FORECASTING

Reference Text:

- William Stevenson, Operations Management —13th ed., McGraw Hill Education, NY
  - *Chapter-3: Forecasting*

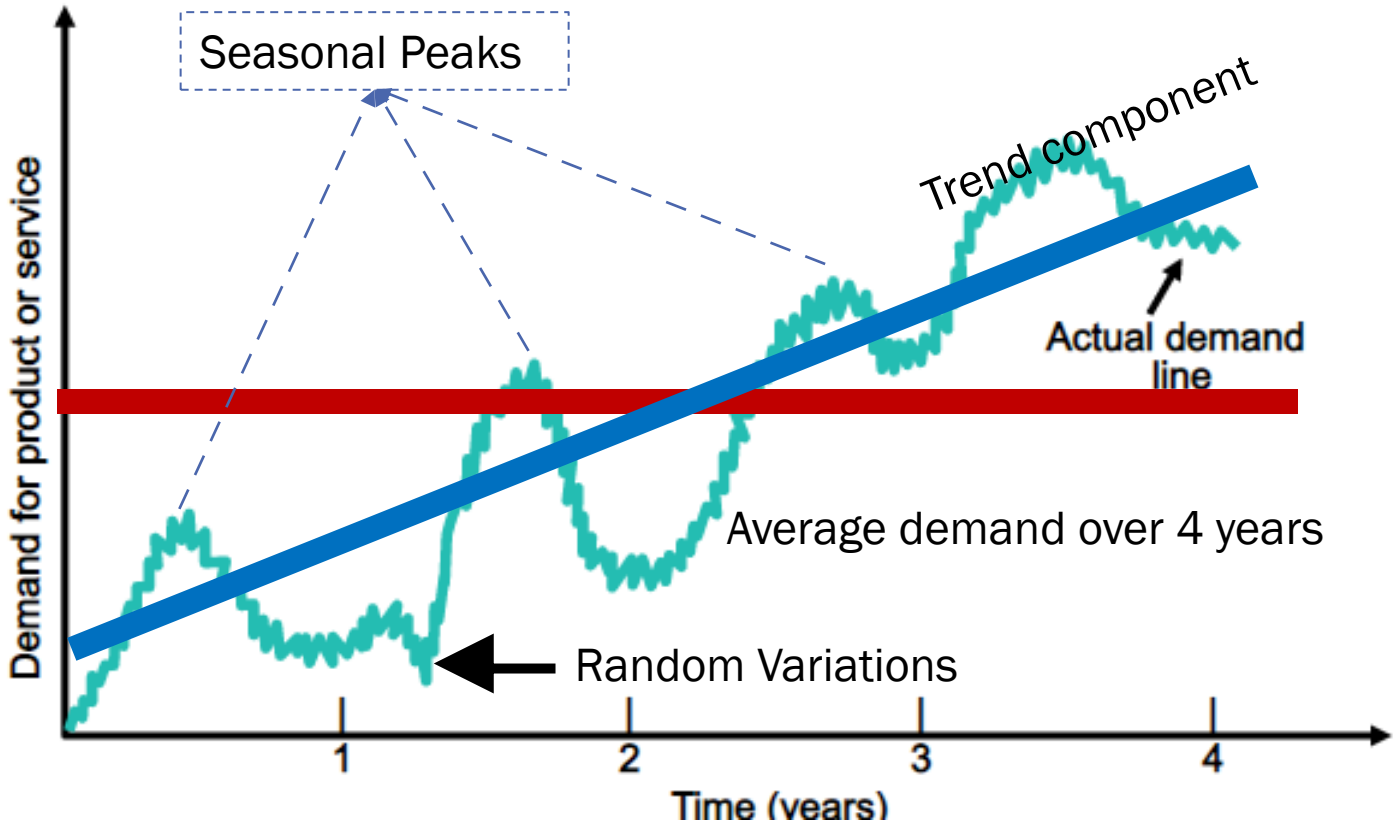
Introduction

Forecast: an estimate about the future value of a variable such as demand

The primary goal of operations management is to match supply to demand.

Demand Characteristics

1. Trend
2. Seasonality
3. Cyclical Element
4. Random Variation



Forecasting

- Forecasting is (scientific) planning tool that helps the process of making predictions of the future based on past and present data and most commonly by analysis of trends.

- Types and Time Horizon
  - *Strategic Forecasts: Medium or long-term forecasts that are used for decisions related to strategy and aggregate demand.*
    - Facility location, new product plan, R&D investments etc.
  - *Tactical Forecasts: Short term forecasts used for making day-to-day decisions related to meeting demand.*
    - Purchasing, job scheduling, workforce planning etc.

Forecasting Approaches

- Qualitative Method
  - *Involves intuition or experience*
  - *When no or little data exists*
  - *E.g., launch of new products, new technology etc.*

- Quantitative methods
  - *When historical data exists e.g. for existing product or technology*
  - *The situation is 'stable'*
  - *Involves mathematical modelling*

How reliable/accurate is the forecasts?

- It assumes that same underlying causal system of the past will persist
- Forecasts are not perfect, allowances of error should be made
- Forecasting Error = Actual Value − Forecasted Value

$e_t = A_t - F_t$ Where t = Any given time period

- Forecast accuracy decreases as the *time horizon* increases.

Steps in forecasting

1. Determine the objective of forecast
2. Determine the time horizon of the forecast
3. Select a Forecasting Technique
4. Collect, Clean and Analyze the Data
5. Make forecast
6. Monitor the forecasting errors

QUANTITATIVE FORECASTING

Time Series Forecasting

- TSM looks at historical patterns of values of the same variable to make future prediction. E.g., past sales figures are used to make future sales predictions

    - Time series observations are recorded at equal intervals (e.g. daily, weakly, monthly or yearly basis)
    - **Time** is the one variable which is **used to predict the other variable** (e.g., sales) of interest.
    - Time series can be plotted on a two dimensional plane where X-axis represents the time and the Y-axis represents the other variable such as demand or sales.

Associative Forecasting

- This type of forecasting assumes that one values of one variable is influenced by the values of another variable in the environment. E.g., Investment in advertisement is used to predict future sales.

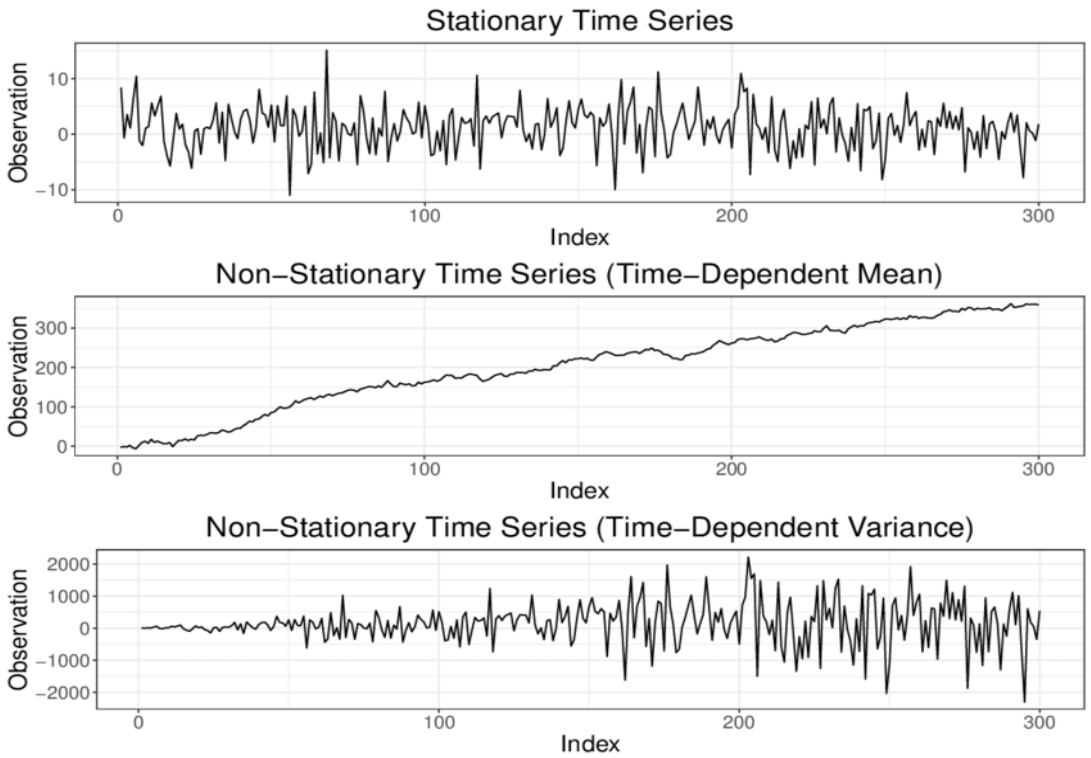
- At least two different variables (other than time) are used where one variable acts as **predictor** variable for the other which is predicted (or forecasted)

Time Series Forecasting

- Simple Moving Average
  - *Normally done with 6-12 month data, weekly data are often used,*
  - *Data pattern is stationary (i.e. no trend or seasonality)*
- Weighted Moving Average & Simple exponential Smoothing
  - *5-10 observations are needed to start,*
  - *Data pattern is stationary*
- Linear Regression
- Trends and Seasonal Models

Stationary Time Series Indicates:

- Constant Mean
- Constant Variance
- No Trend or Seasonality



Simple Moving Average Method

- This is a series of arithmetic means used for smoothing
- This method is used when there is little or no trend

$$\text{Moving average} = \frac{\sum \text{demand in previous } n \text{ periods}}{n}$$

$$F_t = \frac{A_{t-1} + A_{t-2} + A_{t-3} + \ldots + A_{t-n}}{n}$$

F_t = Forecast for the coming period

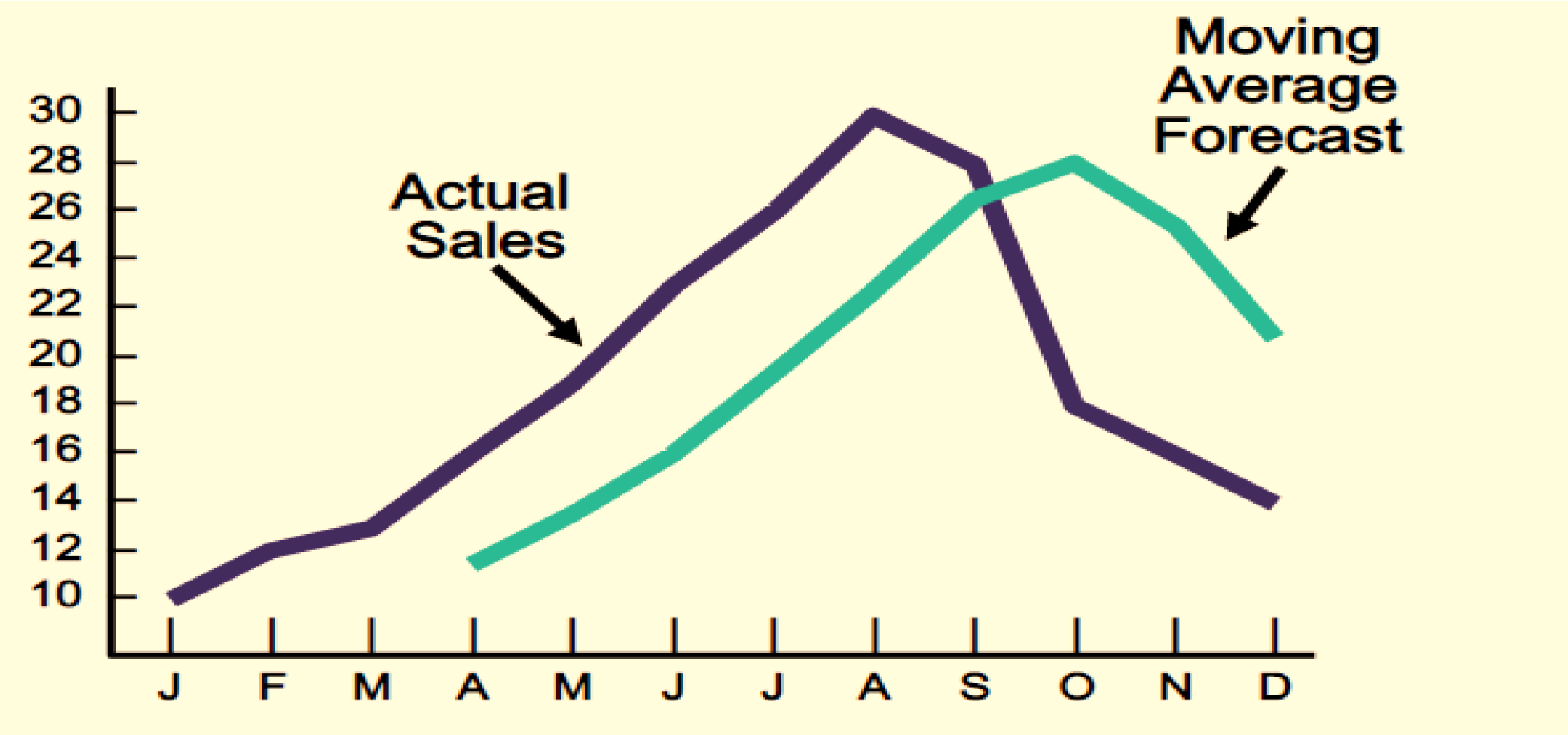
N = Number of periods to be averaged

A_{t-1} = Actual occurrence in the past period

Simple Moving Average

Month	Actual Sales	3 Months Moving Average
January	10	
February	12	
March	13	
April	16	(10 + 12 + 13)/3 = 11 $^{2}/_{3}$
May	19	(12 + 13 + 16)/3 = 13 $^{2}/_{3}$
June	23	(13 + 16 + 19)/3 = 16
July	26	(16 + 19 + 23)/3 = 19 $^{1}/_{3}$

Graph of Simple Moving Average



Weighted Moving Average

Month	Actual Sales	3 Months Moving Average
January	10	
February	12	
March	13	
April	16	[(3 x 13) + (2 x 12) + (10)]/6 = 12 1/6
May	19	[(3 x 16) + (2 x 13) + (12)]/6 = 14 1/3
June	23	[(3 x 19) + (2 x 16) + (13)]/6 = 17
July	26	[(3 x 23) + (2 x 19) + (16)]/6 = 20 1/2

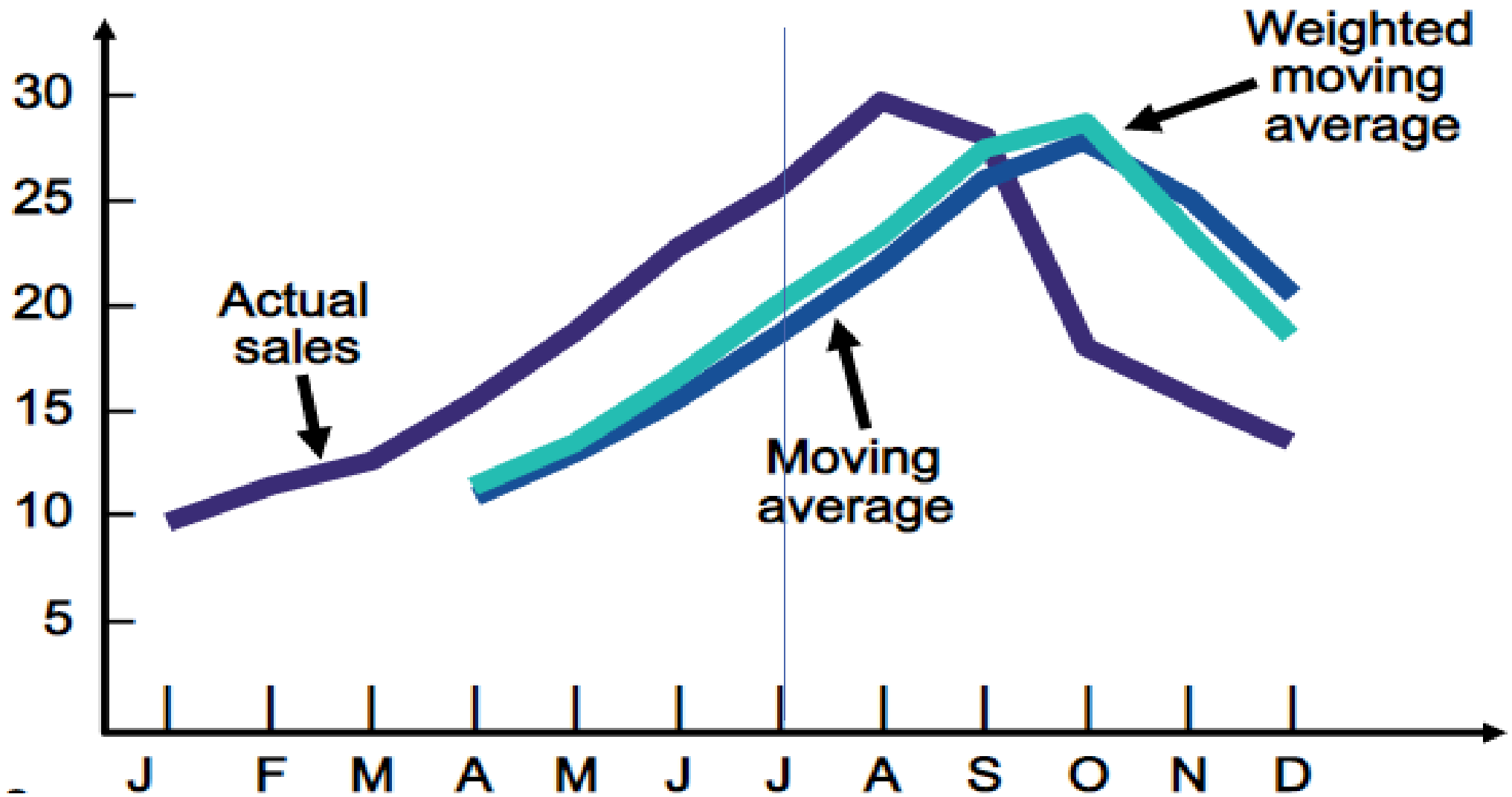
Weights Applied	Period
3	Last Month
2	Two Months Ago
1	Three Months Ago
Total = 6	

$$F_t = w_1 A_{t-1} + w_2 A_{t-2} + w_3 A_{t-3} + \ldots + w_n A_{t-n}$$

w_t = weight given to time period "t" occurrence (weights must add to one)

$$\sum_{i=1}^{n} w_i = 1$$

Assumes unequal weights given on different time periods


30
25
20
15
10
5
Actual sales
Moving average
Weighted moving average
J
F
M
A
M
J
J
A
S
O
N
D

Exponential Smoothing

New Forecast = Last Period's Forecast + α (Last period's actual demand - Last period's forecast)

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$$

Or $F_t = \alpha A_{t-1} + (1-\alpha) F_{t-1}$

where F_t = ***new forecast***

F_{t-1} = ***previous forecast***

α = ***smoothing (or weighting) constant*** $(0 \le \alpha \le 1)$

- An advanced form of weighted moving average, that has limited use of historical data
- Most recent data is weighted the most
- A smoothing constant 'α' is subjectively chosen
- Weights of the preceding periods decline exponentially