# Chapter 9

## Applied Statistics

Sum : $Y = T + S + C + I$

Product : $Y = T S C I$

Least Square :

$Y = a + bx$ , a, b Constant

Y - actual value

x - Time.

$\Sigma y = na + b\Sigma x$.

$\Sigma xy = a\Sigma x + b\Sigma x^2$.

$a = \frac{\Sigma y}{n} = \bar{y}$. , $b = \frac{\Sigma xy}{\Sigma x^2}$.

Methods of Simple Average :

Seasonal Indices : S.I.

$S.I = \frac{SA}{GA} \times 100$.

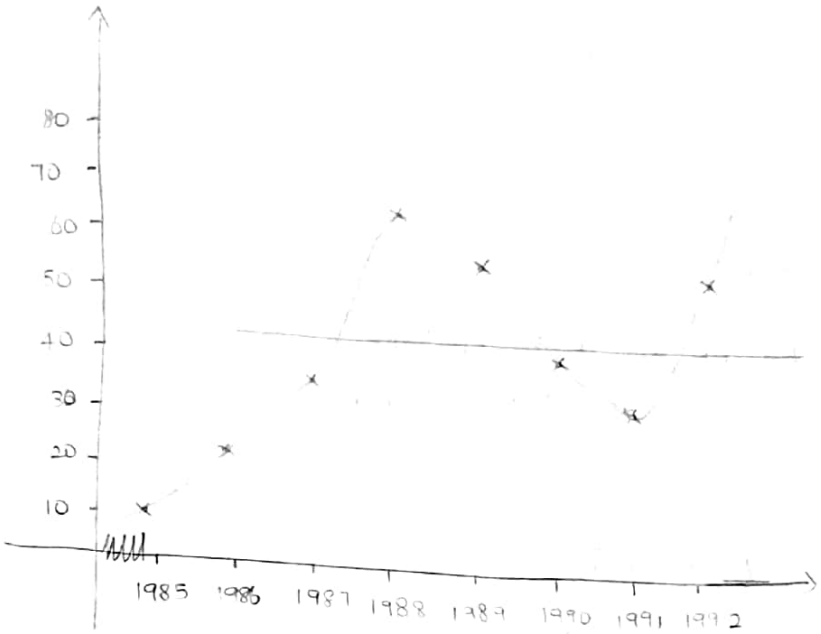
Month . $SI = \frac{SA\,(each)}{GA} \times 100$.

Year $SI = \frac{SA\,(each)}{GA} \times 100$

Quarterly $SI = \frac{SA\,(each)}{GA} \times 100$

16.

| Y | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|---|---|---|---|---|---|---|---|---|
| Sale | 10 | 22 | 36 | 62 | 35 | 40 | 34 | 50 |




17.

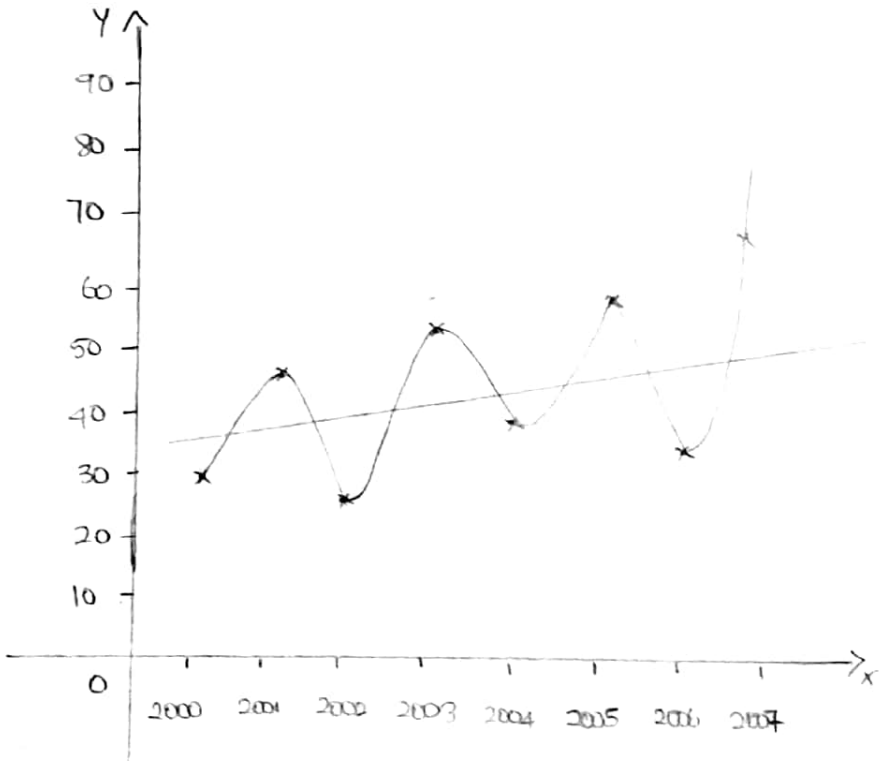
| Y | Production | 5 Years | 5 Average |
|---|---|---|---|
| 1979 | 126 | – | – |
| 1980 | 123 | – | – |
| 1981 | 117 | 619 | 123.8 |
| 1982 | 128 | 617 | 123.4 |
| 1983 | 125 | 624 | 124.8 |
| 1984 | 124 | 621 | 124.2 |
| 1985 | 130 | 615 | 123.0 |
| 1986 | 114 | 609 | 121.8 |
| 1987 | 112 | 619 | 123.8 |
| 1988 | 129 | 613 | 122.6 |
| 1989 | 118 | 606 | 121.2. |
| 1990 | 123. | – | – |

14.

| Y | Profit | 3 Years | 3 Average |
|---|---|---|---|
| 1986 | 15420 | - | - |
| 1987 | 15,470 | 46,410 | 15470 |
| 1988 | 15,520 | 52010 | 17333.67 |
| 1999 | 21,020 | 63040 | 21013.33 |
| 1990 | 26,500 | 79,470 | 26490 |
| 1991 | 31,950 | 94.050 | 31350 |
| 1992 | 35,600 | 67,550 | 22516.67 |
| 1993 | 34,900 | - | - |

Eg:9.1

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Sale | 30 | 46 | 25 | 54 | 40 | 60 | 38 | 65 |



Eg:9.4

| Year | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| No of Stu | 332 | 317 | 357 | 392 | 402 | 405 | 410 | 427 | 435 | 438 |

| Year | No of Student | 3 Year | 3 Y Average |
|---|---|---|---|
| 1995 | 332 | - | - |
| 1996 | 317 | 1006 | 335.33 |
| 1997 | 357 | 1066 | 355.33 |
| 1998 | 392 | 1151 | 383.67 |
| 1999 | 402 | 1199 | 399.67 |
| 2000 | 405 | 1217 | 405.67 |
| 2001 | 410 | 1242 | 414 |
| 2002 | 427 | 1272 | 424 |
| 2003 | 435 | 1300 | 433.33 |
| 2004 | 438 | - | - |

17

| Year | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|
| No of Production units | 155 | 162 | 171 | 182 | 188 | 180 | 178 |

| x | y | $x = x - A$ $\times 1998$ | $x^2$ | xy | Tv $y_t$ |
|---|---|---|---|---|---|
| 1995 | 155 | -3 | 9 | -465 | 159.57 |
| 1996 | 162 | -2 | 4 | -324 | 162.85 |
| 1997 | 171 | -1 | 1 | -171 | 166.19 |
| 1998 | 182 | 0 | 0 | 0 | 169.42 |
| 1999 | 158 | 1 | 1 | 158 | 172.71 |
| 2000 | 180 | 2 | 4 | 360 | 175.99 |
| 2001 | 178 | 3 | 9 | 534 | 179.28 |
| $n=7$ | $\Sigma y = 1186$ | $\Sigma x = 0$ | $\Sigma x^2 = 28$ | $\Sigma xy = 92$ | |

$$a = \frac{\Sigma y}{n} = \frac{1186}{7} = 169.42 \qquad b = \frac{\Sigma xy}{\Sigma x^2} = \frac{92}{28} = 3.285$$

$y = a + bx$

$y = 169.42 + 3.285(x - 1998)$

$y_t = 159.565$

18.

| x | y | $X = x - A$ $= x - 2002$ | $x^2$ | xy | $y_t$ |
|---|---|---|---|---|---|
| 2000 | 35 | -2 | 4 | -70 | 43.2 |
| 2001 | 36 | -1 | 1 | -36 | 48.6 |
| 2002 | 79 | 0 | 0 | 0 | 54.00 |
| 2003 | 80 | 1 | 1 | 80 | 59.4 |
| 2004 | 46 | 2 | 4 | 80 | 64.8 |
| $n=5$ | $\Sigma y = 270$ | $\Sigma x = 0$ | $\Sigma x^2 = 10$ | $\Sigma xy = 54$ | |

$$a = \frac{\Sigma y}{n} = \frac{270}{5} = 54 \qquad b = \frac{\Sigma xy}{\Sigma x^2} = \frac{54}{10} = 5.4$$

$Y = a + bx$

$Y = 54 + 5.4(x - 2002)$

$x = 2000$

$Y_1 = 43.2$

Eg: 9.7

| x | y | $x = x - A = \frac{x - 1998.5}{0.5}$ | $x^2$ | xy | $y_t$ |
|---|---|---|---|---|---|
| 1995 | 6.7 | -7 | 46.9 | 49 | 5.6166 |
| 1996 | 5.3 | -5 | 26.5 | 25 | 5.7190 |
| 1997 | 4.3 | -3 | 12.9 | 9 | 5.8214 |
| 1998 / 1998.5 | 6.1 | -1 | 6.1 | 1 | 5.9238 |
| 1999 | 5.6 | 1 | 5.6 | 49 | 6.0261 |
| 2000 | 7.9 | 5 | 28.7 | 25 | 6.1285 |
| 2001 | 5.8 | 3 | 29.0 | 9 | 6.2309 |
| 2002 | 6.1 | 7 | 42.7 | 1 | 6.333 |
| n=8 | $\Sigma y = 47.8$ | $\Sigma x = 0$ | $\Sigma x^2 = 194.6$ | $\Sigma xy = 168$ | |

$a = \frac{\Sigma y}{n} = \frac{47.8}{8} = 5.975$, $b = \frac{\Sigma xy}{\Sigma x^2} = \frac{8.6}{168} = 0.10238$

$Y = a + bx$

$Y = 5.9754 + 0.051\frac{(x - 1998.5)}{0.5}$

Eg: $x = 1995$, $Y_t = 5.61$

Eg: 9.6

| Year | Sugarcane | $x = x - A$ <br> $= x - 2003$ | $x^2$ | $xy$ | $Y_t$ |
|---|---|---|---|---|---|
| 2000 | 40 | -3 | 9 | -120 | 42.034 |
| 2001 | 45 | -2 | 4 | -90 | 43.07 |
| 2002 | 46 | -1 | 1 | -46 | 44.11 |
| 2003 | 42 | 0 | 0 | 0 | 45.143 |
| 2004 | 47 | 1 | 1 | 47 | 46.179 |
| 2005 | 50 | 2 | 4 | 100 | 47.22 |
| 2006 | 46 | 3 | 9 | 138 | 48.251 |
| $n = 7$ | $\Sigma y = 316$ | $\Sigma x = 0$ | $\Sigma x^2 = 28$ | $\Sigma xy = 29$ | |

$$a = \frac{\Sigma y}{n} = \frac{316}{7} = 45.143 \quad , \quad b = \frac{\Sigma xy}{\Sigma x^2} = \frac{29}{28} = 1.0357$$

$$Y = a + bx$$

$$Y = 45.143 + 1.0357(x - 2003)$$

$$= 42.034.$$

2.

| $x$ | $Y$ | $x = x - 1994$ | $x^2$ | $xy$ |
|---|---|---|---|---|
| 1992 | 46 | -2 | 4 | -92 |
| 1993 | 48 | -1 | 1 | -48 |
| 1994 | 42 | 0 | 0 | 0 |
| 1995 | 56 | 1 | 1 | 56 |
| 1996 | 52 | 2 | 4 | 104 |
| $n = 5$ | $\Sigma y = 244$ | $\Sigma x = 0$ | $\Sigma x^2 = 10$ | $\Sigma xy = 20$ |

$$a = \frac{\Sigma y}{n} = \frac{244}{5} = 48.8 \quad , \quad b = \frac{\Sigma xy}{\Sigma x^2} = \frac{20}{10} = 2$$

$Y = a + bx$

$Y = 48.8 + 2(x - 1994)$

at $x = 1997$

$Y_1 = 48.8 + 2(1997 - 1994)$

$= 48.8 + 6$

$= 54.8$

13.

| Year | Q I | Q II | Q III | Q IV |
|---|---|---|---|---|
| 2002 | 3.5 | 3.8 | 3.7 | 3.5 |
| 2003 | 3.6 | 4.2 | 3.4 | 4.1 |
| 2004 | 3.4 | 3.9 | 3.7 | 4.2 |
| 2005 | 4.2 | 4.5 | 3.8 | 4.4 |
| 2006 | 3.9 | 4.4 | 4.2 | 4.6 |
| Total | 18.6 | 20.8 | 18.8 | 20.8 |
| Average | 3.72 | 4.16 | 3.76 | 4.16 |

Grand Average $= \frac{3.72 + 4.16 + 3.76 + 4.16}{4}$

$= \frac{15.8}{4} = 3.95.$

S.I for Q I $= \frac{3.72}{3.95} \times 100 = 94.17$

S.I for Q II $= \frac{4.16}{3.95} \times 100 = 105.32.$

S.I for Q III $= \frac{3.76}{3.95} \times 100 = 95.18$

S.I for Q IV $= \frac{4.16}{3.95} \times 100 = 105.32.$

20.

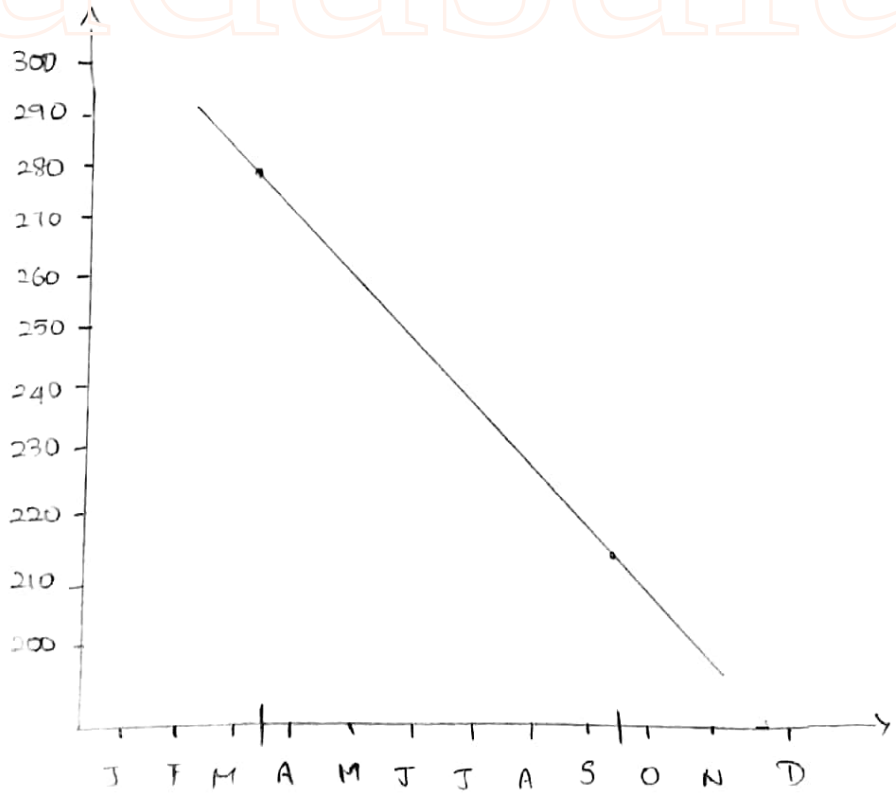
| x. | J | F | M | A | M | J | J | A | S | O | N | D. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2002 | 15 | 18 | 17 | 19 | 16 | 20 | 21 | 18 | 17 | 15 | 14 | 18 |
| 2003 | 20 | 18 | 16 | 13 | 12 | 15 | 22 | 16 | 18 | 20 | 17 | 15 |
| 2004 | 18 | 25 | 21 | 11 | 14 | 16 | 19 | 20 | 17 | 16 | 18 | 20 |
| Total | 53 | 61 | 54 | 43 | 42 | 51 | 62 | 54 | 52 | 51 | 49 | 53 |
| Average | 17.67 | 20.33 | 18 | 14.33 | 14 | 17 | 20.67 | 18 | 17.33 | 17 | 16.33 | 17.67 |

$$\text{Grand Average} = \frac{\text{Total Average}}{\text{Total Number}}$$

$$= \frac{208.33}{12} = 17.36.$$

19.

| Month | Sale | Average |
|---|---|---|
| Jan | 280 | |
| Feb | 240 | |
| Mar | 270 | |
| Apr | 300 | $\frac{1660}{6} = 276.67$ |
| May | 280 | |
| Jun | 290 | |
| Jul | 210 | |
| Aug | 200 | |
| Sep | 230 | |
| Oct | 200 | $\frac{1280}{6} = 213.33$ |
| Nov | 230 | |
| Dec | 210 | |



Eg: 9.5

## Four Yearly Centred Moving Average

| Y | Sales | Four Yearly | 4Y Average | 4Y Centred Average |
|---|---|---|---|---|
| 2001 | 124 | | | |
| | | | | |
| 2002 | 120 | | | |
| | | 519 | 129.75 | |
| 2003 | 135 | | | 132.37 |
| | | 540 | 135.00 | |
| 2004 | 140 | | | 139.75 |
| | | 578 | 144.5 | |
| 2005 | 145 | | | 147.81 |
| | | 605 | 151.25 | |
| 2006 | 158 | | | 155.00 |
| | | 635 | 158.75 | |
| 2007 | 162 | | | |
| | | | | |
| 2008 | 170 | | | |
| | | | | |

Eg: 9.2.

| Y | Production | Average |
|---|---|---|
| 2000 | 105 | |
| 2001 | 115 ⟶ | $\frac{340}{3} = 113.33$ |
| 2002 | 120 | |
| ~~2003~~ | ~~100~~ | |
| 2004 | 110 | |
| 2005 | 125 ⟶ | $\frac{370}{3} = 123.33$ |
| 2006 | 135 | |

# Exercise 9.2

## 1 Price Index method:

0 - base Year.

1 - Current Year

Price Index $P_{01} = \frac{\sum P_1 W}{\sum P_0 W} \times 100$.

$W \rightarrow$ weight, $P_1$ & $P_0$ = current + base Price.

$q_1$ & $q_0$ = current + base Quantity.

Laspeyre's PIN

$$P^L_{01} = \frac{\sum P_1 q_0}{\sum P_0 q_0} \times 100.$$

~~Paasche's~~ Paasche's PIN:

$$P^P_{01} = \frac{\sum P_1 q_1}{\sum P_0 q_1} \times 100$$

Fisher's PIN:

$$P^F_{01} = \sqrt{P^L_{01} \times P^P_{01}}$$

$$= \sqrt{\frac{\sum P_1 q_0}{\sum P_0 q_0} \times \frac{\sum P_1 q_1}{\sum P_0 q_1}} \times 100$$

## 2. Test's:

1. Time Reversal test: (TRT)

$$P^F_{01} = \sqrt{\frac{\sum P_1 q_0}{\sum P_0 q_0} \times \frac{\sum P_1 q_1}{\sum P_0 q_1}} \times 100.$$

$$P_{10}^{F} = \sqrt{\frac{\sum P_0 q_1}{\sum P_1 q_1} \times \frac{\sum P_0 q_0}{\sum P_1 q_0}} \times 100$$

$$TRT = P_{01}^{F} \times P_{10}^{F} = 1$$

Factoral Reversal test :

(FRT):

$$P_{01} \times Q_{01} = \frac{\sum P_1 q_1}{\sum P_0 q_0}$$

$$P_{01} = \sqrt{\frac{\sum P_1 q_0}{\sum P_0 q_0} \times \frac{\sum P_1 q_1}{\sum P_0 q_1}} \times 100 \quad , \quad Q_{01} = \sqrt{\frac{\sum q_1 P_0}{\sum q_0 P_0} \times \frac{\sum q_1 P_1}{\sum P_0 q_1}}$$

$P_{01}$ → change in price & $q_{01}$ → change in quantity.

3. Cost of Living Index Numbers:

LIN's.

i) Aggregate Expenditure (or) Weighted Aggregate method:

$$\text{Cost of LIN} = \frac{\sum P_1 q_0}{\sum P_0 q_0} \times 100.$$

ii) family budget Method:

$$\text{weight} \rightarrow V \Rightarrow \sum P_0 q_0.$$

$$\text{Cost of LIN} = \frac{\sum PV}{\sum V} \quad , \quad P = \frac{P_1}{P_0} \times 100$$

4.

| Commodity | base $p_0$ | base $q_0$ | Current $p_1$ | Current $q_1$ | $p_1q_0$ | $p_0q_0$ | $p_1q_1$ | $p_0q_1$ |
|---|---|---|---|---|---|---|---|---|
| A | 10 | 20 | 16 | 10 | 320 | 200 | 160 | 100 |
| B | 18 | 34 | 18 | 42 | 612 | 408 | 756 | 504 |
| C | 15 | 30 | 20 | 26 | 600 | 450 | 520 | 390 |
| | | | | | 1532 | 1058 | 1436 | 994 |

Laspeyre's $P_{01}^{L} = \frac{\sum p_1q_0}{\sum p_0q_0} \times 100$

$= \frac{1532}{1058} \times 100$

$= 144.80$

Paasche's $P_{01}^{P} = \frac{\sum p_1q_1}{\sum p_0q_1} \times 100$

$= \frac{1436}{994} \times 100$

$= 144.46$

Fisher's $P_{01}^{F} = \sqrt{\frac{\sum p_1q_0}{\sum p_0q_0} \times \frac{\sum p_1q_1}{\sum p_0q_1}} \times 100$

$= \sqrt{144.80 \times 144.46}$

$= 144.62$

Increased by $P_{01}^{L} = 45\%$, $P_{01}^{P} = 44\%$, $P_{01}^{F} = 45\%$

15.

| Commodity | 1995 $P_0$ | 1995 $q_0$ | 2005 $P_1$ | 2005 $q_1$ | $P_1q_0$ | $P_0q_0$ | $P_1q_1$ | $P_0q_1$ |
|---|---|---|---|---|---|---|---|---|
| A | 5 | 60 | 15 | 70 | 900 | 300 | 1050 | 350 |
| B | 4 | 20 | 8 | 35 | 160 | 80 | 280 | 140 |
| C | 3 | 15 | 6 | 20 | 90 | 45 | 120 | 60 |
| | | | | | 1150 | 425 | 1450 | 550 |

a) Laspeyre's :

$$P_{01}^{L} = \frac{\sum P_1 q_0}{\sum P_0 q_0} \times 100$$

$$= \frac{1150}{425} \times 100$$

$$= 270.58.$$

b) Paasche's :

$$P_{01}^{P} = \frac{\sum P_1 q_1}{\sum P_0 q_1} \times 100$$

$$= \frac{1450}{550} \times 100$$

$$= 263.63.$$

Increased by.

$P_{01}^{L} = 171\%$

$P_{01}^{P} = 164\%$.

16. Commodity Price Quantity.

| | $P_0$ | $P_1$ | $q_0$ | $q_1$ | $P_1q_0$ | $P_0q_0$ | $P_1q_1$ | $P_0q_1$ |
|---|---|---|---|---|---|---|---|---|
| A | 12 | 14 | 18 | 16 | 252 | 216 | 224 | 192 |
| B | 15 | 16 | 20 | 15 | 320 | 300 | 240 | 225 |
| C | 14 | 15 | 24 | 20 | 360 | 336 | 300 | 280 |
| D | 12 | 12 | 29 | 23 | 348 | 348 | 276 | 276 |
| | | | | | 1280 | 1200 | 1040 | 973 |

a) Laspeyre's

$$P_{01}^{L} = \frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times 100$$

$$= \frac{1280}{1200} \times 100$$

$$= 106.67$$

b) Paache's:

$$P_{01}^{P} = \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1} \times 100$$

$$= \frac{1040}{973} \times 100$$

$$= 106.89.$$

c) Fisher's:

$$P_{01}^{F} = \sqrt{\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1}} \times 100$$

$$= \sqrt{106.67 \times 106.89}$$

$$= 106.779.$$

Increased : $P_{01}^{L} = 7\%$, $P_{01}^{P} = 7\%$, $P_{01}^{F} = 7\%$.

19. Commodity

| | 2016 | | 2017 | | $P_1q_0$ | $P_0q_0$ | $P_1q_1$ | $P_0q_1$ |
|---|---|---|---|---|---|---|---|---|
| | $P_0$ | $q_0$ | $P_1$ | $q_1$ | | | | |
| Food | 40 | 12 | 65 | 14 | 780 | 480 | 910 | 560 |
| Fuel | 72 | 14 | 78 | 20 | 1092 | 1008 | 1560 | 1440 |
| clothing | 36 | 10 | 36 | 15 | 360 | 360 | 540 | 540 |
| wheat | 20. | 6 | 42 | 4 | 252 | 120 | 168 | 80 |
| others | 46 | 8 | 52 | 6 | 416 | 368 | 312 | 276 |
| | | | | | 2900 | 2336 | 3490 | 2896. |

~~TRT~~ : Fisher $P_{01}^{F} = \sqrt{\frac{\sum P_1 q_0}{\sum P_0 q_0} \times \frac{\sum P_1 q_1}{\sum P_0 q_1}} \times 100$

$= \sqrt{\frac{2900}{2336} \times \frac{3490}{2896}} \times 100$

$= \sqrt{1.2414 \times 1.2051} \times 100$

$= 122.286$

TRT :

$$P_{01}^{F} \times P_{10}^{F} = \sqrt{\frac{\sum P_1 q_0}{\sum P_0 q_0} \times \frac{\sum P_1 q_1}{\sum P_0 q_1} \times \frac{\sum P_0 q_1}{\sum P_1 q_1} \times \frac{\sum P_0 q_0}{\sum P_1 q_0}}$$

$$= \frac{2900}{2336} \times \frac{3490}{2896} \times \frac{2896}{3490} \times \frac{2336}{2900}$$

$= 1$

Eg. 9.10 ~~TRT~~ :

| Commodity | Price $P_0$ | Price $P_1$ | Quantity $q_0$ | Quantity $q_1$ | $P_0 q_0$ | $P_0 q_1$ | $P_1 q_0$ | $P_1 q_1$ |
|---|---|---|---|---|---|---|---|---|
| Rice | 38 | 35 | 6 | 7 | 228 | 266 | 210 | 245 |
| Wheat | 12 | 18 | 7 | 10 | 84 | 120 | 126 | 180 |
| Rent | 10 | 15 | 10 | 15 | 100 | 150 | 150 | 225 |
| Fuel | 25 | 30 | 12 | 16 | 300 | 400 | 360 | 480 |
| Miscellaneous | 30 | 33 | 8 | 10 | 240 | 300 | 264 | 330 |
| | | | | | 952 | 1236 | 1110 | 1460 |

Lapeyres :

$$P_{01}^{L} = \frac{\sum P_1 q_0}{\sum P_0 q_0} \times 100$$

$$= \frac{1160}{952} \times 100 = 116.6$$

Paasche's

$$P_{01}^{P} = \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1}$$

$$= \frac{1460}{1236} \times 100.$$

$$= 118.12$$

Fisher's :

$$P_{01}^{F} = \sqrt{\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1}} \times 100$$

$$= \sqrt{116.6 \times 118.12} \times 100$$

$$= 117.36$$

Increased.

$P_{01}^{L} = 17\%$, $P_{01}^{P} = 18\%$, $P_{01}^{F} = 17\%$

18.

| Commodity | $P_0$ | $q_0$ | $P_1$ | $q_1$ | $P_1q_0$ | $P_0q_0$ | $P_1q_1$ | $P_0q_1$ |
|---|---|---|---|---|---|---|---|---|
| A | 5 | 10 | 4 | 12 | 40 | 50 | 48 | 60 |
| B | 8 | 6 | 7 | 7 | 42 | 48 | 49 | 56 |
| C | 6 | 3 | 5 | 4 | 15 | 18 | 20 | 24 |
| | | | | | 97 | 72 | 117 | 140 |

Fisher's :

$$P_{01}^{F} = \sqrt{\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1}} \times 100$$

$$= \sqrt{\frac{97}{72} \times \frac{117}{140}} \times 100.$$

$$= 106.1\%$$

Increased · 6%.

20.

| Commodity | (I N) P | (W) V | PV |
|---|---|---|---|
| Food | 2450 | 48 | 17600 |
| Fuel | 1240 | 20 | 24800 |
| clothes | 3250 | 12 | 39000 |
| Rent | 3750 | 15 | 56250 |
| Miscell | 4190 | 10 | 41900 |
| | | 105 | 279550 |

∴ Family budget:

$$\text{Cost of LIN} = \frac{\Sigma PV}{\Sigma V} = \frac{279550}{105}$$

$$= 2662.380$$

21.

| Commodity | Price $P_0$ | Price $P_1$ | Weight | $P = \frac{P_1}{P_0} \times 100$ | PV |
|---|---|---|---|---|---|
| R | 250 | 280 | 10 | 112.0 | 1120 |
| W | 70 | 85 | 5 | 121.4 | 607 |
| C | 150 | 170 | 6 | 113.3 | 679.8 |
| O | 25 | 35 | 4 | 140.0 | 560 |
| D | 85 | 90 | 3 | 105.9 | 317.7 |
| | | | 28 | | 3284.5 |

Family budget

Cost of LIN : $\frac{\Sigma Pv}{\Sigma v}$

$= \frac{3284.5}{28}$

$= 117.30$

Increased by 17%.

22.

| Commodity | Price $P_0$ $P_1$ | weight $q_0$ | $P_1q_0$ | $P_0q_0$ |
|---|---|---|---|---|
| P | 22 | 25 | 2000 | 1760 |
| Q | 30 | 45 | 350 | 1350 |
| R | 42 | 50 | 1250 | 2100 |
| S | 25 | 35 | 1400 | 875 |
| T | 36 | 50 | 2600 | 1820 |
| | | | 8600 | 7905 |

Aggregate Expenditure.

Cost of LIN : $\frac{\Sigma P_1q_0}{\Sigma P_0q_0} \times 100$

$= \frac{8600}{7905} \times 100$

$= 108.79.$

Increased by 9%.

Eg: 9.1

| Commodity | Base $p_0$ | Base $q_0$ | Current $p_1$ | Current $q_1$ | $p_1q_0$ | $p_0q_0$ | $p_1q_1$ | $p_0q_1$ |
|---|---|---|---|---|---|---|---|---|
| Rice | 15 | 5 | 16 | 8 | 80 | 75 | 128 | 120 |
| wheat | 10 | 6 | 18 | 9 | 108 | 60 | 162 | 90 |
| Rent | 8 | 7 | 15 | 8 | 105 | 56 | 120 | 64 |
| fuel | 9 | 5 | 12 | 6 | 60 | 45 | 72 | 54 |
| Transport | 11 | 4 | 11 | 7 | 44 | 44 | 77 | 77 |
| Misell | 16 | 6 | 15 | 10 | 90 | 96 | 150 | 160 |
| | | | | | 487 | 376 | 709 | 565 |

Laspeyre's:

$$P_{01}^{L} = \frac{\sum p_1q_0}{\sum p_0q_0} \times 100$$

$$= \frac{487}{376} \times 100$$

$$= 129.52$$

Paasche's:

$$P_{01}^{P} = \frac{\sum p_1q_1}{\sum p_0q_1} \times 100$$

$$= \frac{709}{565} \times 100$$

$$= 125.48$$

Fisher's:

$$P_{01}^{F} = \sqrt{\frac{\sum p_1q_0}{\sum p_0q_0} \times \frac{\sum p_1q_1}{\sum p_0q_1}} \times 100$$

$$= \sqrt{129.52 \times 125.48}$$

$$= 127.48$$

Increased by: 30%, $P_{01}^{P}$ = 25%, $P_{01}^{F}$ = 27%.

Eg: 9.12 T. RT.

| Commodity | Price | | Quantity | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $P_0$ | $P_1$ | $q_0$ | $q_1$ | $P_1q_0$ | $P_0q_0$ | $P_1q_1$ | $P_0q_1$ |
| Rice | 10 | 13 | 4 | 6 | 52 | 40 | 78 | 60 |
| Wheat | 15 | 18 | 7 | 8 | 126 | 105 | 144 | 120 |
| Fuel | 11 | 14 | 8 | 10 | 112 | 88 | 140 | 110 |
| Misc | 14 | 17 | 6 | 7 | 102 | 84 | 119 | 98 |
| Rent | 25 | 29 | 5 | 9 | 145 | 125 | 261 | 225 |
| | | | | | 537 | 442 | 742 | 613 |

Fisher:

$$P_{01}^{F} = \sqrt{\frac{\Sigma P_1q_0}{\Sigma P_0q_0} \times \frac{\Sigma P_1q_1}{\Sigma P_0q_1}} \times 100$$

$$= \sqrt{\frac{537}{442} \times \frac{742}{613}} \times 100$$

$$= 1.211$$

TRT:

$$P_{01} \times P_{10} = \sqrt{\frac{\Sigma P_1q_0}{\Sigma P_0q_0} \times \frac{\Sigma P_1q_1}{\Sigma P_0q_1} \times \frac{\Sigma P_0q_1}{\Sigma P_1q_1} \times \frac{\Sigma P_0q_0}{\Sigma P_1q_0}}$$

$$= \sqrt{\frac{537}{442} \times \frac{742}{613} \times \frac{613}{742} \times \frac{442}{537}}$$

$$= 1$$

FRT:

$$P_{01} \times Q_{01} = \frac{\Sigma P_1q_1}{\Sigma P_0q_0}$$

$$P_{01} \times Q_{01} = \sqrt{\frac{\Sigma P_1q_0}{\Sigma P_0q_0} \times \frac{\Sigma P_1q_1}{\Sigma P_0q_1} \times \frac{\Sigma q_1P_0}{\Sigma q_0P_0} \times \frac{\Sigma q_1P_1}{\Sigma q_0P_1}}$$

$$= \sqrt{\frac{537}{442} \times \frac{742}{613} \times \frac{613}{442} \times \frac{742}{537}}$$

$$= \sqrt{\frac{742 \times 742}{442 \times 442}}$$

$$= \frac{742}{442}$$

$$P_{01} \times Q_{01} = \frac{\Sigma P_1 q_1}{\Sigma P_0 q_0}$$

Eg: 9.13

| Commodity | Base Year $P_0$ | Base Year $q_0$ | Current $P_1$ | Current $q_1$ | $P_1q_0$ | $P_0q_0$ | $P_1q_1$ | $P_0q_1$ |
|---|---|---|---|---|---|---|---|---|
| Rice | 10 | 5 | 11 | 6 | 55 | 50 | 66 | 60 |
| wheat | 12 | 6 | 13 | 4 | 78 | 72 | 52 | 48 |
| Rent | 14 | 8 | 15 | 7 | 120 | 112 | 105 | 98 |
| fuel | 16 | 9 | 17 | 8 | 153 | 144 | 136 | 128 |
| Trans | 18 | 7 | 19 | 5 | 133 | 126 | 95 | 90 |
| M'sce | 20 | 4 | 21 | 3 | 84 | 80 | 63 | 60 |
| | | | | | 623 | 584 | 517 | 484 |

Fisher:

$$P^F_{01} = \sqrt{\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1}} \times 100$$

$$= \sqrt{\frac{623}{584} \times \frac{517}{484}} \times 100$$

$$= 106.74.$$

TRT:

$$P_{01} \times P_{10} = \sqrt{\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1} \times \frac{\Sigma P_0 q_1}{\Sigma P_1 q_1} \times \frac{\Sigma P_0 q_0}{\Sigma P_1 q_0}}$$

$$= \sqrt{\frac{623}{584} \times \frac{517}{484} \times \frac{484}{517} \times \frac{584}{623}}$$

$$= 1$$

FRT:

$$P_{01} \times Q_{01} = \sqrt{\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1} \times \frac{\Sigma q_1 P_0}{\Sigma q_0 P_0} \times \frac{\Sigma q_1 P_1}{\Sigma q_0 P_1}}$$

$$= \sqrt{\frac{623}{584} \times \frac{517}{484} \times \frac{484}{584} \times \frac{517}{623}}$$

$$= \sqrt{\frac{517 \times 517}{584 \times 584}} = \frac{517}{584}$$

$$P_{01} \times Q_{01} = \frac{\Sigma P_1 q_1}{\Sigma P_0 q_0}$$

Eg: 9.14.

| Commodity | Base $P_0$ | Base $q_0$ | Current $P_1$ | Current $q_1$ | $P_1q_0$ | $P_0q_0$ | $P_1q_1$ | $P_0q_1$ |
|---|---|---|---|---|---|---|---|---|
| Rice | 40 | 5 | 48 | 4 | 240 | 200 | 192 | 160 |
| Wheat | 45 | 2 | 42 | 3 | 84 | 90 | 126 | 135 |
| Rent | 90 | 4 | 95 | 6 | 380 | 360 | 570 | 540 |
| Fuel | 85 | 3 | 80 | 2 | 240 | 225 | 160 | 170 |
| Trans | 50 | 5 | 65 | 8 | 325 | 250 | 520 | 400 |
| Misc | 65 | 1 | 72 | 3 | 72 | 65 | 216 | 195 |
| | | | | | 1341 | 1220 | 1784 | 1600 |

Fisher:

$$P_{01}^{F} = \sqrt{\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1}} \times 100$$

$$= \sqrt{\frac{1341}{1220} \times \frac{1784}{1600}} \times 100$$

$$= 110.71$$

TRT :

$$P_{01} \times P_{10} = \sqrt{\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1} \times \frac{\Sigma P_0 q_1}{\Sigma P_1 q_1} \times \frac{\Sigma P_0 q_0}{\Sigma P_1 q_0}}$$

$$= \sqrt{\frac{1341}{1220} \times \frac{1784}{1600} \times \frac{1600}{1784} \times \frac{1220}{1341}}$$

$$= 1$$

FRT :

$$P_{01} \times Q_{01} = \frac{\Sigma P_1 q_1}{\Sigma P_0 q_0}$$

$$P_{01} \times Q_{01} = \sqrt{\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1} \times \frac{\Sigma q_1 P_0}{\Sigma q_0 P_0} \times \frac{\Sigma q_1 P_1}{\Sigma q_0 P_1}}$$

$$= \sqrt{\frac{1341}{1220} \times \frac{1784}{1600} \times \frac{1600}{1220} \times \frac{1784}{1341}}$$

$$= \sqrt{\frac{1784}{1220}}$$

$$= \frac{1784}{1220}$$

$$P_{01} \times Q_{01} = \frac{\Sigma P_1 q_1}{\Sigma P_0 q_0}$$

Eg: 9.18

| Commodity | Price $P_0$ | Price $P_1$ | weight $q_0$ | $P_1 q_0$ | $P_0 q_0$ |
|---|---|---|---|---|---|
| A | 7 | 9 | 10 | 90 | 70 |
| B | 6 | 8 | 12 | 96 | 72 |
| C | 10 | 15 | 17 | 255 | 170 |
| D | 14 | 16 | 19 | 304 | 266 |
| E | 12 | 17 | 15 | 255 | 180 |
| | | | | 1000 | 758 |

Cost of LIN $= \frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times 100 = \frac{1000}{758} \times 100$

$= 131.93$

Eg: 9.16

| Commodity | Price $P_0$ | Price $P_1$ | weight $q_0$ | $P_0q_0$ | $P_1q_0$ |
|---|---|---|---|---|---|
| Rice | 1500 | 1700 | 5 | 7500 | 8150 |
| Sugar | 1100 | 1200 | 3.5 | 3850 | 4200 |
| Pulses | 800 | 950 | 3 | 2400 | 2850 |
| cloth | 1200 | 1550 | 2 | 2400 | 3100 |
| Ghee | 550 | 700 | 0.75 | 412.5 | 525 |
| Rent | 2500 | 3000 | 12 | 30000 | 36000 |
| fuel | 750 | 600 | 8 | 6000 | 4800 |
| Misc | 3200 | 3500 | 10 | 32000 | 35000 |
| | | | | 84562.5 | 95225 |

Cost of LIN = $\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0} \times 100$

$= \frac{84562.5}{95225} \times 100$ $\quad \frac{95225}{84562.5} \times 100$

$= 112.61$

Increased by 13%.

Eg: 9.17

| Commodity | Price $P_0$ | Price $P_1$ | Quantity $q_0$ | $P_1q_0$ | $P_0q_0$ |
|---|---|---|---|---|---|
| Rice | 32 | 48 | 25 | 1200 | 800 |
| Sugar | 25 | 42 | 10 | 420 | 250 |
| Oil | 54 | 85 | 6 | 510 | 324 |
| coffee | 250 | 460 | 1 | 460 | 250 |
| Tea | 175 | 275 | 2 | 550 | 350 |
| | | | | 3140 | 1974 |

Cost of LIN = $\frac{\Sigma P_1 v_0}{\Sigma P_0 v_0} \times 100$

$= \frac{3140}{1974} \times 100$

$= 159.06$

Increased by 59%

Eg: 9.18

| Commodity | Price $P_0$ | Price $P_1$ | weight (V) | $P = \frac{P_1}{P_0} \times 100$ | PV |
|---|---|---|---|---|---|
| A | 350 | 400 | 40 | 114.28 | 4571.4 |
| B | 175 | 250 | 35 | 142.85 | 4999.99 |
| C | 100 | 115 | 15 | 115.00 | 1725 |
| D | 75 | 105 | 20 | 114.00 | 2280 |
| E | 60 | 80 | 25 | 133.33 | 3333.33 |
| | | | 135 | | 16909.73 |

Family budget Method:

Cost of LIN = $\frac{\Sigma PV}{\Sigma V}$

$= \frac{16909.73}{135}$

$= 125.26$

Increased by 25%

# Exercise 9.3

CL → Centre line

UCL → Upper Control line

LCL → Lower Control line

## Charts

Mean $\bar{x}$ Range $\bar{R}$

$$\bar{\bar{x}} = \frac{\Sigma \bar{x}}{no} \qquad \bar{x} = \frac{\Sigma x}{no}$$

$$\bar{R} = \frac{\Sigma R}{no}$$

$$R = x_{max} - x_{min}.$$

$\bar{\bar{x}}$

Case I Case in $\sigma_n$

$$UCL = \bar{\bar{x}} + \frac{3\sigma}{\sqrt{n}}$$

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

$$LCL = \bar{\bar{x}} - \frac{3\sigma}{\sqrt{n}}.$$

Case II

$\sigma_n$ not given.

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

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

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

R:

Case I: $\sigma_n$

$$UCL = \bar{R} + 3\sigma_R.$$

$$CL = \bar{R}.$$

$$LCL = \bar{R} - 3\sigma_R.$$

Case II not given $\sigma$.

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

$$CL = \bar{R}.$$

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

16.

| Sample | $x_1$ | $x_2$ | $x_3$ | $\bar{x}$ | R. |
|---|---|---|---|---|---|
| 1 | 32 | 36 | 42 | 36.7 | 43-32=10 |
| 2 | 28 | 32 | 40 | 33.3 | 12 |
| 3 | 39 | 52 | 28 | 39.7 | 24 |
| 4 | 50 | 42 | 31 | 41.0 | 19 |
| 5 | 42 | 45 | 34 | 40.3 | 11 |
| 6 | 50 | 29 | 21 | 33.3 | 29 |
| 7 | 44 | 52 | 35 | 43.7 | 17 |
| 8 | 22 | 35 | 44 | 33.7 | 22 |
| | | | | 301.7 | 144 |

$$\bar{\bar{x}} = \frac{\Sigma \bar{x}}{n} = \frac{301.7}{8} = 31.71$$

$$\bar{R} = \frac{\Sigma R}{n} = \frac{144}{8} = 18$$

14.

| S | $\bar{x}$ | R. |
|---|---|---|
| 1 | 15 | 7 |
| 2 | 17 | 7 |
| 3 | 15 | 4 |
| 4 | 18 | 9 |
| 5 | 17 | 8 |
| 6 | 14 | 7 |
| 7 | 18 | 12 |
| 8 | 15 | 4 |
| 9 | 17 | 11 |
| 10 | 16 | 5 |
| | 162 | 74 |

$$\bar{\bar{x}} = \frac{\Sigma \bar{x}}{n} = \frac{162}{10} = 16.2$$

$$\bar{R} = \frac{\Sigma R}{n} = \frac{74}{10} = 7.4$$

Mean $\bar{\bar{x}}$

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

$= 16.2 + 0.58 \times 7.4$

$UCL = 20.5$

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

$= 16.2$

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

$= 16.2 - 0.58 \times 7.4$

$LCL = 11.9$

Range $\bar{R}$

$UCL = D_4\bar{R}$

$= 2.115 \times 7.4$

$= 15.65$

$CL = \bar{R}$

$= 7.4$

$LCL = D_3\bar{R}$

$= 0 \times 7.4$

$= 0$

21.

| Time | weights in ml | | | | | $\bar{x}$ | $R$ |
|---|---|---|---|---|---|---|---|
| 8:00 AM | 43 | 41 | 42 | 43 | 41 | 42 | 43-41 = 2 |
| 9:00 AM | 40 | 39 | 40 | 39 | 44 | 40.2 | 5 |
| 10:00 AM | 42 | 42 | 43 | 38 | 40 | 41 | 5 |
| 11:00 AM | 39 | 43 | 40 | 39 | 42 | 40.6 | 4 |
| | | | | | | 164 | 16 |

$n = 5$ ; $A_2 = 0.58$, $D_3 = 0$, $D_4 = 2.115$.

(Sample size)

$\bar{\bar{x}} = \frac{\Sigma \bar{x}}{n}$ $R = \frac{\Sigma R}{n}$

$= \frac{164}{4}$ $= \frac{16}{4}$

$= 41$ $= 4$

Mean $\bar{\bar{x}}$ :

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

$= 42 + 0.58(4)$

$= 44.32$.

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

$= 42$.

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

$= 42 - 0.58(4)$

$= 39.68$.

Range ($\bar{R}$):

$UCL = D_4\bar{R}$

$= 2.115 \times 4$

$= 8.46$

$CL = \bar{R}$

$= 4$.

$LCL = D_3\bar{R}$

$= 0(4)$

$= 0$.

17

| Sample | Mean $\bar{x}$ | Range (R) |
|---|---|---|
| 1 | 11.2 | 7 |
| 2 | 11.8 | 4 |
| 3 | 10.8 | 8 |
| 4 | 11.6 | 5 |
| 5 | 11.0 | 7 |
| 6 | 9.6 | 4 |
| 7 | 10.4 | 8 |
| 8 | 9.6 | 4 |
| 9 | 10.6 | 7 |
| 10 | 10.0 | 9. |
| | 106.6 | 63 |

$$\bar{\bar{x}} = \frac{\Sigma \bar{x}}{n}$$

$$= \frac{106.6}{10}$$

$$= 10.67$$

$$\bar{R} = \frac{\Sigma R}{n} = \frac{63}{10} = 6.3.$$

Mean $\bar{\bar{x}}$ :

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

$= 10.67 + 0.58(6.3)$

$= 14.324.$

$CL = \bar{\bar{x}} = 10.67$

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

$= 10.67$

Range

$UCL = D_4 \bar{R}$

$= 2.115\ (6.3)$

$= 13.32.$

$CL = \bar{R}$

$= 6.3.$

$LCL = D_3 \bar{R}$

$= 0.$

19)

| Sample | $\bar{x}$ | R. |
|---|---|---|
| 1 | 29 | 39 |
| 2 | 26 | 10 |
| 3 | 37 | 39 |
| 4 | 34 | 17 |
| 5 | 14 | 12 |
| 6 | 45 | 20 |
| 7 | 39 | 5 |
| 8 | 20 | 21 |
| 9 | 34 | 23 |
| | 23 | 15 |
| | 301 | 201. |

$$\bar{\bar{x}} = \frac{\Sigma \bar{x}}{n} = \frac{301}{10} = 30.1$$

$$\bar{R} = \frac{\Sigma R}{n} = \frac{201}{10} = 20.1$$