

"Statistical Quality Control" - (SQC)

Meaning: It is an effective use of statistical methods & tools in the monitoring, maintaining and improving the quality of products & services, throughout the entire operating process of specification (set parameters) production & inspection based on continuous testing with random sampling.

Method: One method is referred to as acceptance sampling. It is used when a decision must be made to accept or reject a group of parts or items based on quality found in a sample.

Second method uses graphical displays known as control charts to determine whether a process should be continued or should be adjusted to achieve the desired quality or else process be discontinued & replaced by a new process if the group of items or parts reach the region of rejection in terms of defectives.

Need & Importance:

Need for quality control emerges from the fact that even after the standard for quality are established, some variations in quality in the process of manufacture exists. The manufacturer needs to detect if the variations are insignificant & can be ignored or improvement or vital changes are required to be induced.

In this manner this concept generates an alarm or is a barometer to check the quality of goods manufactured.

Other need / importance for statistical quality control :

- (i) **It encourage quality consciousness:** It encourages quality consciousness among the workers in the factory which is helpful in achieving desired level of quality in the product.
- (ii) **Satisfaction of the Consumers:** Consumers are greatly benefited as they get better quality products & their satisfaction level goes high due to quality control.
- (iii) **Reduction in production Cost:** Quality control checks the production of inferior products & wastages are reduced thereby bringing down the cost of production.
- (iv) **Most effective utilisation of resources:** it ensures maximization of utilisation of resources.

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of resources & minimisation of wastage & inefficiency of every kind.

- (i) Increases goodwill : Better quality of goods leading to increased satisfaction of customers raises goodwill of the public about the particular product & brand.
- (ii) Higher morale of employees : The employees of the concern feel proud that they are part of the organisation producing better & higher quality products.
- (iii) Improved employer-employee relations : higher morale of employees, better control over the market, higher profits increased bonuses generate cordial employer-employee relation.
- (iv) Improved techniques & methods of production : While making efforts to conform to established standards better techniques & methods of production are utilised.
- (v) Effective advertisement : Better quality of products have effective advertisement. Mouth to Mouth advertisements prove effective & the products become most popular.
- (vi) Increased sales : High quality of products have a competitive advantage hence the sales of the product or brand record a massive sales.

Construction of control charts for attributes :

Construction charts for attributes are classified into two groups :

- Control chart for defectives - fractional defectives: \bar{p} -chart or $n\bar{p}$ chart.
- Control chart for defects - Average defectives : \bar{c} -chart

Steps involved in the case of \bar{p} or $n\bar{p}$ chart for fractional defectives :

1. First we define & detect non conformance available in units in a sample out of a number of samples .

2. Then we detect sample size (~~and~~) (n) and the number of sample in hand

3. Fractional defectives (\bar{p}) are calculated by the formula:

$$(\bar{p}) = \frac{\text{Sum of defectives in all samples } (\Sigma d)}{\text{Sample size } (n) \times \text{No. of samples (together } N)} = \frac{\text{No. of defectives}}{\text{Total No. inspected}}$$

4. If sample size is unequal then fractional defective for each sample is obtained as

$$\bar{p}_1 = \frac{d_1}{n} ; \bar{p}_2 = \frac{d_2}{n} ; \bar{p}_3 = \frac{d_3}{n} \dots \dots \dots K.$$

5. We set 3σ (std deviations) control limits to detect whether the process is under control, or out of control with respect to fractional defectives. Control limits are given by :

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$$C_L \text{ (Central line)} = \bar{p}$$

$$\text{Upper Control Limit (UCL)} = \bar{p} + 3 \text{ Std error}(\bar{p}) \text{ or } UCL = \bar{p} + 3 \sqrt{\frac{pq}{n}}$$

$$\text{Lower Control Limit (LCL)} = \bar{p} - 3 \text{ Std error}(\bar{p}) \text{ or } LCL = \bar{p} - 3 \sqrt{\frac{pq}{n}}$$

where \bar{p} is probability of getting a defective

& $q\bar{p}$ is probability of not getting a defective i.e. $1 - \bar{p}$

6. We then proceed to construct \bar{p} -chart & control limits associated with it. The sample number is shown on x-axis & defectives corresponding to each sample on y-axis. We draw control lines LCL, C_L & UCL as solid lines & show the region above C_L as region of rejection. Then we plot the value of the sample fractional defective against the sample number. The sample points are joined by line segments.

7. Then we proceed to interpret the results: If most sample points (all) lie between upper & lower control limits then the process is under control. If one or more points lie outside the upper or control limit i.e. in region of rejection the process is not under control & a corrective action is required.

Control chart for number of defectives i.e. $n\bar{p}$ chart:

The $n\bar{p}$ chart is an adaptation of the basic \bar{p} chart. The purpose is to provide a better understanding to operators who understand actual number of defectives than the proportional defectives. However $n\bar{p}$ chart can be used only for equal sample size.

Under $n\bar{p}$ chart process adopted is same for that of \bar{p} -chart. However the control limits are given by:

$$\text{Central line (C.L)} = n\bar{p}$$

$$\text{Upper Control Limit (UCL)} = n\bar{p} + 3 \sqrt{n\bar{p}q}$$

$$\text{Lower Control Limit (LCL)} = n\bar{p} - 3 \sqrt{n\bar{p}q}$$

The limits have been drawn by multiplying control limits of \bar{p} chart by n . So if that:- $C_L = \bar{p}$ or else $C_L = n\bar{p}$

$$UCL = \bar{p} + 3 \sqrt{\frac{pq}{n}} \text{ or else } UCL = n\bar{p} + 3 \sqrt{\frac{n^2 pq}{n}} \text{ or } UCL = n\bar{p} + 3 \sqrt{n\bar{p}q}$$

$$LCL = \bar{p} - 3 \sqrt{\frac{pq}{n}} \text{ or else } LCL = n\bar{p} - 3 \sqrt{\frac{n^2 pq}{n}} \text{ or } LCL = n\bar{p} - 3 \sqrt{n\bar{p}q}$$

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Control chart for defects in single unit sample when a few samples are chosen on random basis, like carpet, aeroplanes etc.

Steps involved in preparation of \bar{c} chart for average defectives:-

Step 1 No. of defects in each of the sample are detected and recorded.

2. Calculate average number of defects for all samples taken together

$$\bar{c} = \frac{\text{Total defectives}}{\text{Total No. of samples}}$$

3. Calculate control limits for c -chart

$$\text{Central line (CL)} = \bar{c} \quad (\text{mean of defectives or average defective per unit of sample})$$

$$\text{Upper Control Limit (UCL)} = \bar{c} + 3\sqrt{\bar{c}}$$

$$\text{Lower Control Limit (LCL)} = \bar{c} - 3\sqrt{\bar{c}}$$

4. Plot the defectives for each sample by placing samples on x-axis & corresponding number of defectives on y-axis.

5. ~~Show~~ Join all points showing defectives for each sample by a straight line.

6. Show CL, UCL & LCL by bold lines.

7. Points between LCL & UCL control limits can be accepted

however points beyond UCL i.e. in the region of rejection then a reconsideration of production process is necessary.

To use a c -control chart the chance of defects to occur must be large but actual number that occur must be small for acceptance purposes

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Quality Control of Variables: "Mean & Standard Deviation chart"

(A) \bar{x} chart

(B) σ -chart

$$C_L = \bar{\bar{X}}$$

$$UCL = \bar{\bar{X}} + A_3 \bar{S}$$

$$LCL = \bar{\bar{X}} - A_3 \bar{S}$$

$$C_L = \bar{S}$$

$$UCL = B_4 \bar{S}$$

$$LCL = B_3 \bar{S}$$

In respect of 10 samples of sample size 6

$A_3 = 1.4$, $B_3 = 0.03$ & $B_4 = 1.97$ $\bar{\bar{X}} = \text{Mean of Means}$, $\bar{S} = \text{Mean of } \sigma$.

Ex1 The following figures relates to 10 samples of 6 items of department producing some tools:

Mean of Samples: 46 44 64 72 52 60 44 72 49 47

σ of Samples: 4 9 12 16 14 15 12 20 18 10

Prepare Control chart for \bar{x} & σ (Mean & Std. Deviation)

(A) Mean chart:

$$C_L = \bar{\bar{X}} = \text{Mean of Means of Samples} = \frac{\sum \bar{x}}{n} = \frac{550}{10} = 55$$

$$UCL = \bar{\bar{X}} + A_3 \bar{S} \text{ or } UCL = 55 + 1.4 \times 13 \quad (\because \bar{S} = \frac{\sum S}{n} = \frac{130}{10} = 13) \\ = 55 + 18.2 \text{ or } UCL = 73.2$$

$$LCL = \bar{\bar{X}} - A_3 \bar{S} \text{ or } LCL = 55 - 1.4 \times 13 \text{ or } LCL = 55 - 18.2 = 36.8$$

(B) Standard Deviation - chart.

$$C_L = \bar{S} = \frac{130}{10} = 13$$

$$UCL = B_4 \bar{S} = 1.97 \times 13 \text{ or } UCL = 25.61$$

$$LCL = B_3 \bar{S} = 0.03 \times 13 \text{ or } LCL = 0.39$$

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Quality Control of Variables : Mean and Range Charts

(A) Mean chart (\bar{x} -chart)

$$C_L = \bar{X}$$

$$UCL = \bar{X} + A_2 \bar{R}$$

$$LCL = \bar{X} - A_2 \bar{R}$$

$$C_L = \bar{R}$$

$$UCL = D_4 \bar{R}$$

$$LCL = D_3 \bar{R}$$

Ex 2 [Value of $A_2 = 0.483$, $D_4 = 2.004$ & $D_3 = 0$ for 10 samples of size 6]
 TU 1998 The following figures relate to 10 samples of 6 items of a dept. producing some tools :

Sample No.	1	2	3	4	5	6	7	8	9	10
\bar{x} of Samples	383	508	505	582	557	337	514	614	707	753
Range of Samples	95	128	106	91	68	65	148	21	37	80

Mean chart for Range Analysis :

$$C_L = \bar{\bar{x}} \text{ or } C_L = \frac{5460}{10} = \bar{\bar{x}} = 546 \text{ so that } CL = 546$$

$$UCL = \bar{\bar{x}} + A_2 \bar{R} \text{ or } UCL = 546 + 0.483 \times 83.3 \text{ or } UCL = 586.2339$$

$$LCL = \bar{\bar{x}} - A_2 \bar{R} \text{ or } LCL = 546 - 0.483 \times 83.3 \text{ or } LCL = 505.766$$

Range Chart :

$$\bar{R} = C_L = \frac{833}{10} = 83.3$$

$$UCL = D_4 \bar{R} \text{ or } UCL = 2.004 \times 83.3 = 166.9332$$

$$LCL = D_3 \bar{R} \text{ or } LCL = 0 \times 83.3 = 0 \text{ (zero)}$$

Feb 8
Bombay Univ 1986

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The following data shows the values of sample mean & range for sample size 5 each. calculate CL, UCL & LCL.

Sample No.	1	2	3	4	5	6	7	8	9	10
Mean (\bar{x})	11.2	11.8	10.8	11.6	11.0	9.6	10.4	9.6	10.6	10.0
Range	7	4	8	5	7	4	8	4	7	9

Conversion factors for $n=5$ are $A_2 = \frac{0.577}{10} = 0.0577$, $D_3 = 0.0$, $D_4 = 2.115$

Mean chart (\bar{x}) chart :

$$CL = (\bar{\bar{x}}) = \frac{\sum \bar{x}}{N} \text{ or } CL = \frac{106.6}{10} \text{ or } CL (\bar{x}) = 10.66$$

$$UCL = \bar{\bar{x}} + A_2 \bar{R} \text{ or } UCL = 10.66 + \frac{0.577}{10} \times 6.3 = 14.2951 \quad (\because \bar{R} = \frac{63}{10} = 6.3)$$

$$LCL = \bar{\bar{x}} - A_2 \bar{R} \text{ or } LCL = 10.66 - 0.577 \times 6.3 = 7.0249$$

Range chart :

$$CL = (\bar{R}) = \frac{63.0}{10} = 6.3$$

$$UCL = D_4 \bar{R}, \text{ or } UCL = 2.115 \times 6.3 = 13.3245$$

$$LCL = D_3 \bar{R} \text{ or } LCL = 0.0 \times 6.3 = 0.0$$

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"Quality Control Chart for attributes"

P chart for fractional defectives.

P is probability of getting a defective. $\frac{\sum \text{No. of defectives}}{\text{Total number}}$

Q/\bar{q} is probability of not getting a defective: $1 - P$

$C_L = \bar{P} = \frac{\Sigma D}{n}$ where i is No. of units in each sample x total number of samples

$$UCL = \bar{P} + 3 \sqrt{\frac{\bar{P}\bar{q}}{n}}$$

$$LCL = \bar{P} - 3 \sqrt{\frac{\bar{P}\bar{q}}{n}}$$

Incase of np chart:

$$C_L = np$$

$$UCL = np + 3\sqrt{npqr}$$

$$LCL = np - 3\sqrt{npqr}$$

where n = no. of units in each sample.

Ex1 Samples of 100 are investigated and following data in respect of defectives is obtained: Prepare a p chart for detecting CL, UCL & LCL.

Day	No. of defectives
1	5
2	6
3	7
4	4
5	8

Probability of getting a defective = $30/5 \times 100 = 0.06$ Hence $C_L = 0.06$

$$UCL = \bar{P} + 3 \sqrt{\frac{\bar{P}\bar{q}}{n}} \text{ or } UCL = 0.06 + 0.3 \times \sqrt{0.06 \times 0.94} = 0.06 + 0.0712 = 0.1312$$

$$LCL = \bar{P} - 3 \sqrt{\frac{\bar{P}\bar{q}}{n}} \text{ or } LCL = 0.06 - 0.0712 = -0.0112 \text{ or zero.}$$

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Quality Control of variables:

A) (i) \bar{x} -chart

$$(a) CL = \bar{\bar{x}}$$

$$(b) UCL = \bar{\bar{x}} + A_s \bar{s}$$

$$(c) LCL = \bar{\bar{x}} - A_s \bar{s}$$

(ii) σ -chart.

$$(a) CL = \bar{s}$$

$$(b) UCL = B_4 \bar{s}$$

$$(c) LCL = B_3 \bar{s}$$

For 10 samples of 6 sample size:

$$A_1 = 1.4; A_2 = 0.483 \quad B_3 = 0.03 \quad B_4 = 1.97.$$

B) (i) \bar{x} chart

$$CL = \bar{\bar{x}}$$

$$UCL = \bar{\bar{x}} + A_2 \bar{R}$$

$$LCL = \bar{\bar{x}} - A_2 \bar{R}$$

(ii) \bar{R} - chart.

$$CL = \bar{R}$$

$$UCL = D_4 \bar{R}$$

$$LCL = D_3 \bar{R}$$

For 10 samples of 6 sample size:

$$A_2 = 0.483 \quad D_4 = 2.004, D_3 = 0$$

& for sample size 5, $A_2 = 0.577, D_3 = 0, D_4 = 2.115$

Quality Control of Attributes

In Industrial practice the inspection results are based on the classification of products as being defective or not defective, acceptable as good or bad, accordingly as that product conforms or fails to conform to the specified specifications.

Sometimes it is required to control burns, cracks, voids, dents, scratches, missing & wrong components, rust etc. Here we inspect products as good or bad or Go or Not Go gauges. Here our aim is to tell that whether product conforms or does not conform to the specified values. Quality expressed in this manner is termed as attributes.

Various control charts for ~~per~~ defective Items :

(i) P-chart for percent defectives or fractional defectives :

(a) The Central Line : (\bar{p}) - it is the ratio between Total number of defective observed in all samples combined and the total number of products inspected. For instance if 15 products are found to be defective in a sample of 200. The \bar{p} (probability of getting a defective) is $15/200 = 0.075$ and probability of not getting a defective $q = 1 - \bar{p}$.

(b) UCL & LCL (Upper Control Limit & Lower Control limit)

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}q}{n}} \quad \text{or} \quad UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}q}{n}} \quad \text{or} \quad LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

(ii) $n\bar{p}$ -chart :

$$CL = n\bar{p}$$

$$UCL = n\bar{p} + 3\sqrt{n\bar{p}q}$$

$$\& LCL = n\bar{p} - 3\sqrt{n\bar{p}q}$$

(iii) \bar{c} -chart for average defectives

$$CL = \bar{c}$$

$$UCL = \bar{c} + 3\sqrt{\bar{c}}$$

$$LCL = \bar{c} - 3\sqrt{\bar{c}}$$

~~Ex 2~~
MBA Ranchi Univ
1986

"Quality Control of Attributes"

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15 Samples of 100 tubes each are randomly selected & defectives are drawn as per data given. Prepare a control chart for fractional defectives:

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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Defectives	8	10	13	9	8	10	14	6	10	13	18	15	12	14	9
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Solu: Probability of getting a defective (\bar{p}) = $\frac{\sum D}{N} \text{ or } \frac{\sum D}{n \times \text{samples no.}} = \frac{169}{15 \times 100} = 0.11267$

or that:

$$C_L = 0.11267$$

$$UCL = \bar{p} + 3 \sqrt{\frac{pq}{n}} \text{ or } UCL = \bar{p} + 3 \sqrt{\frac{0.11267 \times 0.8873}{100}} = 0.11267 + 0.3 \times 0.31618$$

$$\text{or } UCL = 0.11267 + 0.094855 \text{ or } UCL = 0.20752$$

$$LCL = \bar{p} - 3 \sqrt{\frac{pq}{n}} \text{ or } LCL = 0.11267 - 0.094855 \text{ or } LCL = 0.017815$$

~~Ex 3~~
~~1993~~ 10 Samples of 200 units each are collected randomly & defectives are detected as follows: Prepare a chart showing CL, UCL & LCL:

Samples	1	2	3	4	5	6	7	8	9	10
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No. of Defectives	3	12	0	11	5	7	9	6	16	18
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Solu: $C_L = \bar{p} = \text{Probability of getting a defective} = \frac{\sum D}{N} = \frac{84}{200 \times 10} = \frac{84}{2000} = 0.0435$

$$q\bar{p} = 1 - \bar{p} = 1 - 0.0435 \text{ or } q\bar{p} = 0.9565$$

$n\bar{p}$ -chart: Central line = $n \times \bar{p} = 200 \times 0.0435 = 8.7$

$$UCL = np + 3 \sqrt{n\bar{p}q\bar{p}} \text{ or } UCL = 8.7 + 3 \sqrt{200 \times 0.0435 \times 0.9565}$$

$$\text{or } UCL = 8.7 + 3 \times 2.8847 \text{ or } UCL = 8.7 + 8.65 \text{ or } UCL = 17.357$$

$$LCL = np - 3 \sqrt{n\bar{p}q\bar{p}} \text{ or } LCL = 8.7 - 8.65 = 0.05$$

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~~Epo~~
TU 1997

Construct a suitable control chart for the following data & interpret it?

Sample

(each of 100 items)	1	2	3	4	5	6	7	8	9	10
Defectives	12	10	6	8	9	9	7	10	11	8

$$\text{Probability of getting a defective } (\bar{p}) = \frac{\sum D}{N} = \frac{90}{10 \times 100} = 0.09$$

$$np\text{-chart: } CL = n\bar{p} = 100 \times 0.09 = 9$$

$$UCL = np + 3\sqrt{npq} \quad \text{or} \quad UCL = 9 + 3\sqrt{\frac{0.09 \times 0.91}{100}} \quad \text{or} \quad UCL = 9 + 0.3 \times 0.$$

$$= UCL = n\bar{p} + 3\sqrt{n\bar{p}q} \quad \text{or} \quad UCL = 9 + 3\sqrt{100 \times 0.09 \times 0.91}$$

$$\text{or } UCL = 9 + 3 \times 2.8618 \quad \text{or } UCL = 9 + 8.5854 = 17.5854$$

$$LCL = n\bar{p} - 3\sqrt{n\bar{p}q} \quad \text{or} \quad LCL = 9 - 3\sqrt{100 \times 0.09 \times 0.91}$$

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Quality Control for attributes

 \bar{c} -chart for average defectives

$$C_L = \bar{c}$$

$$UCL = \bar{c} + 3\sqrt{\bar{c}}$$

$$LCL = \bar{c} - 3\sqrt{\bar{c}}$$

Ex1 TU 1998 The following Table shows number of defects found in eight carpets. Calculate Control limits for \bar{c} -chart.

S/N. of Carpets	1	2	3	4	5	6	7	8
Defectives	3	5	6	7	4	1	5	1

$$C_L = \bar{c} = \frac{\sum D}{N} \text{ where } N \text{ is number of carpets} = \frac{32}{8} = 4$$

$$UCL = \bar{c} + 3\sqrt{\bar{c}} \text{ or } UCL = 4 + 3\sqrt{4} \text{ or } UCL = 4 + 3 \times 2 \text{ or } UCL = 10$$

~~$LCL = \bar{c} - 3\sqrt{\bar{c}} \text{ or } LCL = 4 - 3\sqrt{4} \text{ or } LCL = 4 - 3 \times 2 = -2$~~

$$= 4 - 3 \times 2 \text{ or } 4 - 6 \text{ or } LCL = -2 \text{ or zero.}$$

Ex2 TU 2002 Following are defects in 8 aircrafts. Calculate 3σ control limits & interpret it:

Air Craft:-	1	2	3	4	5	6	7	8
Defectives	7	15	13	18	10	14	7	10

$$\text{Average Defectives} = \frac{\sum D}{\text{Sample NO}} = \frac{94}{8} = 11.75 \text{ i.e. } C_L = 11.75$$

$$UCL = \bar{c} + 3\sqrt{\bar{c}} \text{ or } UCL = 11.75 + 3\sqrt{11.75} \text{ or } UCL = 11.75 + 3 \times 3.4278 \\ = 11.75 + 10.28348 = 22.033$$

$$LCL = \bar{c} - 3\sqrt{\bar{c}} \text{ or } LCL = 11.75 - 10.28348 = 1.46652$$

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Chart for Ex 1 where
 $C_h = 4$, $V_{ch} = 10$ & $L_{ch} = 00$ (Zero)

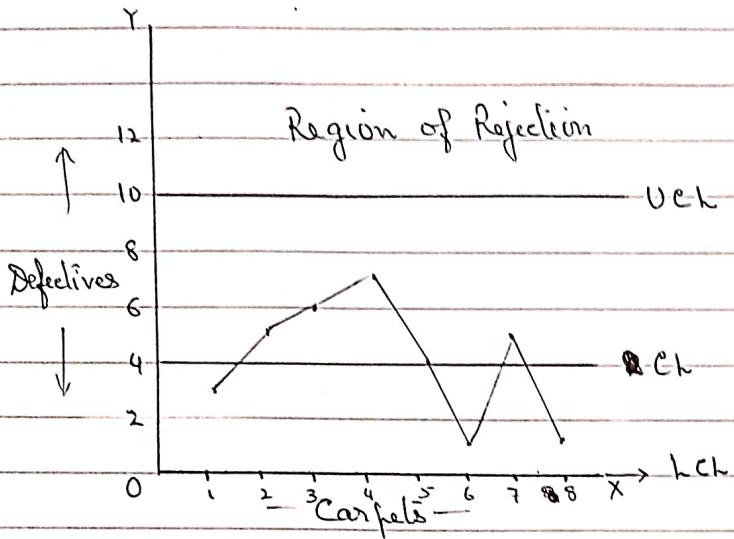
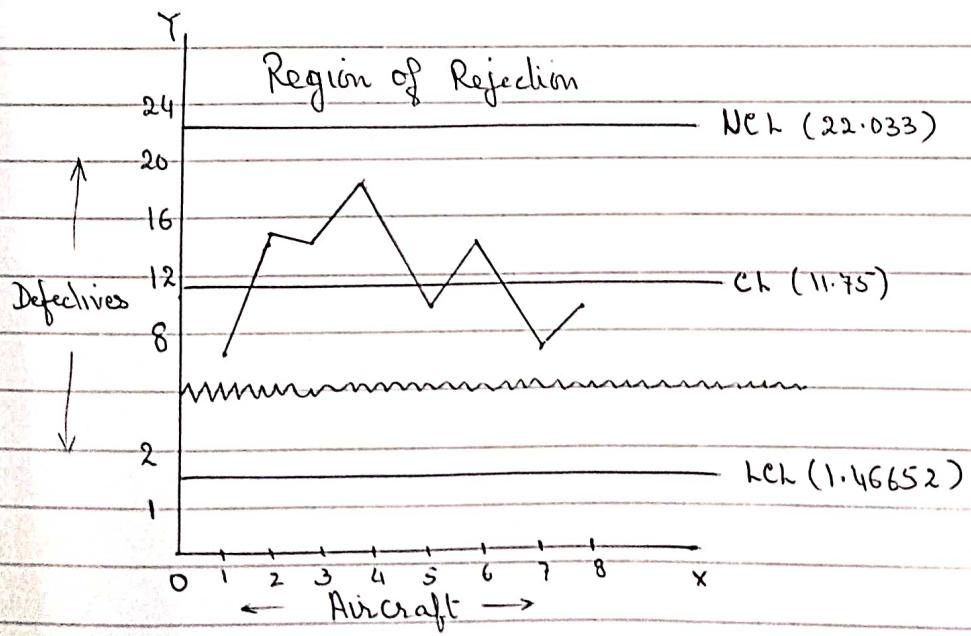


Chart for Ex 2 where
 C_h is 11.75 , $V_{ch} = 22.033$ & $L_{ch} = 1.46652$



Business Forecasting

Meaning:

Forecasting is a systematic estimation of future events with the help of in-depth analysis of past and present events.

Business forecasting is a systematic efforts to peer into future business events on the basis of past and present circumstances & situations. Forecasting increases accuracy & exactness in planning, decision making & strategy formulation.

Importance:

The business today is highly competitive which needs not only constant outcomes and review of current policies, priorities and programmes but it also needs a perfect forecast about the future, so that future policies and programmes of the business may be finalised today and action may be taken in the finalised future policies & programmes. Business forecasting is important owing to following reasons:

- (a) To estimate all business activity : production, sales, working capital requirements, debtors, creditors, sources of finance etc.
- (b) To execute the plans of the business effectively viz vision, Mission and objectives.
- (c) To determine the managerial activities and help the management in effectively managing the affairs of the enterprise.
- (d) To estimate and ascertain the nature and span of control and measures required to be taken for higher effective control in the future when firm grows.
- (e) To establish better and effective coordination in business activity.
- (f) To help the business growth in desired direction.
- (g) In planning, policy framing, decision making, strategy formulation and raising competitive potential.
- (h) It gives confidence to the managers for making important & sound decisions.
- (i) It keeps managers active & alert to face the challenges of future events and changes in the environment.
- (j) It provides analytical analysis to business calculations instead of mere guess-work. Today business is not simply based on guesswork, luck & chance, but on deep scientific foundations.

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Techniques & Method: (A) Non Statistical Techniques :

- (i) Survey Method : Field surveys can be conducted to collect information regarding the attitude of people. Information collected by this technique is useful for proper forecasting. This method is suitable for forecasting demand of both existing and new products.
- (ii) Experts Opinion method : In this method data/information is collected from experts who are associated with market Surveys, researches & studies on the product or brand, at the present & the likely hood in the near future.
- (iii) Market Experiment Method : It involves collecting necessary information regarding the current & future demand for a product. This method carries out the studies & experiments on consumer behaviour under actual market conditions. Here some areas of markets are selected with similar features, such as population, income levels, cultural background & tastes & preferences. The market experiments are carried out with the help of changing prices & expenditures so that resultant changes in demand are recorded. These results help in forecasting future demand.
- (iv) Delphi method : It refers to group decision making technical of forecasting demand. Here questions are individually asked from a group to obtain their opinions on demand for products in future. These questions are repeatedly asked until a consensus is obtained.

(B) Statistical Techniques :

- (i) Business Barometers Method also known as Index Number Method : Index numbers measure the state of economy between two or more periods. When combined with one or more index numbers, they provide an indication of the direction in which the economy is heading to - recession or upward swing in the economy with higher employment & income opportunity after some period. When demand & sales will go higher.
- (ii) Trend analysis method or Time Series Analysis method : It involves trend, seasonal variations, cyclic variations & irregular or random variations. On the basis of analysis of data for past period trend is obtained & with the assumption that trend would continue in the future, futuristic value is calculated.
- (iii) Extrapolation Method : Here too the assumption prevails that trend exists & is likely to continue in the future. Several techniques are used to extrapolate an expected futuristic value.
- (iv) Regression Analysis Method : Here association is established between two

(73) (70) (77) (78)

Variables: demand and price etc. It involves fitting an equation between demand & price or demand & incomes of the people. Two eqns are derived: impact of demand on price & price on demand & putting the value of one the expected value of other is arrived at.

(v) Input-Output Analysis: Here a forecast becomes possible if the relationship between input and output is known. Input can be forecast on the basis of output. For instance power requirement of the country can be forecast: if present usage rate in various sectors viz. industry, transport, household etc and on the basis of how the power requirements in these sectors would increase in the future.

(vi) Economic Barometers / Indicators: On the basis of sales of motor vehicles - petrol & diesel version, the futuristic demand for petrol & diesel can be estimated.

(vii) Econometric Models: Econometrics attempts to discover and measure the quantitative aspects of actual operation of economic system in order to forecast the course of certain economic factors. Here forecasting is made on the basis of model building.

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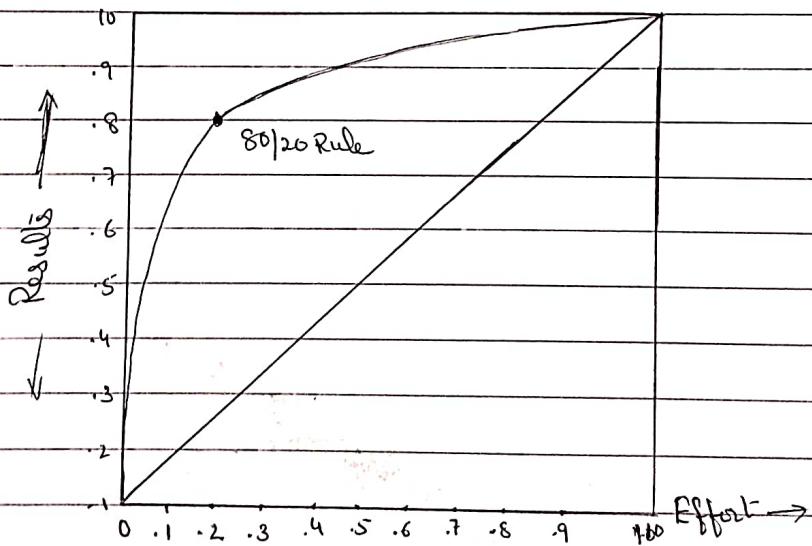
Pareto & Lorenz Curves:

Pareto Curves:

Through Pareto Curves Pareto tried to demonstrate that most things in life are not evenly distributed. He referred to the observation in Italy's wealth where 80% of the wealth belonged to only 20% of the population. It implies:

- 20% of the input creates 80% of the result.
- 20% of the workers produce 80% of the result.
- 20% of the customers create 80% of the revenue
- 20% of the bugs cause 80% of the crashes
- 20% of the features cause 80% of the usage.

Modern thinkers feel 80/20 rule is a rough guide about typical distributions. But in a perfect world, every employee would contribute the same amount, every refugee would be important, every feature would be equally loved by users.



It is clear from the diagram effort of 20% yield 80% results

& " " 80% " 20% results remaining.

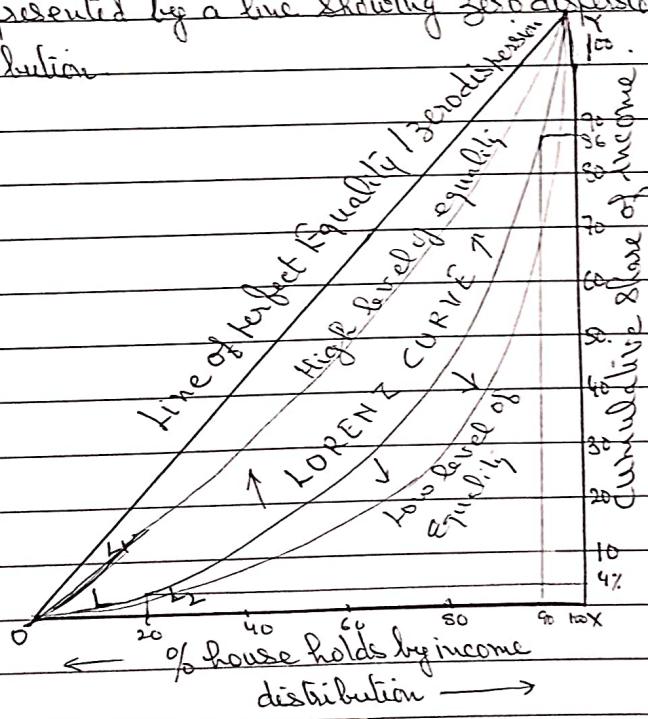
(74) (29) (5) (9)

Lorenz Curve:

It is a way of showing the distribution of income & wealth within an Economy. It was developed by Max O. Lorenz in 1905 for representing wealth distribution.

Lorenz Curve shows the cumulative share of income for different sections of population of the country.

Under ideal conditions it is believed - everyone if has same salary / income i.e. the poorest 20% of the population sharing 20% of the total income & poorest 60% of the population gaining 60% of the total income then this situation would be ideal & would be represented by a line showing zero dispersion i.e. perfect consistency of income distribution.



It is clear from the diagram:

Lorenz curve L₁ show mediocre level of equality, L₂ show low level of inequality & L₃ shows a high level of inequality.

In the given Lorenz Curve 20% of household income is just 4% & 90% of households have an income of 86% while 10% people enjoy 14% of income. Shift of Lorenz curve towards right shows a low level of equality & the towards left shows a high level of equality.

Population Projection :

→ Meaning : A population projection gives a picture of what the future size and structure of the population by sex and age might look like. It is based on the knowledge of the past trends and for the future on assumptions made for three components : fertility, mortality and migration.

Methods of population projection :

(a) Cohort-Component method : It separately projects the components of population change viz. fertility, mortality & net migration.

Features : (i) This method simulates how a population changes according to its components of growth : fertility, mortality and migration.

(ii) Based on past information, assumptions are made about future trends in these components of change.

(iii) Then the projected rates are applied to the age and sex structure of the population, in a simulation () taking into account that people die according to their sex & age, that women have children & that some people change their residence.

Methodology : (i) Base population is grouped into cohorts (small groups having same characteristics) defined by age & sex.

(ii) The projection system proceeds by updating the population of each age - and sex specific group according to assumptions about three components of population change viz. fertility, mortality & migration.

(iii) Each cohort survives ~~for~~ forward to the next age group according to assumed Age Specific Mortality Rates (ASMRs).

(iv) Migration is accounted for by applying age & sex specific net migration rates to each cohort as well.

(v) Projected Age Specific Fertility Rates (ASFRs) are applied to the female population in child bearing ages to estimate the number of births.

(vi) A sex ratio at birth is used to divide total births into males & females.

(vii) These births are exposed to the appropriate mortality schedule & then the survivors fed into the projection model.

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(b) Ratio method: This method is applied mainly for projecting the population of small areas within a country for which all inputs required by cohort component method are not readily available. This method is also useful in the projection of urban and rural populations.

- Features
- (i) This method is used where an area containing the population is to be projected (say a district) of a larger part (parent) area; for which projections are available.
 - (ii) The small areas should exist in a perfect hierarchical structure -
 - (iii) This method assumes that all the smaller areas will grow at the same rate as the rate of the parent area.

Methodology:

- (i) After obtaining the ratio of the district to national population, assumptions are made on the future value of these ratios.
- (ii) Once the future values of ratios are fixed, the population of ratios are fixed. The population of the district can be obtained by applying those ratios to the projected national population in respective years.
- (iii) Once the projection for each small area has been made, ensure the sum of the population of all small areas tallies with the national total.
- (iv) Using the national total as a control, adjust proportionally the projections of the small areas.

(c) Statistical time series methods for short-range forecasts:

With the availability of data for previous years analysis of time series can be made by method of least squares of first degree or second degree and projections for future years can be made.