1. Introduction to Time Series Analysis

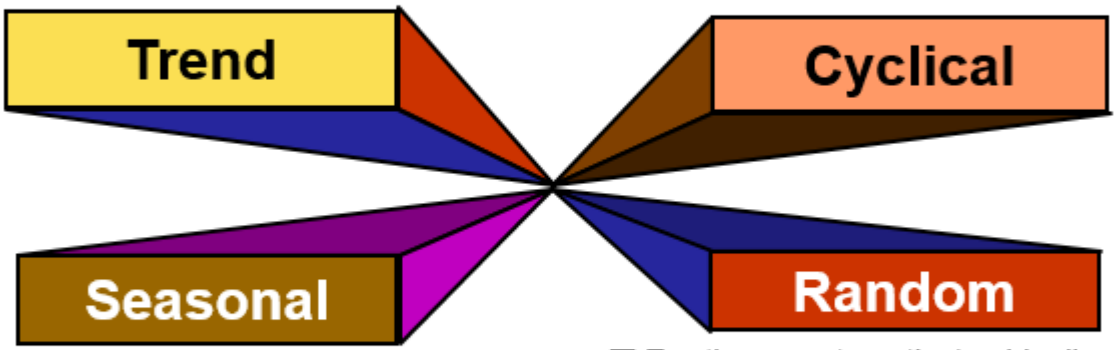
- Time Series Analysis is a statistical technique that is widely used in various fields such as finance, economics, engineering, and social sciences to analyse and forecast data over time.
- It is a powerful tool that allows us to identify patterns, trends, and anomalies in a time series dataset.
- The analysis of time series data provides us with valuable insights into the behaviour of a system and helps us make informed decisions.

2. Components of Time Series

- It is essential to understand the components of a time series.
- A time series can be decomposed into three main components: trend, seasonality, and random variation.
- The trend represents the long-term pattern or direction of the data, which can be increasing, decreasing, or stationary.
- Seasonality refers to the repetitive and predictable patterns that occur at regular intervals, such as daily, weekly, or monthly.
- Random variation, also known as noise, represents the unpredictable fluctuations within the data.

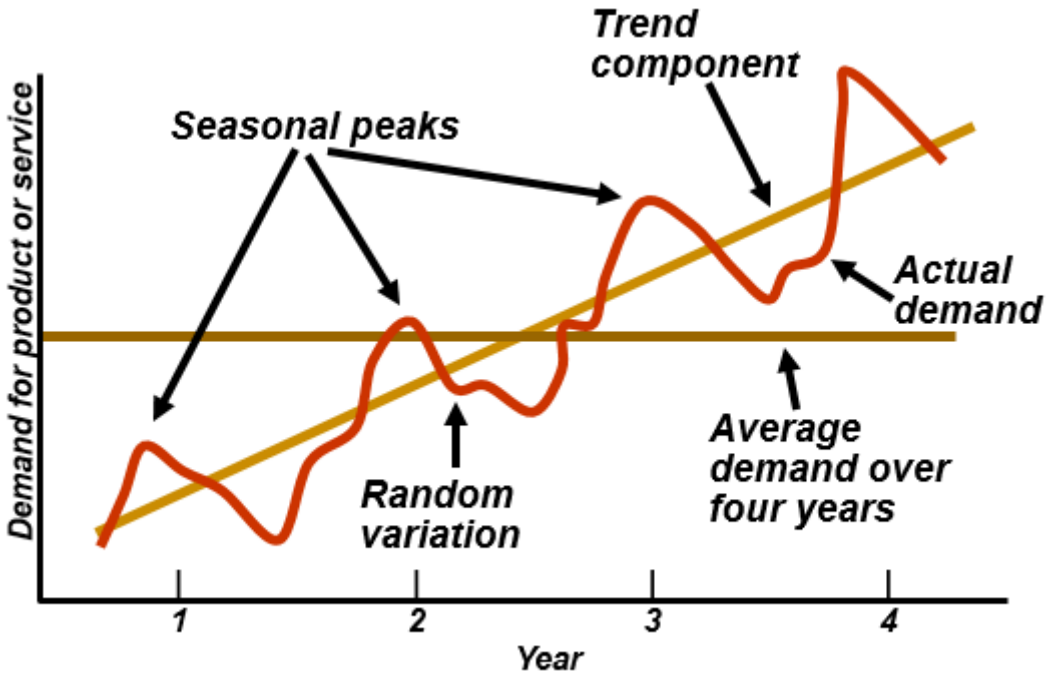
- ☑ Persistent, overall upward or downward pattern
- ☑ Changes due to population, technology, age, culture, etc.
- ☑ Typically several years duration

- ☑ Regular pattern of up and down fluctuations
- ☑ Due to weather, customs, etc.
- ☑ Occurs within a single year



- ☑ Repeating up and down movements
- ☑ Affected by business cycle, political, and economic factors
- ☑ Multiple years duration
- ☑ Often causal or associative relationships

- ☑ Erratic, unsystematic, 'residual' fluctuations
- ☑ Due to random variation or unforeseen events
- ☑ Short duration and nonrepeating



What is forecasting?

1. Process of predicting a future event
2. Underlying basis of all business decisions

Forecasting Time Horizons

☑ Short-range forecast

- ☑ Up to 1 year, generally less than 3 months
- ☑ Purchasing, job scheduling, workforce levels, job assignments, production levels

☑ Medium-range forecast

- ☑ 3 months to 3 years
- ☑ Sales and production planning, budgeting

☑ Long-range forecast

- ☑ 3 years
- ☑ New product planning, facility location, research and development

Types of Forecasts

☑ Economic forecasts

- ☑ Address business cycle – inflation rate, money supply, housing starts, etc.

☑ Technological forecasts

- ☑ Predict rate of technological progress
- ☑ Impacts development of new products

☑ Demand forecasts

- ☑ Predict sales of existing product

Seven Steps in Forecasting

1. Determine the use of the forecast
2. Select the items to be forecasted
3. Determine the time horizon of the forecast
4. Select the forecasting model(s)
5. Gather the data
6. Make the forecast
7. Validate and implement results

Forecasting Approaches

Qualitative Methods

- ☑ Used when situation is vague and little data exist
  - ☑ New products
  - ☑ New technology
- ☑ Involves intuition, experience
  - ☑ e.g., forecasting sales on Internet

Quantitative Methods

- ☑ Used when situation is 'stable' and historical data exist
  - ☑ Existing products
  - ☑ Current technology
- ☑ Involves mathematical techniques
  - ☑ e.g., forecasting sales of color televisions

Overview of Quantitative Methods

1. Naive approach
2. Moving averages
3. Exponential smoothing
4. Trend projection

Time-Series Models

5. Linear regression

Associative Model

1. Simple Moving Averages Method

- **The simple moving average model assumes an average is a good estimator of future behavior**
- **The formula for the simple moving average is:**

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

F_t = Forecast for the coming period

N = Number of periods to be averaged

A_{t-1} = Actual occurrence in the past period for up to "n" periods

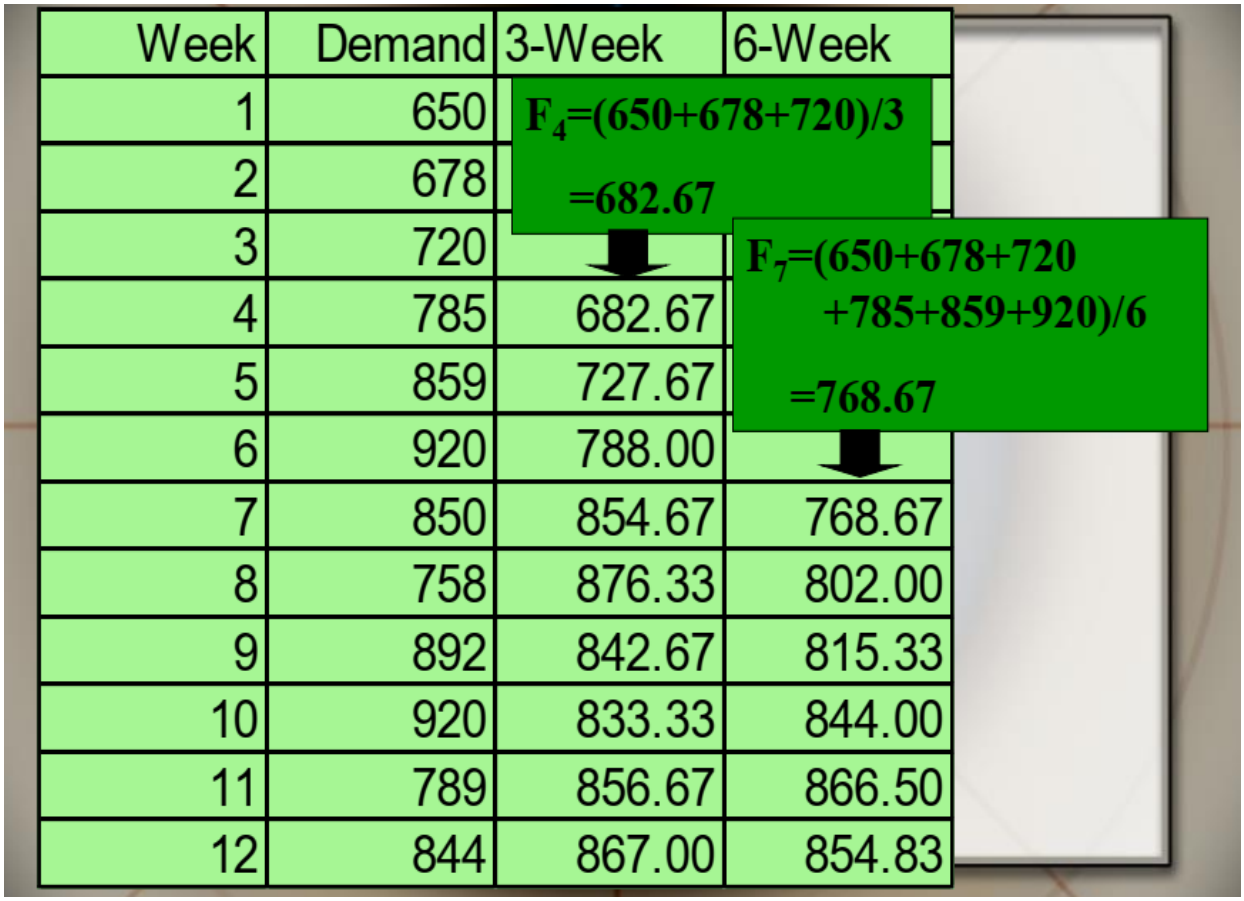
Example

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

Week	Demand
1	650
2	678
3	720
4	785
5	859
6	920
7	850
8	758
9	892
10	920
11	789
12	844

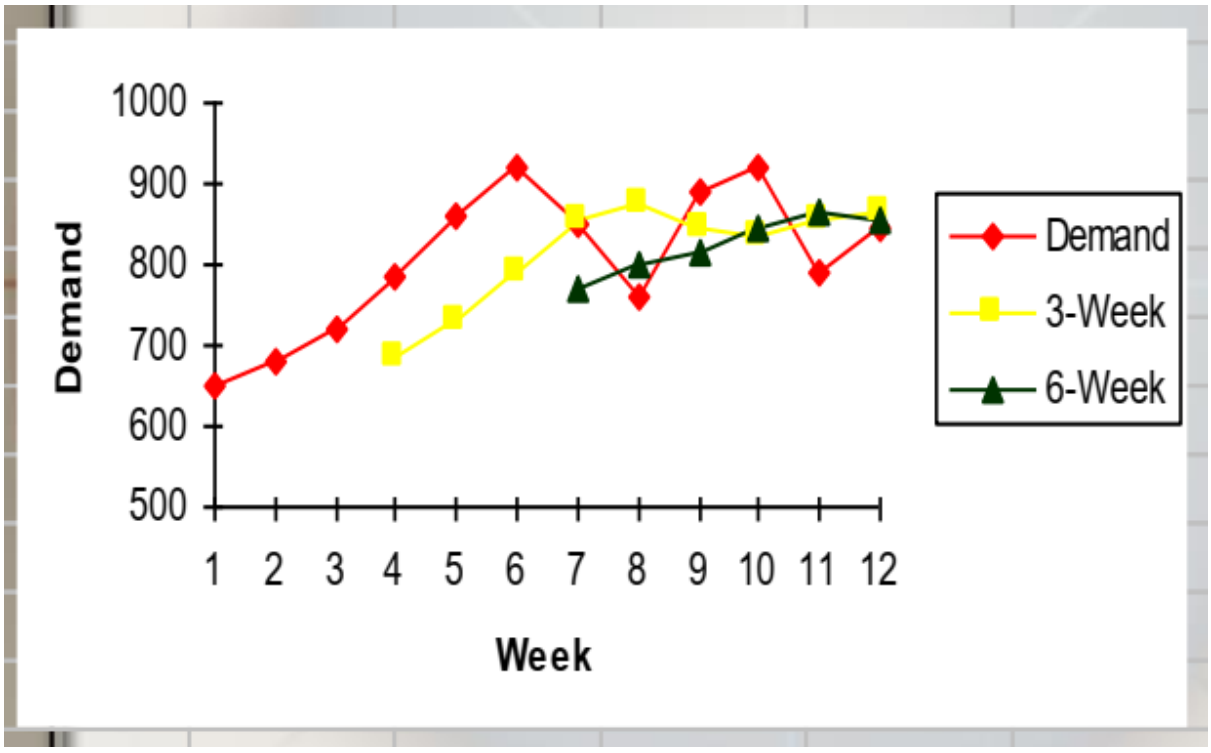
Question: What are the 3-week and 6-week moving average forecasts for demand?

Assume you only have 3 weeks and 6 weeks of actual demand data for the respective forecasts



- F4 – Forecast value in week 4 using 3 week average.
- F5 = [678+720+785]/3 = 727.67 in week 5 using 3 week average [previous three values)
- Similarly, F7 = 768.67 in week 7 using 6 week average [previous 6 values]
- Ft denotes forecast value at time t & At represents Available value at time t.

Moving averages are a common tool used in time series analysis to smooth out fluctuations in data and identify trends. They are calculated by taking the average of a fixed number of data points over a specified period of time. For example, a 30-day moving average of stock prices can help us identify the long-term trend of a particular stock.



"Note that, how the 3-Week is smoother than the Demand, and 6-Week is even smoother"

Sample problem

Week	1	2	3	4	5	6	7
Demand	820	775	680	655	620	600	575

What is the 3 week moving average forecast for the data given in the table?

2. Weighted Moving Average Method

While the moving average method implies an equal weight being placed on each value that is being averaged, the weighted moving average permits an unequal weighting on prior time periods.

The formula for the moving average is:

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

W_t = weight given to time period "t".

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

Sample Problem

Question: Given the weekly demand and weights, what is the forecast for the 4th period or Week 4?

Week	1	2	3	4
Demand	650	678	720	?
Weight	0.2	0.3	0.5	

Solution

Week	1	2	3	4
Demand	650	678	720	693.4

$$F_4 = 0.5(720)+0.3(678)+0.2(650)=693.4$$

Sample Problem

Week	1	2	3	4	5
Demand	820	775	680	655	?
Weight	----	0.1	0.2	0.7	

3. Exponential Smoothing Model

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

F_t = Forcast value for the coming t time period

F_{t-1} = Forecast value in 1 past time period

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

α = Alpha smoothing constant

Why Exponential Smoothing Forecasting is preferred ?

Exponential smoothing is a broadly accurate forecasting method for short-term forecasts. The technique assigns larger weights to more recent observations while assigning exponentially decreasing weights as the observations get increasingly distant. This method produces slightly unreliable long-term forecasts.

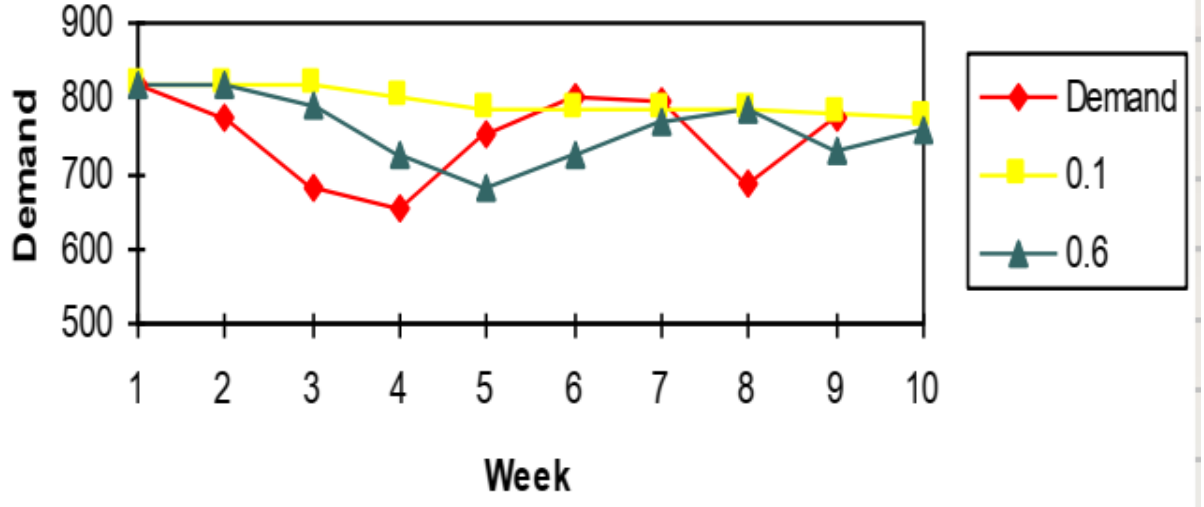
Sample Problem

Week	Demand
1	820
2	775
3	680
4	655
5	750
6	802
7	798
8	689
9	775
10	

Given the weekly demand data, what are the exponential smoothing forecasts for periods 2-10 using α = 0.10 and α = 0.60? Assume F1=D1

Answer: The respective alpha's columns denote the forecast values. Note that you can only forecast one time period into the future

Week	Demand	*0.1*	*0.6*
1	820	820.00	820.00
2	775	820.00	820.00
3	680	815.50	793.00
4	655	801.95	725.20
5	750	787.26	683.08
6	802	783.53	723.23
7	798	785.38	770.49
8	689	786.64	787.00
9	775	776.88	728.20
10		776.69	756.28



Note that, how the smaller α results in a smoother line in this example.

Exercise Problem

What are the exponential smoothing forecasts for periods 2-5 using a =0.5? Assume f1 = d1.

Week	1	2	3	4	5
Demand	820	775	680	655	?
