# Forecasting Methods and techniques

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## What is forecasting

Simply put, forecasting is the process of predicting the future requirement of resources. The resources could be raw materials, finished products, manpower or plant and machinery.

Importance of forecasting

Forecasting is the most important activity based on which the organizations including supply chain prepare their long, medium and short term plan. Based on forecast:-

a)  Supply Chain decides to set up or close manufacturing plants or increase the capacity of the existing plants.
b)  Forecasting is used by marketing to plan their Sales Promotion and Price discounting plans
c)  Based on forecast, the finance team plans their working capital requirement, fund raising plans through debt or equity etc.
d)  Based on forecast, the procurement team enters into contract with the suppliers
e)  Recruitment or retrenchment of workforce is planned based on forecasting

## Characteristics of forecast

a)  Forecast is never accurate. No forecasting technique results in accurate forecast. There will always be an error in the forecast and the role of different forecast techniques is to minimize the error.
b)  Long term forecast is less inaccurate than the short term forecast.
c)  Forecast at aggregate level is more accurate than forecast at the dis-aggregate level. E.g – Forecast for monthly sales of Lay's Chips is more accurate than the forecast for the 50gm pack of Salsa flavor.
d)  The farther the one is in the supply chain, the greater is the forecast in accuracy. This is explained by the Bull Whip effect which states that deviation in the fore cast gets magnified as it moves from the Retailer to distributor to the manufacturer.

## Components of forecast

Forecast has 3 main and one additional component

a) Level – This is the de-seasonalized demand for a product.
b) Trend – This is the uniform increase or decrease observed in a demand over a period of time.
c) Seasonality – This is the periodic increase or decrease in demand which can be predicted.
d) Random component – As the name suggest it is random in nature and cannot be predicted.

## Forecast Error

The difference between the observed demand and forecast is called forecast error.

For e.g. ,if the forecast for period T was 10 and the observed demand was 12, then the forecast error = 12 -10 =2.

Similarly, if the forecast for the period T+1 was 20 and the observed demand was 18, then the forecast error is 18 – 20 = (-) 2.

## Forecasting methods

a) Time Series method
b) Causal method using Regression Analysis
c) Seasonality

## Time series method –

This method uses the past data to make a forecast for the future period. This method is best used when there is no trend or seasonality in the data. That is, the forecast has only the "level" component and no trend and seasonality.

There are 5 types of Time Series based forecasting method

(i)   Naïve Method – This is the simplest form of forecast. Simply put, the demand for the previous time period (day or month) is the forecast for the next period (day or moth)

$$F_t = D_{t-1}$$

(ii)    Cumulative mean – The mean of all demand data available till period T is taken to make a forecast for period T+1.

- This method takes into consideration all past data without considering their relevance on the future demand
- Equal weight age is given to all the past data irrespective of how dated the data is.

$$F_t = \frac{\sum_{i=1}^{t-1} D_i}{t-1}$$

(iii)   Moving Average Method – This method takes the mean of the data in the recent past till time period T to make the forecast for period T+1

a. This method ignores all the previous data and considers only data in the recent past.

b. It gives equal weight age to all the data that is used to make the forecast.

$$L_t = \frac{(D_t + D_{t-1} + \ldots + D_{t-N+1})}{N}$$

$$F_{t+1} = L_t \quad \text{and} \quad F_{t+n} = L_t$$

(iv)    Exponential smoothening – This method considers all the past data and assigns reducing weights to the past data.

$F_{t+1} = \alpha D_t + (1-\alpha)F_t$ ……………………………. (1)

Where $\alpha$ is the weight assigned to the previous demand.

Value of $\alpha$ varies from $0 < \alpha < 1$

$F_t = \alpha \times D_{t-1} + (1-\alpha) F_{t-1}$ ……………………………. (2)

Substituting equation 2 in equation 1,

$F_{t+1} = \alpha D_t + (1-\alpha) \times \{\alpha D_{t-1} + (1-\alpha)F_{t-1}\}$

Continuing with the substitutions, we end up with a equitation which is:-

$F_{t+1} = \alpha D(T) + \alpha \times (1-\alpha) \times D_{t-1} + \alpha (1-\alpha)^2 D_{t-2} + \ldots\ldots$

- The value of weight varies between 0 and 1

- This method takes into consideration all the past data and assigns decreasing value to the past data.

Other Characteristics of Time Series Method

a) It only considers past data and is not suited if there is trend or seasonality in the data.
b) If there is an upward trend, then the forecast will always be on the lower side. If there is an downward trend, then the forecast will be on the higher side.
c) Time series method gives no intelligence. It does not tell what is causing the demand to behave in a particular way. It throws no light on the various factors which might be affecting the demand data.

## Causal Method – Regression Analysis

Regression is the method which is used to prepare a mathematical equation which gives the relationship between dependent variable and independent variables.

This method tries to identify the cause's affecting the data and build a mathematical equation which relates the demand which is the dependent variable to the various factors which are the independent variable.

The objective is to fit a straight line where the slope represents the trend in the data.

## Simple Linear Regression

If the dependent variable (Y) is dependent only on one independent variable (X), then it is called Simple linear regression and the equation which describes the relationship between the dependent and independent variable is of the form

$Y = aX + b$

Where a is the slope and b is the intercept.

## Multiple regressions

If the dependent variable is influences by more than one independent variables then it is called multiple regressions and the equation is of the form

$Y = a_1X + a_2Y + a_3Z$

Where in X, Y, Z are the independent variables and $a_1$, $a_2$ and $a_3$ are are the slopes and b is the intercept.

Microsoft Excel offers an add-in called Data Analysis which enables solving the regression equation.

## Seasonality

This method is used to make a forecast for data showing seasonality. Seasonality is the periodic variation in the dependent variable and can be predicted.

The method used involves converting the data set into a de-seasonalized data set.

The following method is followed:-

Example – Data giving the number of visitors to a hill station

| Visitors to Hill Station ('000) | | | |
|---|---|---|---|
| Year/Season | 2012 | 2013 | 2014 |
| Fall | 16 | 15 | 14 |
| Winter | 7 | 6 | 6 |
| Spring | 12 | 12 | 12 |
| Summer | 23 | 25 | 24 |

## Step 1 – Calculate Sample Mean

Sample Mean = 14.33('000)

## Step 2 – Calculate the Seasonal Mean

| Visitors to National Park ('000) | | | | |
|---|---|---|---|---|
| Year/Season | 2012 | 2013 | 2014 | Season Mean('000) |
| Fall | 16 | 15 | 14 | 15 |
| Winter | 7 | 6 | 6 | 6.33 |
| Spring | 12 | 12 | 12 | 12 |
| Summer | 23 | 25 | 24 | 24 |

**Step 3 – Calculate the Seasonality Index**

$$Seasonality\ Index = \frac{Seasonal\ Mean}{Sample\ Mean}$$

| Visitors to National Park ('000) | | | | | |
|---|---|---|---|---|---|
| Year/Season | 2012 | 2013 | 2014 | Season Mean('000) | Seasonal Index |
| Fall | 16 | 15 | 14 | 15 | 1.046511628 |
| Winter | 7 | 6 | 6 | 6.33 | 0.441860465 |
| Spring | 12 | 12 | 12 | 12 | 0.837209302 |
| Summer | 23 | 25 | 24 | 24 | 1.674418605 |

**Step 4 – Divide the data points with the corresponding seasonal index to generate de-seasonalized data**

| De-Seasonalized Data ('000) | | | | |
|---|---|---|---|---|
| Year/Season | 2012 | 2013 | 2014 | Seasonal Index |
| Fall | 15.29 | 14.33 | 13.38 | 1.046511628 |
| Winter | 15.84 | 13.58 | 13.58 | 0.44 |
| Spring | 14.33 | 14.33 | 14.33 | 0.837209302 |
| Summer | 13.74 | 14.93 | 14.33 | 1.674418605 |

**Step 5 – Determine the average visitors for the year 2014 using the de-seasonalized data by using 4 point moving average method**

Average for the year 2014 = 13.91('000)

**Step 6 – Forecast for the season Fall for the 2015 = Multiply the average from Step 5 with the corresponding seasonal index.**

Forecast for Fall 2015 = 13.91 X 1.046511628  = 14.55('000)


**<u>Forecast Accuracy</u>**

- Forecast accuracy is a measure of good forecast it and how far away it is from the actual demand,

- A forecast is said to have a bias if the forecast consistently tends to over forecast or under forecast.

- Forecast error is measured by subtracting the forecast from the demand

  Forecast Error$_t$ = Demand$_t$ - Forecast$_t$

There are 3 methods to calculate the Forecast Accuracy

a) **Mean Forecast error**

   The simplest form of a forecast accuracy measure is the mean error.
   - Determine the Forecast error for all the time periods
   - Calculate the Average of all the forecast errors and that gives the Mean error.

   $$ME = \frac{\Sigma(D_t - F_t)}{n}$$

b) **Mean Absolute % Error**
   - Determine the Forecast error for all time periods
   - Determine the absolute value of the error
   - Determine the Absolute % error
   - Calculate the average of the absolute % error for all the time periods

   $$MAPE = \frac{\Sigma|D_t - F_t/D_t|}{n}$$

c) **Mean Square Error**
   - Determine the Forecast error for all time periods
   - Square the errors
   - Calculate the average of the squared errors for all the time period

   $$MSE = \frac{\Sigma(D_t - F_t)^2}{n}$$

   - We are squaring the error and the large errors get further magnified.
   - This method gives more weight age to the large errors which needs to be avoided and is difficult to plan for.