CHAPTER-III
FORECASTING

Casting data forward is called forecasting. It is a projection based upon past data or it is an estimate of an event which will happen in future.

Need of forecasting:

- When there is a time lag between awareness of an impending event or need and occurrence of that event. This lead time is the main reason of planning and forecasting.
- Planning is the fundamental activity of management. Forecasting forms the basis of planning.
- It is essential for the organization to know for what level of activities one is planning before investments in input.

Types of Forecasting:

→ **Short Term Forecasting**

→ **Long Term Forecasting**

Short Term forecasting is the forecasting that made for short term objectives covering less than one year. Ex. Material Requirement Planning (MRP), scheduling, sequencing, budgeting etc.

Long Term Forecasting is the forecasting that made for that made for long term objectives covering more than five years. Ex. Product diversification, sales and advertisement.

Elements of Forecasting:

Forecasting consists basically of analysis of the following elements.

a) Internal factors
b) External factors
   i. Controllable
   ii. Non-Controllable (Organizing with national economy,governments,customers and Competitors)

Basic categories of forecasting methods:

Forecasting methods can be divided in to three main categories.

A. Extrapolative or Time-series Methods
B. Casual or explanatory methods
C. Qualitative or judgmental methods

Time-series Methods and explanatory methods are quantitative methods and judgmental methods are qualitative methods. Quantitative methods will be adopted when sufficient quantitative information available and when little or no qualitative information available but sufficient qualitative knowledge available qualitative methods will be preferable.

A. Extrapolative or Time-series Methods

- Time series forecasting models try to predict the future based on past data.
- Relate the forecast to only one factor – time.
- Include
  - ✓ Moving average
  - ✓ Exponential smoothing

Moving Average

- **Naive forecast:** demand in current period is used as next period's forecast
- **Simple moving average**
  - Uses average demand for a fixed sequence of periods.
  - Stable demand with no pronounced behavioral patterns.
- **Weighted moving average**
  - *Weights are assigned to most recent data.*

Moving Average: Naïve Approach

Example: Forecast the order for the month of November by Naïve approach.

MONTH	ORDERS PER MONTH	FORECAST
Jan	120	-
Feb	90	120
Mar	100	90
Apr	75	100
May	110	75
June	50	110
July	75	50
Aug	130	75
Sept	110	130
Oct	90	110
Nov	-	90

Solution: Forecast order for the month of November,

$$(F)_{Nov} = 90 \text{ units}$$

Simple Moving Average

n = number of periods taken to evaluate the moving average

D_t or D_i = Actual demand in that period

SMA_t = simple moving average at the end of the period t or estimated demand at the end of that period.

$$SMA_t = \frac{D_{t-(n-1)} + D_{t-(n-2)} + \ldots + D_{t-1} + D_t}{n}$$

3-month Simple Moving Average

MONTH	ORDERS MONTH PER MONTH	*MOVING AVERAGE*
Jan	120	–
Feb	90	–
Mar	100	–
Apr	75	103.3
May	110	88.3
June	50	95.0
July	75	78.3
Aug	130	78.3
Sept	110	85.0
Oct	90	105.0
Nov	-	110.0

$$MA_3 = \frac{\sum_{i=1}^{3} D_i}{3} = \frac{90+110+130}{3} = 110$$

orders for Nov

5-month Simple Moving Average

MONTH	ORDERS MONTH PER MONTH	*MOVING AVERAGE*
Jan	120	–
Feb	90	–
Mar	100	–
Apr	75	–
May	110	–
June	50	99.0
July	75	85.0
Aug	130	82.0
Sept	110	88.0
Oct	90	95.0
Nov	-	91.0

$$MA_5 = \frac{\sum_{i=1}^{5} D_i}{3} = \frac{90+110+130+75+50}{5} = 91$$

orders for Nov

Smoothing effects

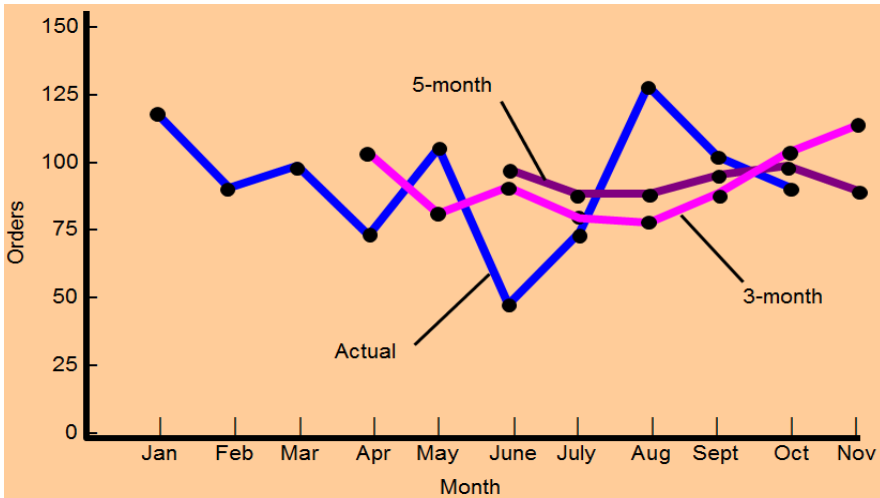


Fig 3.1 Classification of production systems

Note: ⅄ It gives equal weight to the demand in each of the most n periods.

⅄ Small value of n can capture data pattern more closely compared to high value of n Because high value of n averages out more to the data or a greater smoothing effect on random fluctuations.

Weighted Moving Average

While the moving average formula 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

$$WMA_t = \sum_{i=1}^{n} W_i D_i \qquad \sum_{i=1}^{n} w_i = 1$$

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

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

Week	Demand
1	650
2	678
3	720
4	

Weights:
t-1
t-2
t-3

Note that the weights place more emphasis on the most recent data, that is time period "t-1"

Week	Demand	Forecast
1	650	
2	678	
3	720	
4		693.4

INPUT
- Material
- Machines
- Labor

Exponential Smoothing

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

where:

F_{t+1} =forecast for next period

D_t =actual demand for present period

F_t = previously determined forecast for present period

α =weighting factor, smoothing constant

Effect of Smoothing Constant

$0.0 \le a \le 1.0$

If a = 0.20, then $F_{t+1} = 0.20\ D_t + 0.80\ F_t$

If a = 0, then $F_{t+1} = 0\ D_t + 1\ F_t = F_t$

Forecast does not reflect recent data

If a = 1, then $F_{t+1} = 1\ D_t + 0\ F_t = D_t$

Forecast based only on most recent data

Question: Given the weekly demand data, what are the exponential smoothing forecasts for periods 10th using a=0.10 and a=0.60?

Assume $F_1 = D_1$

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

Solution: The respective alphas 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 how that the smaller alpha results in a smoother line in this example

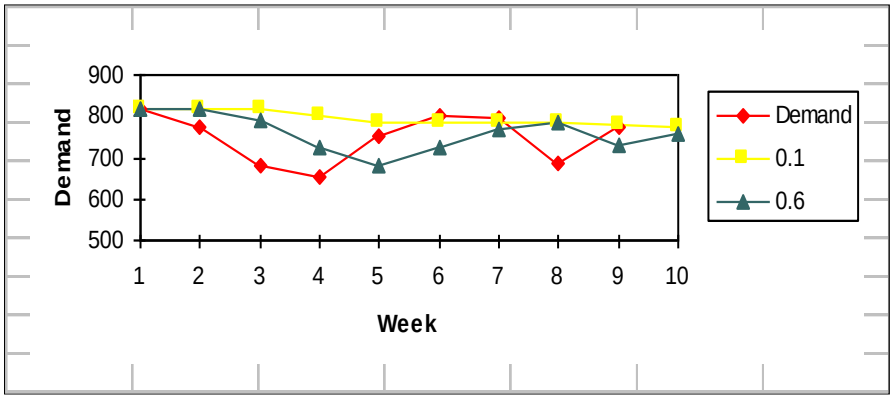


Fig 3.2 Effect of Smoothing Constant

Adjusted Exponential Smoothing

$$AF_{t+1} = F_{t+1} + T_{t+1}$$

where

T = an exponentially smoothed trend factor

$$T_{t+1} = \beta(F_{t+1} - F_t) + (1 - \beta)\, T_t$$

where

T_t = the last period trend factor

β = a smoothing constant for trend

$0 \le \beta \le 1$

$F_{t+1} = A_t + T_t$

Where,

$At = \alpha Dt + (1 - \alpha)(A_{t-1} + T_{t-1})$ and

T = an exponentially smoothed trend factor

$T_t = \beta(A_t - A_{t-1}) + (1 - \beta)T_{t-1}$

T = an exponentially smoothed trend factor

T_{t-1} = the last period trend factor

β = a smoothing constant for trend

$0 \le \beta \le 1$

Question

PM Computer Services assembles customized personal computers from generic parts. they need a good forecast of demand for their computers so that they will know how many parts to purchase and stock. They have compiled demand data for the last 12months. There is an upward trend in the demand. Use trend-adjusted exponential smoothing with smoothing parameter $\alpha = 0.5$ and trend parameter $\beta = 0.3$ to compute the demand forecast for January (Period 13).

Period	Month	Demand	Period	Month	Demand
1	January	37	7	July	43
2	February	40	8	August	47
3	March	41	9	September	56
4	April	37	10	October	52
5	May	45	11	November	55
6	June	50	12	December	54

Solution:

For Period 2,

we have F2 = A1 + T1, so to get the process started, let A0 = 37 and T0 = 0.

$A1 = \alpha D1 + (1 - \alpha)(A0 + T0) = 0.5(37) + (1 - 0.5)(37 + 0) = 37,$

and $T1 = \beta(A1 - A0) + (1 - \beta)T0 = 0.3(37 - 37) + (1 - 0.3)(0) = 0$

$F_2 = A_1 + T_1 = 37 + 0 = 37$

For Period 3,

A2 = αD2 +(1−α)(A1+T1) = 0.5(40)+(1−0.5)(37+0) = 38.5, and

T2 = β(A2 −A1)+(1−β)T1 =0.3(38.5− 37)+ (1 − 0.3)(0) = 0.45.

F3 = A2 + T2 = 38.5+ 0.45 = 38.95.

			Expon. Smooth..	Trend-Adjusted Expon. Smooth. (α= 0.5, β = 0.3)		
Period	Month	Demand	α = 0.5	At	Tt	Ft
1	Jan	37	37.00	37.00	0.00	37.00
2	Feb	40	37.00	38.50	0.45	37.00
3	Mar	41	38.50	39.98	0.76	38.95
4	Apr.	37	39.75	38.87	0.20	40.73
5	May	45	38.38	42.03	1.09	39.06
6	Jun.	50	41.69	46.56	2.12	43.12
7	Jul.	43	45.84	45.84	1.27	48.68
8	Aug.	47	44.42	47.05	1.25	47.11
9	Sep.	56	45.71	52.15	2.41	48.31
10	Oct.	52	50.86	53.28	2.02	54.56
11	Nov.	55	51.43	55.15	1.98	55.30
12	Dec.	54	53.21	55.56	1.51	57.13
13	Jan	?	53.61			57.07

B. Casual or explanatory methods

Simple Linear Regression Model

$y = a + bx$

where

a = intercept

b = slope of the line

x = time period

y = forecast for demand for period x

$Nov_4 = WMA_3$ 0.5(720)+0.3(678)+0.2(650)=693.4

$$a = \bar{y} - b\bar{x}$$

$$b = \frac{\sum xy - n(\bar{y})(\bar{x})}{\sum x^2 - n(\bar{x})^2}$$

Question: Given the data below, what is the simple linear regression model that can be used to predict sales in future weeks?

Week	Sales
1	150
2	157
3	162
4	166
5	177

Solution: First, using the linear regression formulas, we can compute "a" and "b".

Week	Week*Week	Sales	Week*Sales
1	1	150	150
2	4	157	314
3	9	162	486
4	16	166	664
5	25	177	885
3	*55*	*162.4*	*2499*
Average	Sum	Average	Sum

$$b = \frac{\sum xy - n(\bar{y})(\bar{x})}{\sum x^2 - n(\bar{x})^2} = \frac{2499 - 5(162.4)(3)}{55 - 5(9)} = \frac{63}{10} = \mathbf{6.3}$$

$$a = \bar{y} - b\bar{x} = 162.4 - (6.3)(3) = \mathbf{143.5}$$

The resulting regression model is:

$$Y_t = 143.5 + 6.3x$$

Correlation Coefficient, *r*

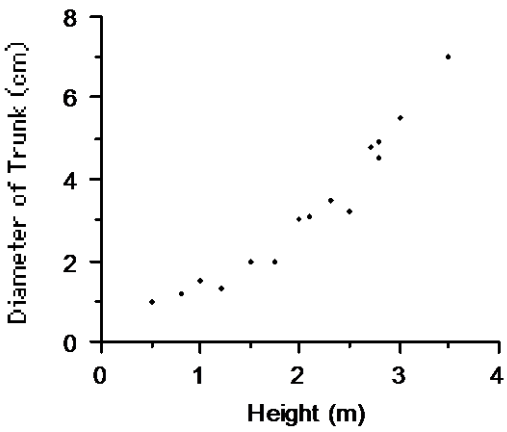
- ✓ The quantity *r*, called the *linear correlation coefficient*, measures the strength and the direction of a linear relationship between two variables. The linear correlation coefficient is sometimes referred to as the *Pearson product moment correlation coefficient* in honor of its developer Karl Pearson.
- ✓ The value of r is such that -1 < r < +1. The + and – signs are used for positive linear correlations and negative linear correlations, respectively.
- ✓ Positive correlation: If x and y have a strong positive linear correlation, r is close

to +1. An r value of exactly +1 indicates a perfect positive fit. Positive values indicate a relationship between x and y variables such that as values for x increases, values for y also increase.

- ✓ Negative correlation: If x and y have a strong negative linear correlation, r is close to -1. An r value of exactly -1 indicates a perfect negative fit. Negative values indicate a relationship between x and y such that as values for x increase, values for y decrease.
- ✓ No correlation: If there is no linear correlation or a weak linear correlation, r is Close to 0. A value near zero means that there is a random, nonlinear relationship between the two variables
- ✓ Note that r is a dimensionless quantity; that is, it does not depend on the units employed.
- ✓ A perfect correlation of ± 1 occurs only when the data points all lie exactly on a straight line. If r = +1, the slope of this line is positive. If r = -1, the slope of this line is negative.

Positive Correlation

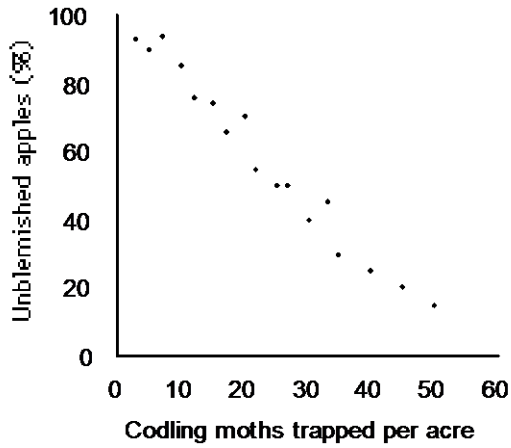
Figure 1: Relationship between height and trunk diameter in Eastern White Pines



Notice that in this example as the heights increase, the diameters of the trunks also tend to increase. If this were a perfect positive correlation all of the points would fall on a straight line. The more linear the data points, the closer the relationship between the two variables.

Negative Correlation

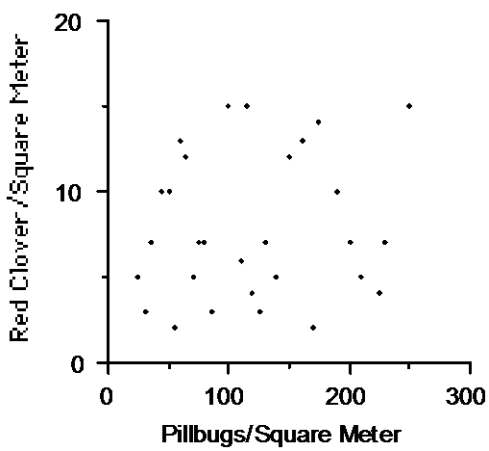
Figure 2: Relationship between incidence of an apple parasite and fruit harvest



Notice that in this example as the number of parasites increases, the harvest of unblemished apples decreases. If this were a perfect negative correlation all of the points would fall on a line with a negative slope. The more linear the data points, the more negatively correlated are the two variables.

No Correlation

Figure 3: Relationship between density of pillbugs and red clover



Notice that in this example there seems to be no relationship between the two variables. Perhaps pillbugs and clover do not interact with one another.

The mathematical formula for computing ***r*** is:

$$r = \frac{n\sum xy - \left(\sum x\right)\left(\sum y\right)}{\sqrt{n\left(\sum x^2\right) - \left(\sum x\right)^2}\sqrt{n\left(\sum y^2\right) - \left(\sum y\right)^2}}$$

Where n is the number of pairs of data.

A correlation greater than .8 is generally described as strong , whereas a correlation less than .5 is generally described as weak.

Coefficient of Determination, r 2 or R2 :

- ✓ The *coefficient of determination*, r^2, is useful because it gives the proportion of the variance (fluctuation) of one variable that is predictable from the other variable. It is a measure that allows us to determine how certain one can be in making predictions from a certain model/graph.
- ✓ The *coefficient of determination* is the ratio of the explained variation to the total variation.
- ✓ The *coefficient of determination* is such that $0 \leq r^2 \leq 1$, and denotes the strength of the linear association between *x* and *y*.
- ✓ The coefficient of determination represents the percent of the data that is the closest to the line of best fit. For example, if r = 0.922, then r 2 = 0.850, which means that 85% of the total variation in y can be explained by the linear relationship between x and y (as described by the regression equation). The other 15% of the total variation in y remains unexplained.
- ✓ The coefficient of determination is a measure of how well the regression line represents the data. If the regression line passes exactly through every point on the scatter plot, it would be able to explain all of the variation. The further the line is away from the points, the less it is able to explain.

C. Qualitative or judgmental methods

- **Delphi Method**
- **Market Research**

Delphi Method

- The Delphi method is a process of gaining consensus from a group of experts While maintaining their anonymity.
- It is forecasting techniques applied to subjective nature demand values.
- It is useful when there is no historical data from which to develop statistical models and when managers inside the firm have no experience.
- Several knowledgeable persons are asked to provide estimates of demand or forecasts of possible advances of technology.
- A coordinator sends questions to each member of the panel of outside experts, and they are unknown to each other. Anonymity is important when some members of the tend to dominate discussion or command a high degree of respect in their field. The members tend to respond to the questions and support their responses freely. The coordinator prepares a statistical summary of the responses along with a summary of arguments for a particular response. If the variation

among the opinions too much the report is sent to the same group for another round and the participants may choose to modify their previous responses. This process will be continuing until consensus is obtained. So Delphi method is a iterative process.

Market Research

- It is systematic approach to determine external consumer interest in a service or product by creating and testing hypothesis through data-gathering surveys.
- It includes all research activities in marketing problem:
    - Gathering, recording and analyzing the utility and marketability of the product
    - The nature of the demand
    - The nature of competition
    - The methods of marketing
    - Other aspects of movements of product from the stage of to the point where they get consumed.
- Market research gathers records and analysis all facts about problems relating to the transfer and sale of goods and services from producer to consumer.
- Market Research procedure
  Define the problem clearly
  Develop a clear set of research objectives.
  Supervise the task of collecting the data from the existing consumers.
  Extract meaningful information from the collected data.
  Prepares a report presenting the major findings and recommendations coming from the study.
- It may be used to forecast demand for the short, medium and long-term. Accuracy is excellent for the short term, good for the medium term and only fair for the long term.

Forecast Error:

Forecast error
Difference between forecast and actual demand.

MAD (mean absolute deviation):

$$MAD = \frac{\sum_{t=1}^{n} |D_t - F_t|}{n}$$

where

t = period number
D_t = demand in period t
F_t = forecast for period t

n = total number of periods

Question: What is the MAD value given the forecast values in the table below?

Month	**Sales**	**Forecast**
1	220	
2	250	255
3	210	205
4	300	320
5	325	315

Solution

Month	**Sales**	**Forecast**	**Abs Error**
1	220		
2	250	255	5
3	210	205	5
4	300	320	20
5	325	315	10
			40

$$MAD = \frac{\sum_{t=1}^{n} |D_t - F_t|}{n} = \frac{40}{4} = 10$$

Note that by itself, the MAD only lets us know the mean error in a set of forecasts

Mean absolute percent deviation (MAPE)

$$MAPE = \frac{1}{n} \frac{\sum_{t=1}^{n} |D_t - F_t|}{D_t} * 100$$

Demand Behavior:

- Trend
  - a gradual, long-term up or down movement of demand
- Random variations
  - movements in demand that do not follow a pattern
- Cycle

    - an up-and-down repetitive movement in demand

- Seasonal pattern
    - an up-and-down repetitive movement in demand occurring periodically

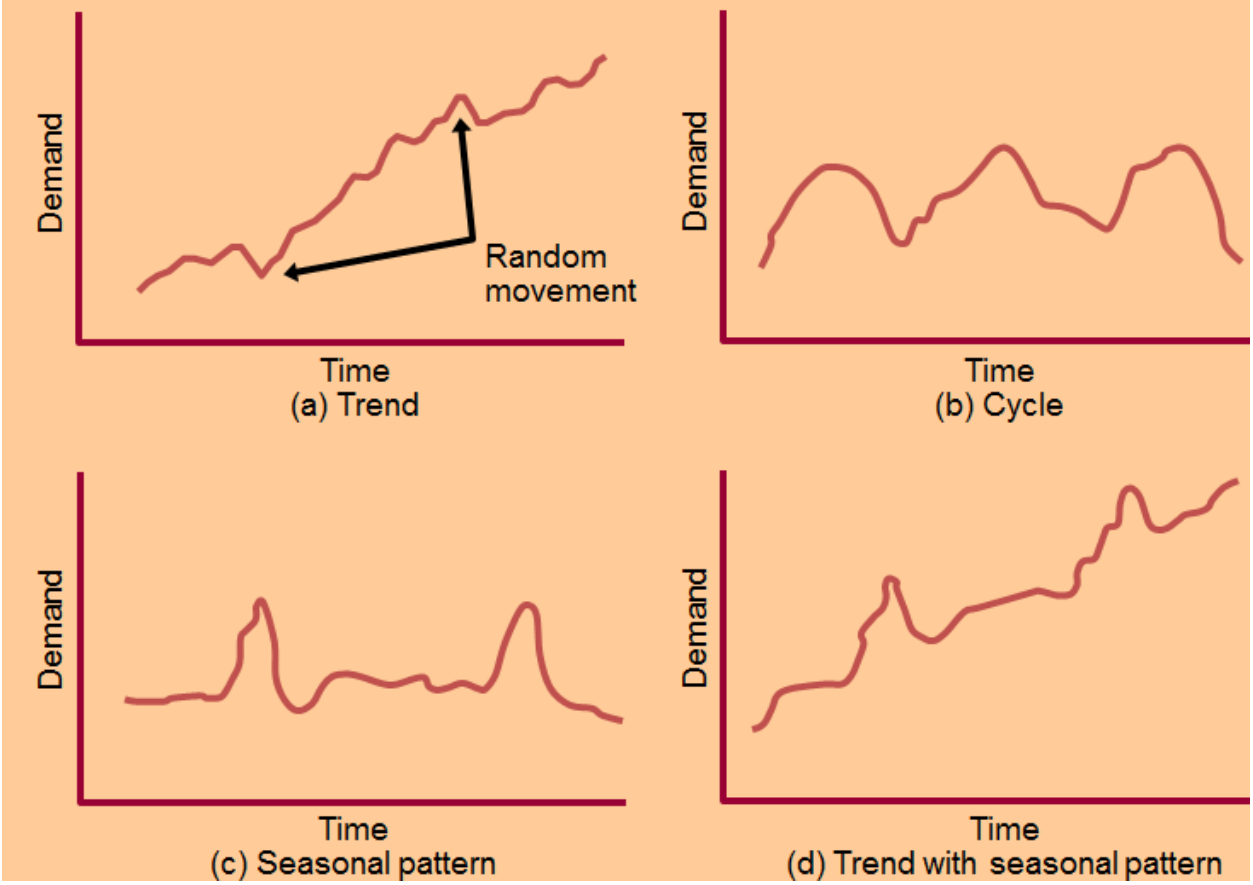


Fig 3.3 Forms of Forecast Movement

* FORECASTING *

Date :

Forecasting is the prediction of Future sales or Demand for a product. It is defined as the Estimation of Future activities i.e the estimation of time, quality, quantity of Future work. These estimate provide the basis for determining the demand of man power, machines and material in future.

It is not a guess work but a projection based on passed sales figure and human judgement.

Need of forecasting

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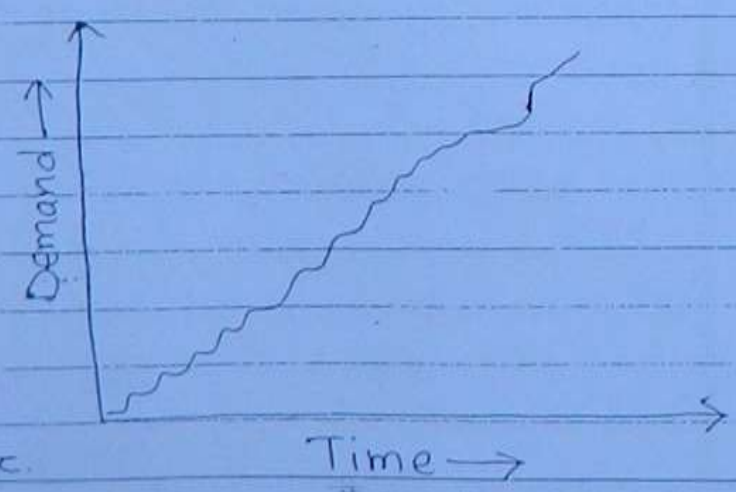
1. It helps in determining the volume of production & production rate.
2. It forms the basis for production budget, Labour budget, material budget etc.
3. It suggest the need for plant expansion.
4. It helps in product design & development.
5. It helps in determining price policies.
6. Helps in determining the extent of marketing, advertisement and distribution required

Types of Demand Variation

1. Trend Variation:

It shows a long term upward or downward movement in the demand or sales of a product. It shows a regular pattern.

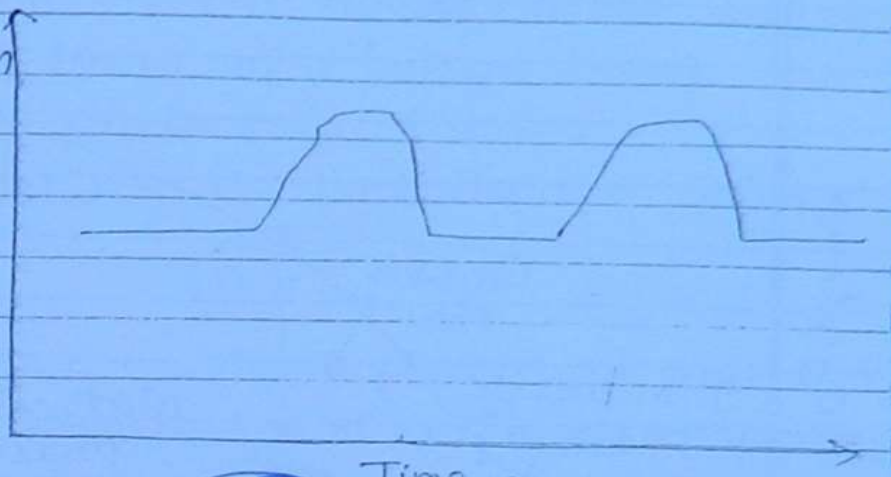


eg Newspaper, Cellphones etc.

Date :

2) Seasonal Variation:

It shows a short-term regular variation related to the time of a day or day of a week



e.g. Electricity Bill (daily)
Movie Tickets etc

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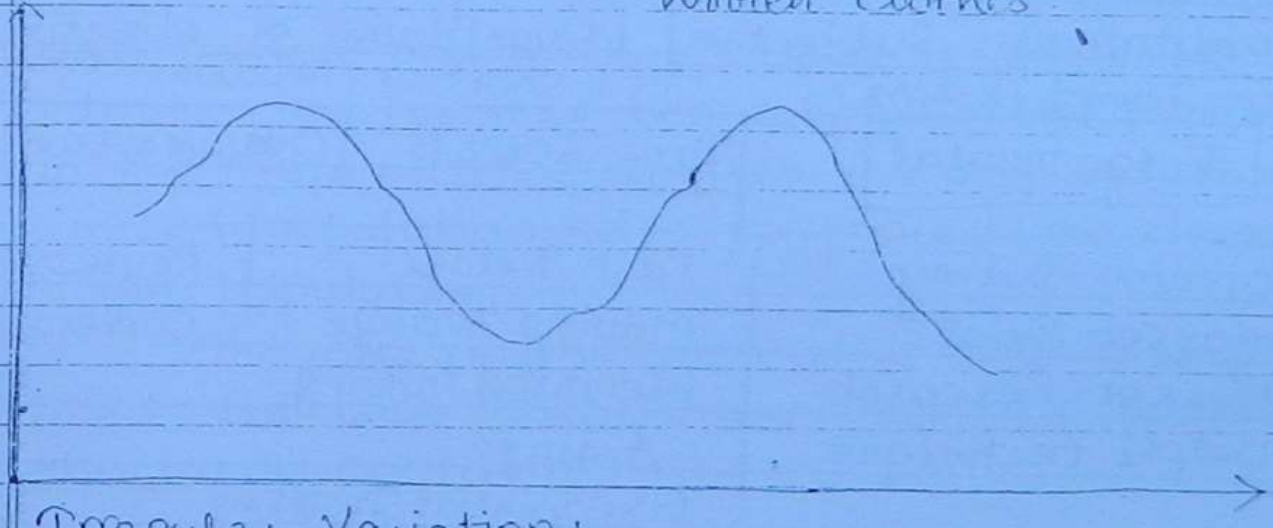
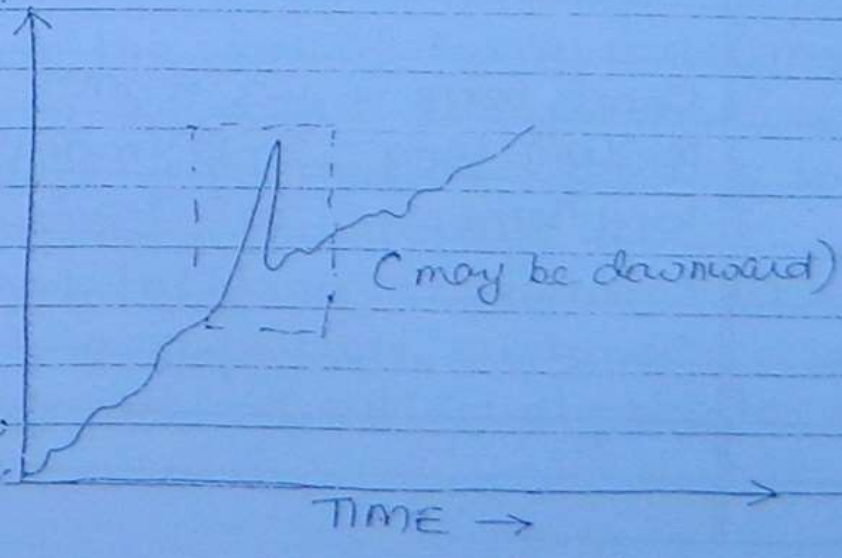
3) Cyclic Variation: Wave like variation lasting more than ~~the earlier~~ a year & it is repeated after a certain period. e.g. Yearly Electricity Bill, Refrigerator, Woolen Clothes



4) Irregular Variation:

These are caused by unusual circumstances which are not reflected of typical behaviour/ Normal behaviour. These may be due to severe weather conditions, strike, Plant shutdown etc.



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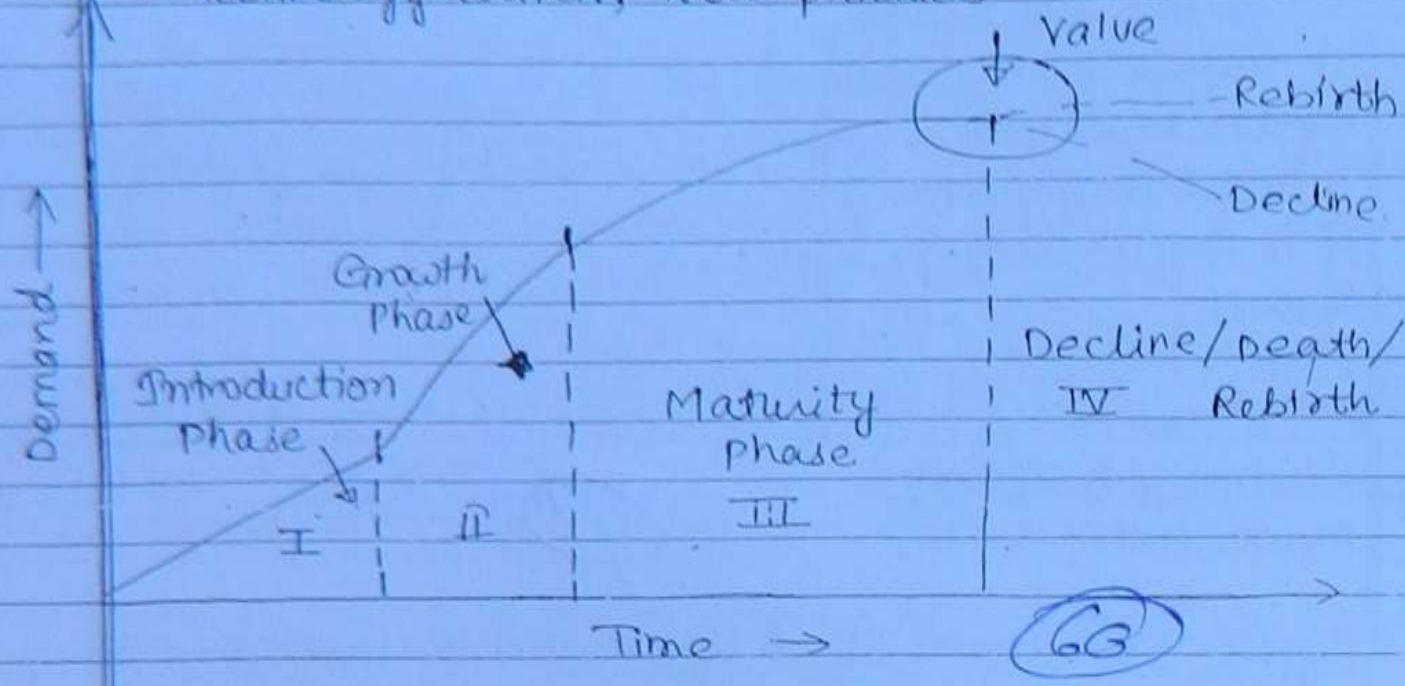
Product life cycle :-

Technology driven, New products



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TYPES OF FORECASTING :

- Qualitative or Subjective — Long Term (2-5 Yrs)
  - Judgemental
    - Opinion survey
    - Market Trial
    - Market Research
    - Delphi technique
- Quantitative or objective (Short or Medium term)
  - Time Series
    - Past Average
    - Moving Average
    - Weighted Moving Average
    - Exponential Smoothing
  - Causal or Econometric
    - Regression
    - Correlation

Short term = 1-3 month
Medium term = 3-12 month
Long Term = 2-5 Years

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Date :

A Qualitative or Subjection

Judgemental: This method is based on the art of human judgement ie How well a human being can predict a demand of product in future.

This method doesnot require past data or sales figure

(6)

1. Opinion Survey: In this method opinions are collected from the customers, retailers and distributor regarding the demand pattern for a product.

They give information regarding why they buy a particular product, what cost they are willing to pay, additional features required in the product, their margin in profit etc.

2. Market Trial: This method is normally used for a New product and in that case it is advisable to introduce the product between a limited population in the form of free samples The response from the limited population helps to project the demand from bigger population.

The cost of this method is High and it is used for low cost consumables like Toothpaste, chocolates, Colddrinks etc.

3. Market Research: Here the work of survey is assigned to external marketting agencies & the purpose of research is to collect information regarding the consumption of a product, the details about various factor which influence the demand like location, customer's occupation, customer's income quantity & quality etc are scientifically related to get the Forecast

Date :

4. Delphi Technique: In this method, a panel of experts are asked a series of questions in which the response to one question is used to produce next question. The information available to some experts are made available to other experts. It is a step by step procedure in which opinion's are collected from the experts to arrive at a reliable forecast.

B. Quantitative or Objective (2)

(i) Time series :- It refers to the past data arranged in a chronological order as dependent variable & Time as independent variable (Year / Demand).

1. Past average: In this method forecast is equal to average sells or demand of a product for previous period.

2. Moving Average: This method uses past data & calculates a rolling average for a constant period (n). Fresh average is computed at the end of each period by adding the demand of the most recent period and deleting the demand for the older period. Since data in this method, changes from period to period, it is called moving average method

$$F_{2008} = \frac{99+116+124+94}{4} \quad (4\text{-Time}$$

$$F_{2008} = 0.25\times99 + 0.25\times116 + 0.25\times124 + 0.25\times94$$

Year	Demand
2004	94
5	124
6	116
7	99
8	136
9	114
10	148

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3. Weighted Moving average:

$F_{2008} = 0.4 \times 99 + 0.3 + 116 + 0.2 \times 124 + 0.1 \times 94.$ $(n=4)$

$(0.4 + 0.3 + 0.2 + 0.1 = 1$ should$)$

In this method, Unequal weights are assigned to the demand data such that sum of all weights equals to one. The most recent data is given the highest weight and the weight assigned to the oldest data is the least.

Here, n = no. of Period.

1. Sum of 'n' natural no's $= \Sigma n = \frac{n(n+1)}{2}$

2. Arrange in decreasing order of

$$\frac{n}{\Sigma n}, \frac{n-1}{\Sigma n}, \frac{n-2}{\Sigma n}, \ldots \frac{1}{\Sigma n}$$

4. Exponential Smoothing: In this method, we need not to carry large data base as this method requires only the current demand & the forecasted value for the current period to give the next forecast. This method is preferred as it assigns weight to all previous data & the pattern of weight assign are

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of exponential form. The most recent data is given the highest weight & the weight assigned to the older data decreases exponentially.

New Forecast = Forecast for the last Period + α [Demand for the last period − Forecast for the last period]

$$F_t = F_{t-1} + \alpha [D_{t-1} - F_{t-1}]$$

$$\boxed{F_t = F_{t-1} + \alpha \cdot \text{Error}}$$

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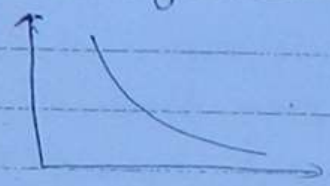
$$\text{Error} = \Delta = D_{t-1} - F_{t-1}$$

where, α is known as smoothing constant and is equivalent of 'n' period, moving average method & is given by

$$\boxed{\alpha = \frac{2}{n+1}}$$



General Equation for Exponential Smoothing:-

$$F_t = \alpha D_{t-1} + \alpha(1-\alpha) D_{t-2} + \alpha(1-\alpha)^2 D_{t-3} + \cdots$$

$$F_t = \alpha D_{t-1} + (1-\alpha)[\alpha \cdot D_{t-2} + \alpha(1-\alpha) D_{t-3} + \cdots \infty]$$

$$\boxed{F_t = \alpha D_{t-1} + (1-\alpha) \cdot F_{t-1}}$$

$$\boxed{F_t = F_{t-1} + \alpha [D_{t-1} - F_{t-1}]}$$

7 If for initial period forecasted value is not given Then :

1. Take the demand for the I period equals to the forecasted value for the I period. i.e $D_1 = F_1$ Naive Method.

2. Take the average of the demand values as the forecasted value for the I period and proceed.

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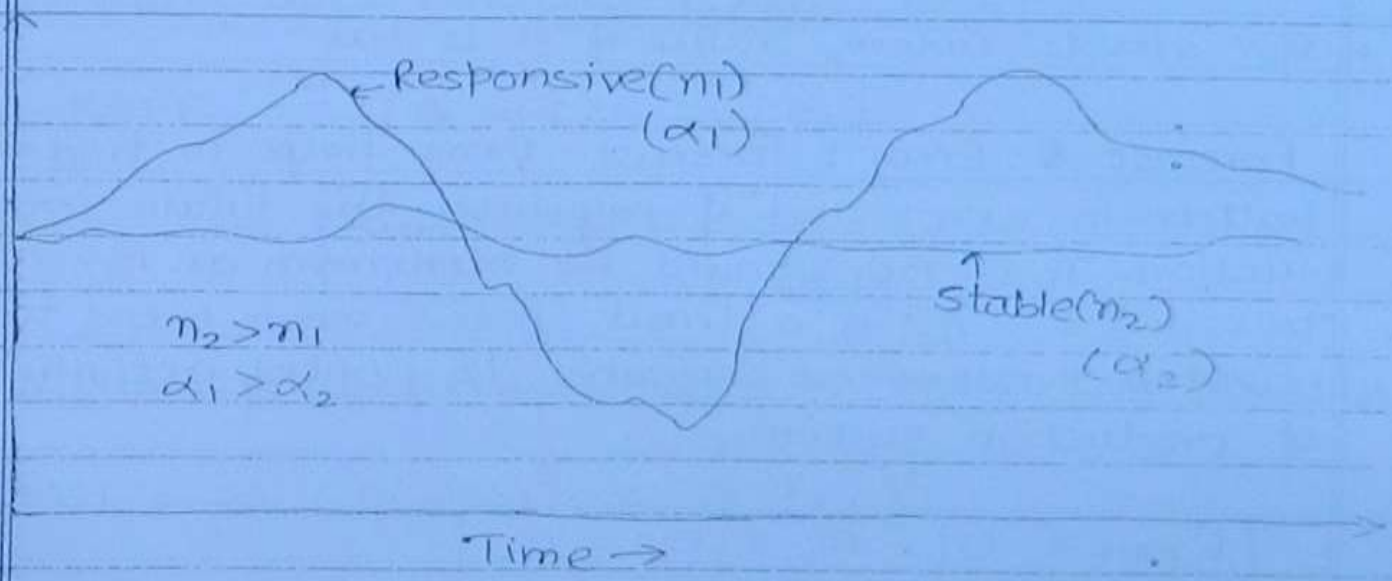
Responsiveness & Stability



1. Responsiveness: It incidates that Forecast have a Fluctuating or swinging pattern. These are preferred for new product & for that number of period is kept low.

2. Stability: It indicates that Forecast pattern have levelled or flat pattern or has less fluctuation. It indicates ideal condition & is used for old existing product & for that no. of period is kept large.

In case of exponential smoothing $\alpha_1 > \alpha_2$.

$\alpha = \frac{2}{n+1}$, $\because$ for α_2, n is more.

$$F_t = F_{t-1} + \alpha [D_{t-1} - F_{t-1}]$$

1. If $\alpha = 0$, $n \rightarrow \infty$.

   $\boxed{F_t = F_{t-1}}$ limit of stability

2. If $\alpha = 1$,

   $\boxed{F_t = D_{t-1}}$ limit of Responsiveness.

* For stable curve, value of α is less.

<u>Forecast Error</u>: Forecast Error helps to find the pattern in error and it regulates the future production. The error should be minimum as for as possible & within a limit. These error helps to find a pattern or sequence to control activities of production system

$$\boxed{\text{Error} = D_i - F_i = e_i = \Delta i}$$

1. <u>Mean Absolute Deviation (MAD)</u>

$$MAD = \frac{\sum_{i=1}^{n} |D_i - F_i|}{n} = \frac{\sum_{i=1}^{n} |e_i|}{n}$$

It gives the magnitude of error, w/o considering sign. It is calculated as the summation of absolute value of error for given period divided by the no. of periods.

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2. Mean Forecast Error: (MFE) or (Bias)

$$MFE = \sum_{i=1}^{n} \frac{(D_i - F_i)}{n} = \sum_{i=1}^{n} \frac{(e_i)}{n}$$

or Bias

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It tells the direction of error & here signs are considered. This Error tells us any chances of over estimated & Under Estimated. Positive value for bias Indicates Under estimated forecasting. Negative value for bias indicates Over estimated forecasting.

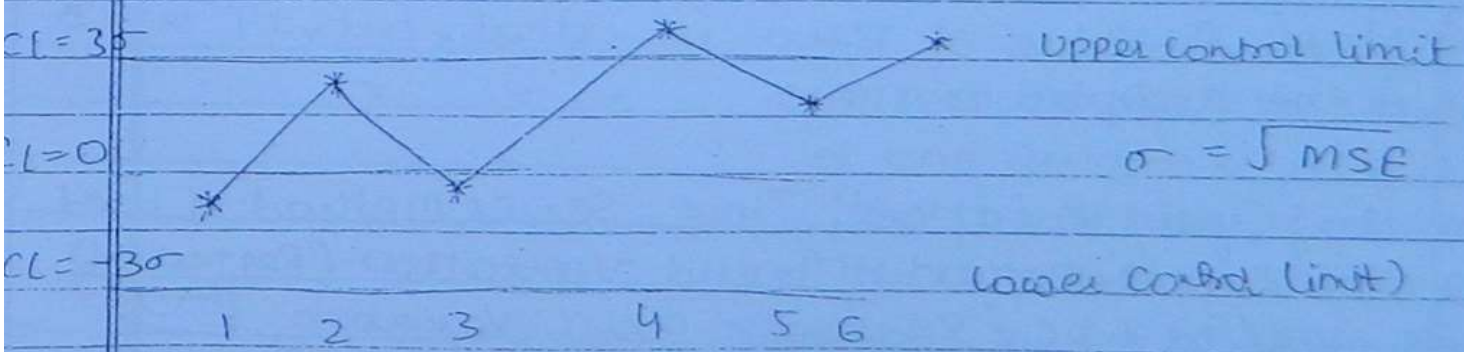
3. Running Sum Forecast Error (RSFE)

$$RSFE = \sum_{i=1}^{n} (D_i - F_i) = \sum_{i=1}^{n} (e_i)$$

$$\boxed{Bias = \frac{RSFE}{n}}$$

4. Mean Square Error (MSE) * Mostly used Nowadays

$$MSE = \sum_{i=1}^{n} \frac{(D_i - F_i)^2}{n} = \sum_{i=1}^{n} \frac{(e_i)^2}{n}$$



we make a range of limits & we want our Forecast value within this limits otherwise our forecasting is out of control.

MSE > MAD > MFE or bias, Give priority if not mention.

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Now-a-days it is the most used one. It is used for plotting control chart for forecast Error. They magnify the ~~magnitude~~ Error of larger magnitude

5 Mean Absolute Percentage Error (MAPE):-

$$MAPE = \frac{\sum_{i=1}^{n} \left| \left(\frac{D_i - F_i}{D_i} \right) \times 100 \right|}{n}$$

$$\boxed{MAPE = \frac{\sum_{i=1}^{n} \left| \left(\frac{e_i}{D_i} \right) \times 100 \right|}{n}}$$

It gives the forecasted error in proportion to actual demand in absolute terms. It pulls error in perspective because there is difference between 10 errors out of 100 & 100 out of 1000.

6 Tracking Signal (T.S) = $\frac{RSFE}{MAD}$

It tells how well the forecast is predicting actual values. A value of zero is ideal, but ±4 or ±5 is the acceptable range.

* a) For Cyclic Variations, Time Series Method is used
b) For Causal Method: Trend Variation (Regression)

Eg. a) 108/92/116/98/112 cyclic Variation
b) 108/112/118/124/142 Trend
c) Exponential is frequently asked.

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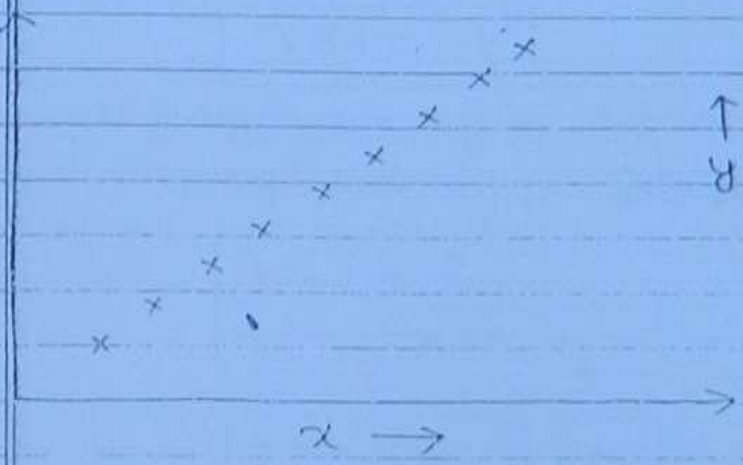
(ii) Causal or Econometric Method:

In this method Forecasted price to establish cause & effect relation between demand & some other parameter that are, related to the demand of product.

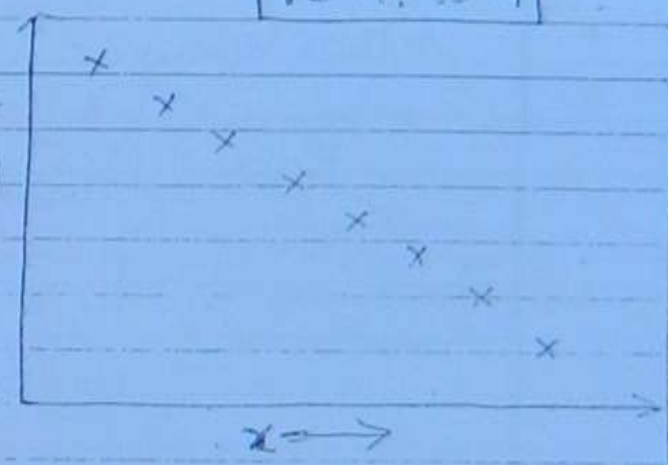
The objective is to establish a relation b/w changes in Demand Value with corresponding change in other variable.

I Correlation Analysis: Value ranges from +1 to −1.

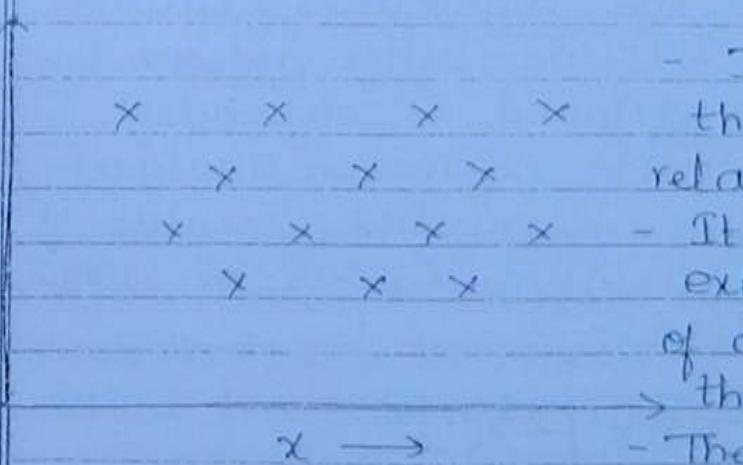
$r = +1$ to -1



$r = +1$



$r = -1$



$r = 0$

No-relation

- It is used in determining the degree of closeness or relationship b/w 2 variable.
- It is an indication of the extent to which the knowledge of one variable is useful in the prediction of other.
- The correlation b/w 2 variables x & y is given by:-

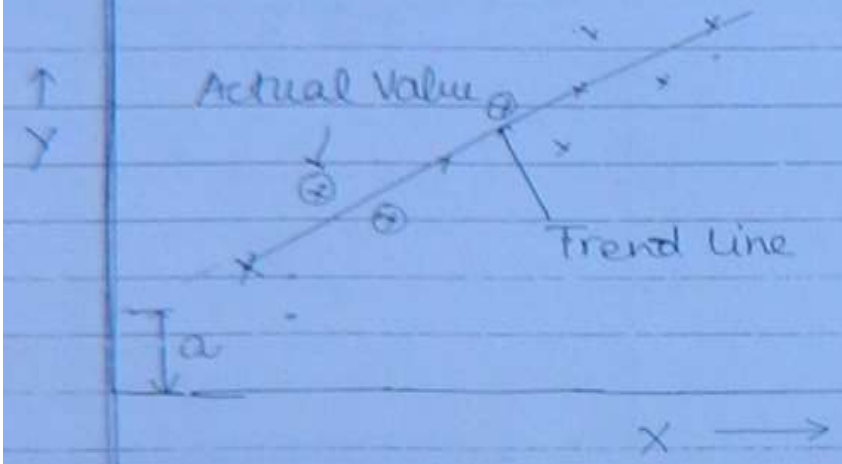
$$r = \frac{\sum (x-\bar{x}) \cdot (y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \cdot \sum (y-\bar{y})^2}}$$

$$r = \frac{\sum (x-\bar{x})\cdot(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \cdot \sum (y-\bar{y})^2}}$$

Where $\bar{x}$ & $\bar{y}$ are the mean value of individual 'x' & 'y' values.

Linear Regression Analysis

(20)



$$\boxed{Y = a + bx}$$

This is mathematical technique of obtaining the line of best fit b/w the dependent variable which is usually demand & some other independent variable on which demand is dependent.

In a simple regression analysis, the relationship b/w the dependent variable 'y' and some independent variable 'x' can be represented by a straight line:-

$$\boxed{Y = a + bx} \rightarrow (1)$$

Where 'a' is the intercept on 'y' axis and 'b' is the slope of line.

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Now taking summation (Σ) both side for 'n' period.

$$\boxed{\Sigma y = a \cdot n + b \Sigma x} \rightarrow (2)$$

Then (1) × (2), $xy = ax + bx^2$

Taking Σ both sides :-

$$\boxed{\Sigma xy = a \cdot \Sigma x + b \Sigma x^2} \rightarrow (3)$$

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Eq. (3) × n − (2) × Σx, we get

$$n \Sigma xy - \Sigma x \cdot \Sigma y = \cancel{an \Sigma x} + bn \Sigma x^2 - \cancel{\Sigma x \cdot a \cdot n} - b \Sigma x^2$$

$$n \Sigma xy - \Sigma x \cdot \Sigma y = nb \Sigma x^2 - b(\Sigma x)^2$$

$$\boxed{b = \frac{n \Sigma xy - \Sigma x \cdot \Sigma y}{n \cdot \Sigma x^2 - (\Sigma x)^2}}$$: When x is independent & y depends on x.

$$\boxed{a = \frac{\Sigma y - b \Sigma x}{n}}$$

Now, put the values of 'a' & 'b' in Regression line or Trend line (1)

$$\underbrace{Y}_{\text{Dependent}} = a + b\underbrace{x}_{\text{Independent}}$$

* Least Square Method * When independent variable 'x' is linear & Uniform and it can be modified such that Σx becomes = 0. Then the method is called Least Square method.

When $\Sigma x = 0$, then, $b = \frac{\Sigma xy}{\Sigma x^2}$ & $a = \frac{\Sigma y}{n}$

ODD	X	EVEN		
2004	−2	2004	−2.5	−5
2005	−1	2005	−1.5	−3
* 2006	0	2006	−0.5	−1
2007	1	2007	0.5	+1
2008	2	2008	1.5	+3
	$\Sigma x = 0$	2009	2.5	+5

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LINE BALANCING (Assembling)

It aims at grouping the task or workers. In an effective manner in order to obtain optimum utilisation of man-Power & machine & to minimise Ideal time.

Task are grouped so that there total time is preferrably equal to or a little lesser than the time available at each work station. This reduces the ideal time.

Advantages :-

1. Uniform rate of production.
2. Less material handling.
3. Less work in process inventory.
4. Effective Utilisation of man power & machine.
5. Easy production control.
6. Less ~~tran~~ conjestion within production system.

Terminology :-

1. Work Element : → (M) → (T) → (D) → (G) →

Element

(2min)

Task Time.