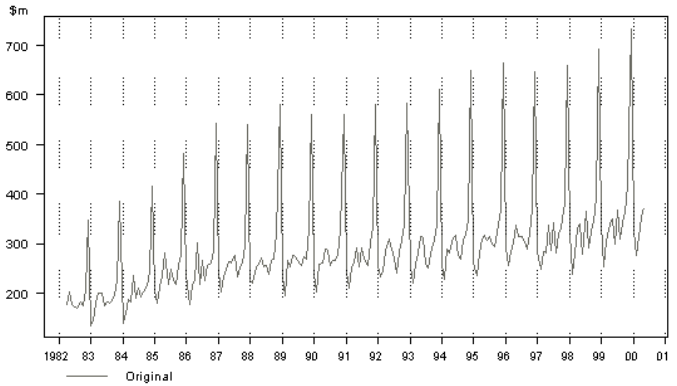
Components of Time Series

Trend



Direction in which something is increasing or decreasing

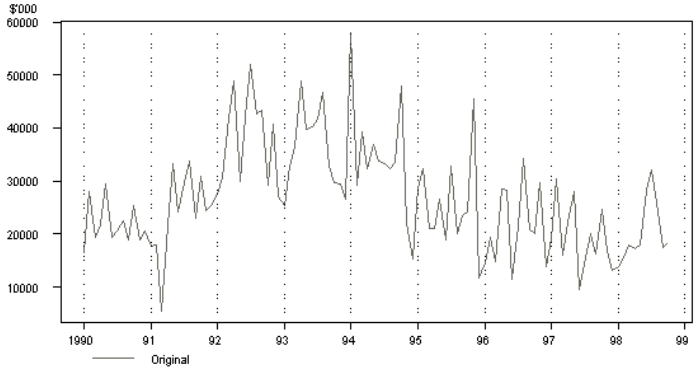
Seasonal

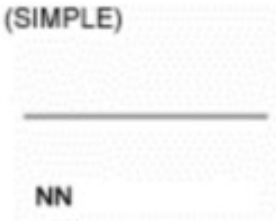
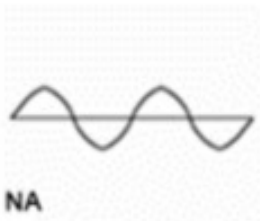
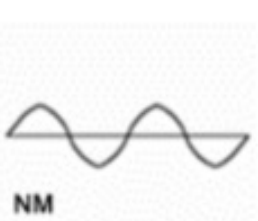
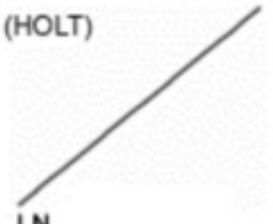
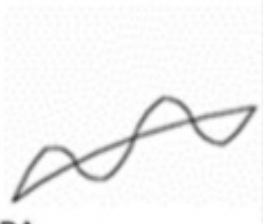
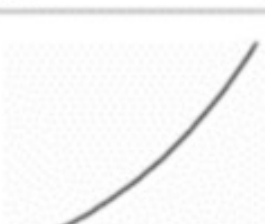
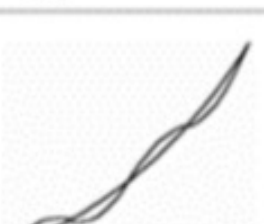
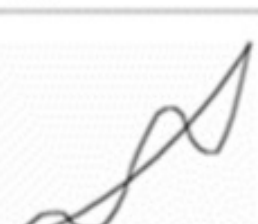


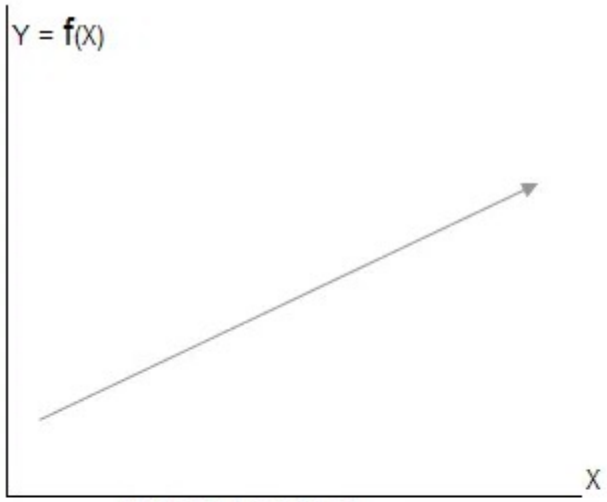
Repetition of peak or dip at regular intervals

Random

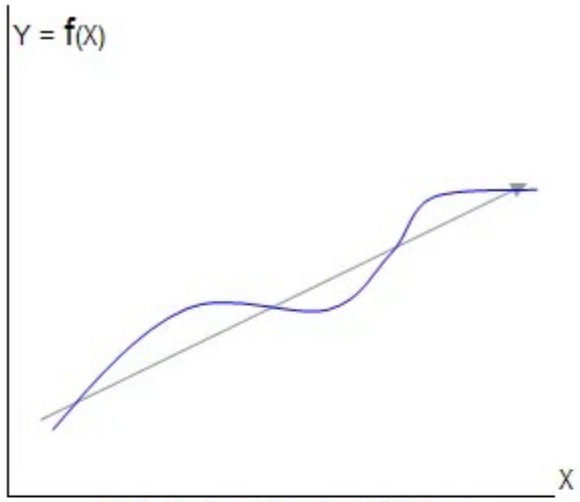
Irregular fluctuations – uncontrolled situations contributing to changes in values



	Nonseasonal	Additive Seasonal	Multiplicative Seasonal
Constant Level	(SIMPLE)  NN	 NA	 NM
Linear Trend	(HOLT)  LN	 LA	(WINTERS)  LM
Damped Trend (0.95)	 DN	 DA	 DM
Exponential Trend (1.05)	 EN	 EA	 EM

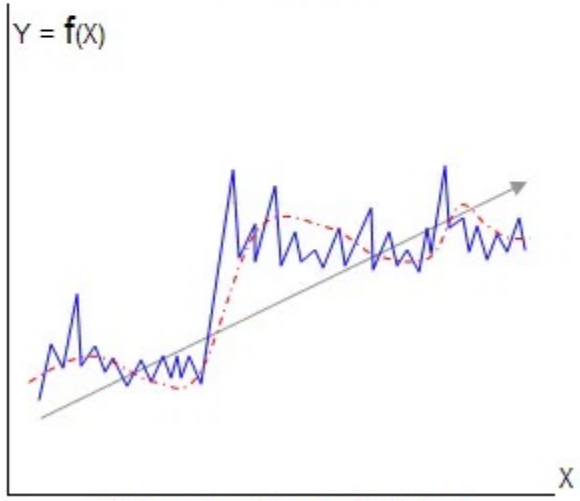


(1) Long-term Trend



(2) Long-term Trend with Cyclical Variations/Movements

(3) Long-term Trend with Cyclical and Seasonal Variations/Movements



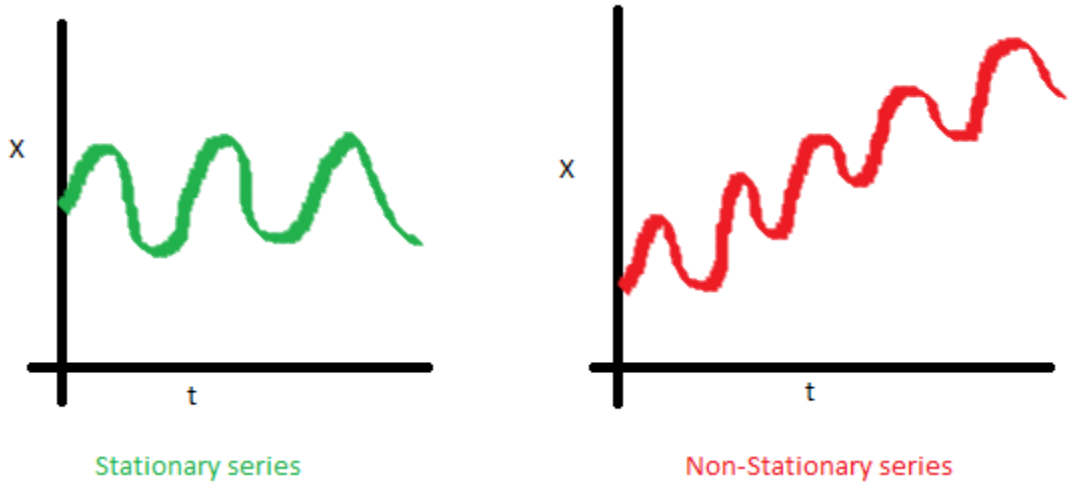
(4) Long-term Trend with Cyclical, Seasonal, and Random Variations/Movements

Stationary Series

- *A* **stationary** *time series, x*t *, has* three basic criteria
  - Constant Mean $(\mu(t) = \mu)$
  - Constant Variance $(\sigma^2(t) = \sigma^2)$
  - Co-variance - constant

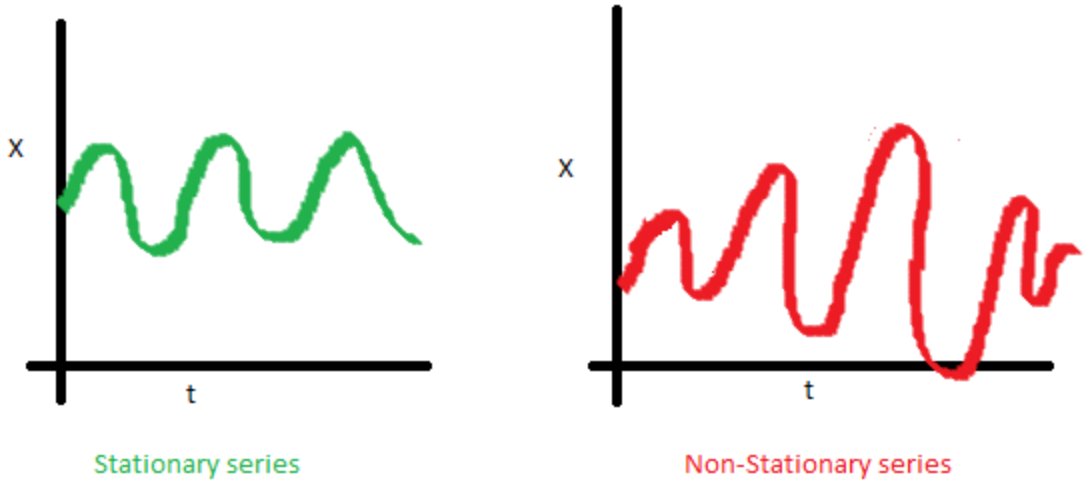
Stationarity of Time series

- The mean of the series should not be a function of time rather should be a constant.



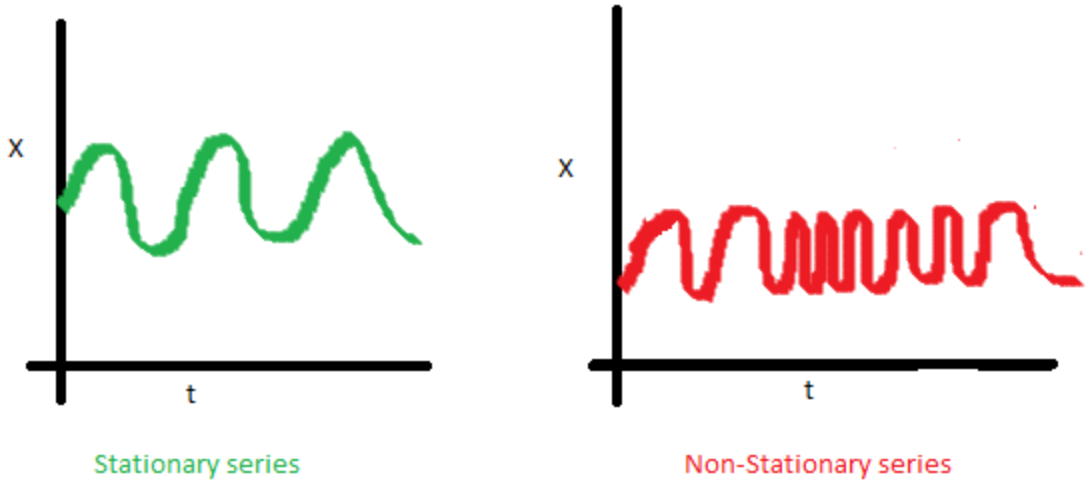
Stationarity of Time series

- The variance of the series should not a be a function of time - Homoscedasticity



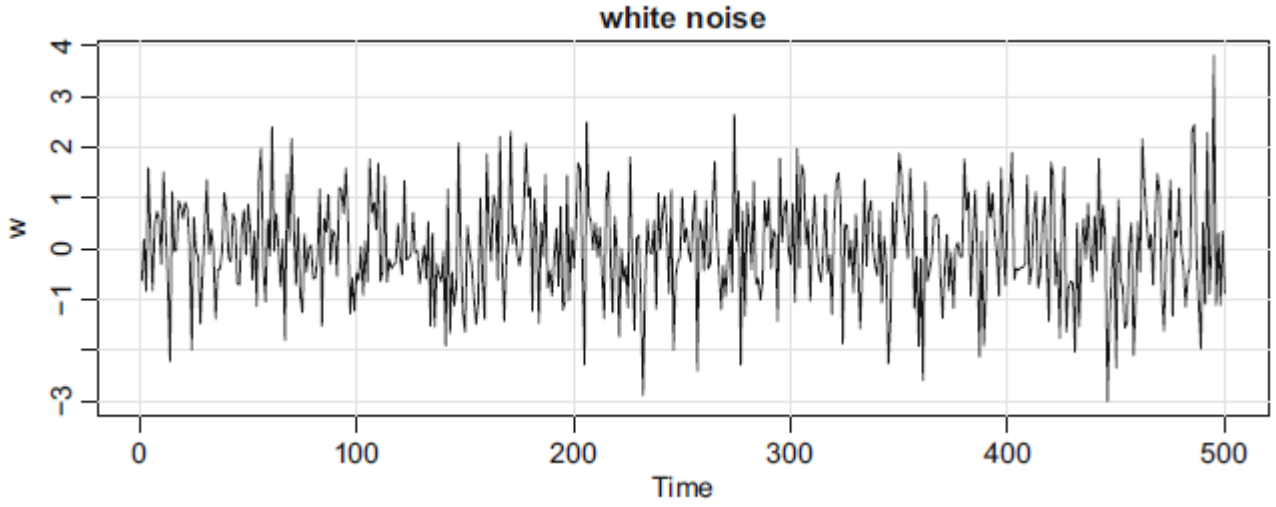
Stationarity of Time series

- The covariance of the i th term and the (i + m) th term should not be a function of time.



Time series Models

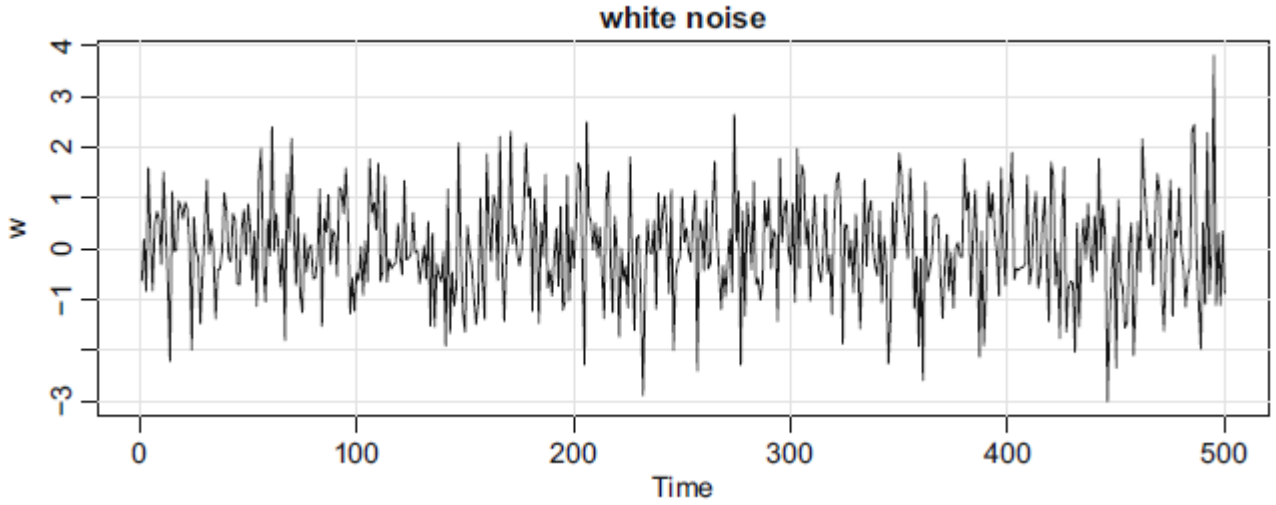
- White Noise
  - series might be a collection of uncorrelated random variables, w_t, with mean 0 and finite variance σ_{2w}



Time series Models

- Autoregression (AR)
  - x_t depends on its past values $x_{t-1}, x_{t-2} \ldots$
  - $x_t = f(x_{t-1}, x_{t-2}, \ldots, w_t)$

$$x_t = x_{t-1} - .9x_{t-2} + w_t$$



Time series Models

- Moving Average (MA)
  - w_t depends on its past values $w_{t-1}, w_{t-2} \ldots$
  - $x_t = f(w_{t-1}, w_{t-2}, \ldots)$

- ARMA
  - Mix of both AR and MA models
  - ARMA(p,q) - model depends on p of its own past values and q past values of white noise

- ARIMA
  - Autoregression Integrated Moving Average Model
  - ARIMA(p,d,q) where d-no. of differences