Correlation

Definition

Two variables are said to be correlated if the change in one variable results in a corresponding change in the other variable. That is, when two variables move together, we say they are correlated. For example, when the price of a commodity rises, the supply for that commodity also rises. On the other hand, if price falls the supply also falls. So both variables move together or they move in sympathy. Hence price and supply are correlated.

Correlation and Causation

The word correlation usually implies cause and effect relationship. For example, a change in price is the cause for a change in demand. But when two variables are correlated there need not be cause and effect relationship always. It is just possible that a high degree of correlation between the variables may be due to the same cause affecting each variable. For example, a high degree of correlation between the yield per acre of rice and tea may be due to the fact that both are related to the amount of rainfall. But none of the two variables is the cause of the other.

Spurious Correlation

Two series may show a high degree of correlation which may result purely from chance also. For example, during the last decade, there has been a significant increase in the sales of news papers and in the number of crimes. That does not mean that there exists any correlation between sales of news paper and crimes. But we can try to establish correlation between the two variables on the basis of the data. Such illogical correlation is referred to as nonsensical or spurious correlation. It is a case of casual relationship.

Positive and Negative correlation

Correlation can be either positive or negative. When the values of two variables move in the same direction, correlation is said to be positive ie an increase in the value of one variable results into an increase in the value of the other variable also or if a decrease in the value of one variable, results into a decrease in the value of the other variable also correlation is said to be positive. If on the other hand, the value of two variables move in opposite directions so that an increase in the value of one variable, results in to a decrease in the value of the other variable or the decrease in the value of one variable results into an increase in the value of the other variable the correlation is said to be negative. Generally, price and supply are positively correlated because when price increases supply also increases and when price comes down supply follows. Correlation between price and demand is said to be inverse or negative because with a fall in price, demand goes up and with a rise in price, demand comes down.

Linear and Non linear Correlation

Correlation may be linear or non linear. When the amount of change in one variable leads to a constant ratio of change in the other variable, correlation is said to be linear. For example if price goes up by 10% it leads to a rise in supply by 15% each time, then there is a linear relation between price and supply. When there is linear correlation, the points plotted on a graph will give a straight line. Generally we do not find linear correlation in the economic and social phenomena becauase of the influence of multiple and complex factors on the variable.

Ex

x :	20	25	30	35	40
y :	30	37.5	45	52.5	60

In this example there is linear relationship as there is the ratio 2 : 3 at all points. If we plot these points, they will lie on a straight line.

Correlation is said to be non linear (or curvilinear), when the amount of change in one variable is not in constant ratio to the change in the other variable. In the case of curvilinear correlation, the ratio of change fluctuates and is never constant.

Methods for studying correlation (Measures of Correlation)

Correlation between two variables can be measured by both graphic and algebraic methods. Scatter diagram is an important graphic method while coefficient of correlation is an algebraic method.

(1) Scatter diagram

This is a graphical method of studying correlation between two variables. One of the variables is shown on the X – axis and the other on the Y - axis. Each pair of values is plotted on the graph by means of a dot mark. After, all the values are plotted we get as many dots on the graph paper as the number of pairs of values. If these points show some trend either upward or downward, the two variables are said to be correlated. If the plotted points do not show any trend, the two variables are not correlated. If on the other hand the tendency is reverse so that the points show a downward trend from the left top to the right bottom, correlation is negative.

The scatter diagram is a visual aid to show the presence or absence of correlation between two variables. A line of best fit can be drawn using the method of least squares. This line will be as close to the points as possible. If the points are falling very close to this line, there is very high degree of correlation . If they lie very much away from this line it shows that the correlation is not much.

For the two sets of data given below draw scatter diagrams and comment on the relationship between variables x and y.

Set I

x	y
5	6
8	10
2	3
4	4
10	12
6	8
8	8

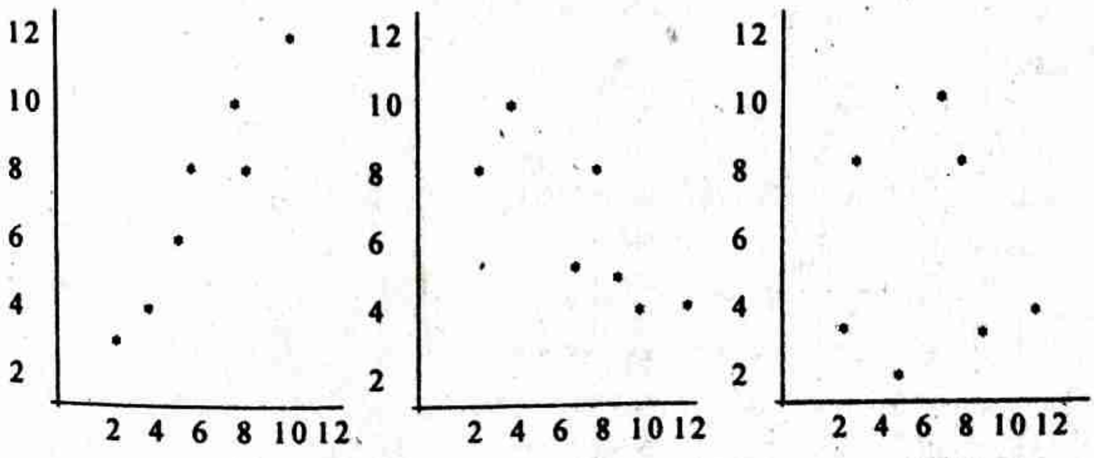
Set II

x	y
12	4
7	5
10	4
8	8
4	10
9	5
2	8

Set III

x	y
2	3
5	2
7	10
8	8
3	8
9	3
11	4

Ans: Scatter diagram



Set I Set II Set III

From the three scatter diagrams we can conclude that there is positive correlation between x and y in the I set, there is negative correlation between x and y in the II set and there is no correlation between x and y in the set III.

(3) Coefficient of correlation

Coefficient of correlation is an algebraic method of measuring correlation. Under this method, we measure correlation by finding a value known as the coefficient of correlation using an appropriate formula. Correlation coefficient is a numerical value. It shows the degree or the extent of correlation between two variables.

Karl Pearson's method and Spearman's method are the two important algebraic methods for measuring correlation.

KARL PEARSON'S COEFFICIENT OF CORRELATION

Of the several methematical methods of measuring correlation the Karl Pearson's method, popularly known as Pearsonian Coefficient of correlation, is most widely used in practice. Karl Pearson, the great biologist and statistician has given a formula for calculation of coefficient of correlation. The Pearsonian Coefficient of Correlation is denoted by the symbol 'r'. The formula for computing Pearsonial Coefficient of Correlation is $r = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{n\,\sigma_x\,\sigma_y}$ where σ_x = Standard deviation of x series. σ_y = Standard deviation of y series and n = Number of pairs of observations. This is also known as product moment correlation coefficient.

The above formula can be expressed in the following form also

$$\frac{n\Sigma xy - (\Sigma x.\Sigma y)}{\sqrt{n\Sigma x^2 - (\Sigma x)^2}\sqrt{n\Sigma y^2 - (\Sigma y)^2}}$$

Ex. 1: Calculate coefficient of correlation

x	**:**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
y	**:**	**4**	**5**	**6**	**12**	**9**	**5**	**4**

Ans:

x	y	xy	x^2	y^2
2	4	8	4	16
3	5	15	9	25
4	6	24	16	36
5	12	60	25	144
6	9	54	36	81
7	5	35	49	25
8	4	32	64	16
35	45	228	203	343

Coefficient of correlation (r)

$$= \frac{n\Sigma xy - (\Sigma x.\Sigma y)}{\sqrt{n\Sigma x^2 - (\Sigma x)^2}\sqrt{n\Sigma y^2 - (\Sigma y)^2}}$$

$$= \frac{7\times 228 - (35\times 45)}{\sqrt{7\times 203 - (35)^2}\sqrt{7\times 343 - (45)^2}} = \frac{1596 - 1575}{\sqrt{1421 - 1225}\sqrt{2401 - 2025}}$$

$$= \frac{21}{\sqrt{196}\sqrt{376}} = \frac{21}{14\times 19.39} = \frac{21}{271.46} = \underline{0.077}$$

Degree of correlation (Interpretation of r)

The degree of correlation can be classified into:-

1. **Perfect Correlation:** When the change in two variables is such that with an increase in the value of one, the value of the other increases in a fixed proportion, correlation is said to be perfect. Perfect correlation may be positive or negative. Coefficient of correlation is +1 for perfect positive correlation and it is –1 for perfect negative correlation.
2. **No Correlation:** If changes in the value of one variable are not associated with changes in the value of the other variable, there will be no correlation. When there is no correlation the coefficient of correlation is zero.
3. **Limited degree of correlation:** In between perfect correlation and no correlation there may be limited degree of correlation. Limited degree of correlation may also be positive or negative. Limited degree of correlation may be termed as high, moderate or low. For limited degree of correlation the coefficient of correlation lies between 0 and 1 numerically.

Ex. 2: What would be your interpretation if the correlation coefficient 'r' is equal to (1) 0 (2) –1 (3) 1 (4) .2 (5) .9 (6) .52

Ans:

(1) when r = 0, there is no correlation between the variables.
(2) when r = –1, there is negative perfect correlation.
(3) when r = 1, there is perfect positive correlation.
(4) When r = 0.2, there is very low positive correlation.
(5) When r = –0..9, there is high positive correlation.
(6) When r = 0.52, there is moderate positive correlation.

Ex. 3: Compute Karl Pearson's Coefficient of Correlation

Price (Rs) :	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Demand (Rs) :	**30**	**29**	**29**	**25**	**24**	**24**	**24**	**21**	**18**	**15**

Also comment on the result obtained.

Price (x)	Demand (y)	xy	x^2	y^2
11	30	330	121	900
12	29	348	144	841
13	29	377	169	841
14	25	350	196	625
15	24	360	225	576
16	24	384	256	576
17	24	408	289	576
18	21	378	324	441
19	18	342	361	324
20	15	300	400	225
155	239	3577	2485	5925

$$\text{Coefficient of correlation} = \frac{n\Sigma xy - (\Sigma x.\Sigma y)}{\sqrt{n\Sigma x^2 - (\Sigma x)^2}\sqrt{n\Sigma y^2 - (\Sigma y)^2}}$$

$$= \frac{10\times 3577-(155\times 239)}{\sqrt{10\times 2485-(155)^2}\sqrt{10\times 5925-(239)^2}} = \frac{35770-37045}{\sqrt{24850-24025}\sqrt{59250-57121}}$$

$$= \frac{-1275}{\sqrt{825}\ \sqrt{2129}} = \frac{-1275}{28.72\times 46.14} = \frac{-1275}{1325.2} = \underline{\underline{-.962}}$$

There is very high negative correlation between price and demand

Note: Coefficient of correlation is not affected by change of scale. Therefore if we multiply or divide all the values of a variable by a constant, the coefficient of correlation will not change.

Ex. 4: Find the coefficient of correlation between x and y and interpret the result.

X :	**1.2**	**1.1**	**1.9**	**1.8**	**1.0**	**0.9**
Y :	**15**	**10**	**20**	**10**	**10**	**5**

Ans: Multiply x values by 10 and divide y values by 5. Then we get new x values and y values.

x	y	xy	x^2	y^2
12	3	36	144	9
11	2	22	121	4
19	4	76	361	16
18	2	36	324	4
10	2	20	100	4
9	1	9	81	1
79	14	199	1131	38

$$\text{Coefficient of correlation} = \frac{n\Sigma xy - (\Sigma x.\Sigma y)}{\sqrt{n\Sigma x^2 - (\Sigma x)^2}\sqrt{n\Sigma y^2 - (\Sigma y)^2}}$$

$$= \frac{6\times 199-(79\times 14)}{\sqrt{6\times 1131-(79)^2}\ \sqrt{6\times 38-(14)^2}} = \frac{1194-1106}{\sqrt{6786-6241}\ \sqrt{228-196}} = \frac{88}{\sqrt{545}\ \sqrt{32}} = \underline{0.67}$$

$\therefore$ There is good positive correlation between x and y.

***NOTE :** Similarly if we take deviation from an arbitrary number for one or both the variables the correlation coefficient of these deviation will be the same as that of the . orginal values.*

Ex. 5: Find coefficient of correlation between age and playing habit of the following students.

Age :	**14.5-15.5**	**15.5-16.5**	**16.5-17.5**	**17.5-18.5**	**18.5-19.5**	**19.5-20.5**
No. of students:	**250**	**200**	**150**	**120**	**100**	**80**
Regular Players:	**200**	**150**	**90**	**48**	**30**	**12**

Ans: Hint: 1) Age is given in class intervals. So mid values are taken.

2) Playing habit in % = $\frac{\text{No. of regular players}}{\text{No. of students}} \times 100$

Age	Playing habit	x	y	xy	x^2	y^2
15	80	–3	30	–90	9	900
16	75	–2	25	–50	4	625
17	60	–1	10	–10	1	100
18	40	0	–10	0	0	100
19	30	1	–20	20	1	400
20	15	2	–35	4	4	1225
		–3	0	–240	19	3350

$$r = \frac{n\Sigma xy - (\Sigma x . \Sigma y)}{\sqrt{n\Sigma x^2 - (\Sigma x)^2}\sqrt{n\Sigma y^2 - (\Sigma y)^2}} = \frac{6 \times -240 - (-3 \times 0)}{\sqrt{6 \times 19 - (-3)^2}\sqrt{6 \times 3350 - (0)^2}}$$

$$= \frac{-1440}{10.25 \times 141.77} = \frac{-1440}{1453.14} = \underline{\underline{-.99}}$$

Note : For age, deviations are taken from 18. ie x = Age – 18. Similarly y = playing habit – 50

Properties of Correlation Coefficient

1. Correlation coefficient has a well defined formula.
2. Correlation coefficient is a pure number and is independent of the units of measurement.
3. It lies between –1 and +1.
4. Correlation coefficient does not change with reference to change of origin or change of scale.
5. Coefficient of correlation between x and y is same as that between y and x.

Probable Error

Probable error of the coefficient of correlation is a statistical measure which measures reliability and dependability of the value of coefficient of correlation. If probable error is added to or subtracted from the coefficient of correlation it would give two such limits within which we can reasonably expect the value of coefficient of correlation to vary. Usually the coefficient of correlation is calculated from samples. For different samples drawn from the same population the coefficient of correlation may vary. But the numerical value of such variations is expected to be less than the probable error.

The formula for finding probable error is

Probable Error $= \frac{.6745(1-r^2)}{\sqrt{n}}$ where 'r' stands for the correlationcoefficient and 'n' number of pairs of observation.

The quantity $\frac{1-r^2}{\sqrt{n}}$ is known as standard Error of correlation coefficient.

Interpretation of coefficient of correlation on the basis of probable error.

(1) If the coefficient of correlation is less than its probable error, correlation is not at all significant.

(2) If the coefficient of correlation is more than six times its probable error, it is significant.

(3) If the probable error is not much and if the coefficient of correlation is .5 or more it is generally considered to be significnat.

Ex. 6: If r=.6 and n=64, find Probable Error and Standard error.

Ans:

$$\text{P. E.} = \frac{.6745(1-r^2)}{\sqrt{n}} = \frac{.6745(1-.36)}{\sqrt{64}} = \frac{.6745 \times .64}{8} = \underline{\underline{.054}}$$

$$\text{Standard error} = \frac{1-r^2}{\sqrt{n}} = \frac{1-.36}{\sqrt{64}} = \underline{\underline{0.08}}$$

Since probable error is very small the correlation is significant.

RANK CORRELATION

In many cases quantitative measurement is not possible because they are in qualitative form. For example, we cannot measure the beauty or intelligence quantitatively. But it may be possible, in their case, to rank the individuals in some order. The correlation coefficient obtained from the ranks so obtained is called rank correlation. Therefore rank correlation is the correlation obtained from ranks, instead of their quantitative measurement.

Thus, when the values of two variables are expressed in ranks and therefrom correlation is obtained, that correlation is known as rank correlation.

Spearman's Rank Correlation Coefficient

Spearman has devised a formula known as Spearman's rank correlation coefficient to find the correlation coefficient from the ranks. According to spearman's method, the formula for Rank Correlation Coefficient is $1 - \frac{6\Sigma D^2}{n(n^2-1)}$

where 'D' is the difference between ranks and n, number of items.

Ex.7: The ranking of 10 individuals at the start and at the finish of a course of a training are as follows

Individuals :	A	B	C	D	E	F	G	H	I	J
Rank before :	1	6	3	9	5	2	7	10	8	4
Rank after :	6	8	3	2	7	10	5	9	4	1

Calculate Spearmen's Rank correlation coefficient.

Ans:

Rank before	Rank after	Rank difference (D)	D^2
1	6	5	25
6	8	2	4
3	3	0	0
9	2	7	49
5	7	2	4
2	10	8	64
7	5	2	4
10	9	1	1
8	4	4	16
4	1	3	9
			176

$$\text{Rank correlation coefficient} = 1 - \frac{6\Sigma D^2}{n(n^2-1)} = 1 - \frac{6 \times 176}{10\ (100-1)}$$

$$= 1 - \frac{1056}{990} = 1 - 1.07 = \underline{\underline{-0.07}}$$

Ex. 8: Ten competitors in a beauty contest are ranked by three judges in the following order.

First Judge :	1	6	5	10	3	2	4	9	7	8
Second Judge:	3	5	8	4	7	10	2	1	6	9
Third Judge :	6	4	9	8	1	2	3	10	5	7

Use the correlation coefficient to discuss which pair of judges have nearest approach to common tastes in beauty.

Ans:

J_1	J_2	J_3	$D_1^2=(J_1-J_2)^2$	$D_2^2=(J_1-J_3)^2$	$D_3^2=(J_2-J_3)^2$
1	3	6	4	25	9
6	5	4	1	4	1
5	8	9	9	16	1
10	4	8	36	4	16
3	7	1	16	4	36
2	10	2	64	0	64
4	2	3	4	1	1
9	1	10	64	1	81
7	6	5	1	4	1
8	9	7	1	1	4
			200	60	214

Rank Correlation Coefficient between J_1 and J_2 $= 1 - \frac{6\Sigma D_1^2}{n(n^2 - 1)} = 1 - \frac{6 \times 200}{10(100-1)} = 1 - 1.21 = -.21$

Rank Correlation Coefficient between J_1 and J_3 $= 1 - \frac{6\Sigma D_2^2}{n(n^2 - 1)} = 1 - \frac{6 \times 60}{10(100-1)} = 1 - .364 = \underline{.636}$

Rank Correlation coefficient between J_2 and J_3 $= 1 - \frac{6\Sigma D_3^2}{n(n^2 - 1)} = 1 - \frac{6 \times 214}{990} = 1 - 1.30 = \underline{-0.30}$

The rank correlation coefficient in the case of I and III Judges is greater than the other two pairs. Therefore I and III judges have highest similarity of thought and have the nearest approach to common taste in beauty.

Ex. 9: Find the rank correlation coefficient between poverty and over-crowding from the table below:

Town	A	B	C	D	E	F	G	H	I	J
Poverty	17	13	15	16	6	11	14	9	7	12
Over crowding	36	46	35	24	12	18	27	22	2	8

Ans:

Town	Poverty		Overcrowding		D^2
	Values	Rank (R_1)	Values	Rank (R_2)	$= (R_1 - R_2)^2$
A	17	1	36	2	1
B	13	5	46	1	16
C	15	3	35	3	0
D	16	2	24	5	9
E	6	10	12	8	4
F	11	7	18	7	0
G	14	4	27	4	0
H	9	8	22	6	4
I	7	9	2	10	1
J	12	6	8	9	9
					44

Rank correlation coefficient =

$$1 - \frac{6\Sigma D^2}{n(n^2 - 1)} = 1 - \frac{6 \times 44}{10(100-1)} = 1 - \frac{264}{990} = 1 - .267 = \underline{0.733}$$

Repeated Rank (Tie in Rank)

When the values repeat in one or both the series, we add a correction factor $\Sigma \frac{m^3 - m}{12}$ to ΣD^2. The formula for Rank correlation coefficient thus obtained is, $1 - \frac{6(\Sigma D^2 + \frac{m^3 - m}{12})}{n(n^2 - 1)}$

where 'm' stands for number of times each value repeats in any one series.

Ex. 10: Obtain the rank correlation coefficient for the following data

X	**: 68**	**64**	**75**	**50**	**64**	**80**	**75**	**40**	**55**	**64**
Y	**: 62**	**58**	**68**	**45**	**81**	**60**	**68**	**48**	**50**	**70**

Ans:

X	Rank of x	y	Rank of y	Rank difference. (D)	D^2
68	4	62	5	1	1
64	6	58	7	1	1
75	2.5	68	3.5	1	1
50	9	45	10	1	1
64	6	81	1	5	25
80	1	60	6	5	25
75	2.5	68	3.5	1	1
40	10	48	9	1	1
55	8	50	8	0	0
64	6	70	2	4	16
					$\Sigma D^2 = 72$

75 Occurs 2 times $\therefore$ m = 2 $\qquad m^3 - m = 2^3 - 2 = 6$

64 Occurs 3 times $\therefore$ m = 3 $\qquad m^3 - m = 3^3 - 3 = 24$

68 Occurs 2 times $\therefore$ m = 2 $\qquad m^3 - m = 2^3 - 2 = 6$

$\therefore$ Total $m^3 - m = \Sigma\ (m^3 - m) = 36$

$\therefore$ Rank correlation coefficient

$$= 1 - \frac{6(\Sigma D^2 + \frac{m^3 - m}{12})}{n(n^2-1)} = 1 - \frac{6 \times (72 + \frac{36}{12})}{10(100-1)} = 1 - \frac{6 \times 75}{990} = \underline{\underline{.545}}$$

How to assign rank when there is repetition ?

Ans: When a value repeats, rank is the average of ranks due for all of them if they are different. For example: In the last problem, highest value in the x - series is 80. So it is given rank I. Next two values are the same 75. They are given the average of 2 and 3 ie 2.5. Then 4th rank is given to the next highest value 68. Then 64 occurs 3 times. So each 64 is given the average of ranks 5, 6, 7 ie 6 and so on.

Merits and Demerits of Rank correlation

Merits

1. It is easy to calculate.
2. It is simple to understand.
3. It can be applied to both quantitative and qualitative data.

Demerits

1. Rank correlation coefficient is only approximate measure as the actual values are not used.
2. It is not convenient when 'n' is large.
3. Further algebraic treatment is not possible.

Uses of Correlation

1. It helps to study the Association between two variables. For example, we can examine whether there is any relation between sale and profit, with the help of correlation.

2. Correlation measures degree of relation between two variables. Karl Pearson's coefficient of correlation provides a formula for finding the degree of relation between two variables.

3. From the correlation coefficient, we can develop a measure called probable error. Probable error indicates whether the correlation is significant or not.

4. Correlation analysis helps to estimate the future values. For example, from the correlation coefficient between income and investment one can predict the possible quantum of investment for a particular amount of income.

EXERCISES

1. Define the term Correlation
2. Does correlation always signify cause and effect relationship ?
3. Why is study of correlation important ?
4. What are the uses of correlation ?
5. Explain the various methods of studying correlation.
6. Write notes on scatter diagram.
7. What is a Scattered Diagram ? From the Scatter diagram how do you infer the nature of relationship of the variables.
8. Explain the term Coefficient of Correlation ?
9. Distinguish between Positive and Negative Correlation.
10. How do you interpret the sign of the coefficient of correlation ?
11. Explain Linear and Non linear Correlations ?
12. What is meant by perfect correlation ?
13. What do you mean by spurious correlation ?
14. Write notes on Karl Pearson's Coefficient of Correlation.
15. What are the properties of Correlation Coefficient ?
16. What does coefficient of correlation intend to measure ?
17. What do you mean by probable error ?
18. How do you interpret the correlation on the basis of probable error?
19. What do you mean by Rank Correlation ?
20. State the merits and demerits of Rank correlation method.
21. Under what circumstances is the rank correlation used ?
22. For the data given below obtain the correlation coefficinet between the average pirce and demand of a particular commodity in a region.

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Average price (Rs.)	:	11	19	15	13	17
Demand (kgs)	:	30	18	24	29	24

23. Is there any correlation between X and Y ?

X :	200	270	340	310	400
Y :	150	162	170	180	180

24. Find the coefficient of correlation between the sales and expenses of the following 10 firms (figures '000 Rs.)

Firms :	1	2	3	4	5	6	7	8	9	10
Sales :	50	50	55	60	65	65	65	60	60	50
Expenses :	11	13	14	16	16	15	15	14	13	13

[Hint : Ignore first row]

25. Calculate the Correlation coefficient between cost of living indices of two cities from the following data giving these indices for 10 years.

Year :	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936
City A :	148	145	141	116	96	91	87	89	91	91
City B :	137	137	133	108	95	99	97	96	99	102

[Hint : Ignore the row 'year']

26. Find the coefficient of correlation from the following data.

x :	10.5	10.9	10.2	10.1	10.9	9.9	9.8	9.6	9.3	9.2
y :	10.1	10.3	10.0	9.8	9.5	9.6	10.4	9.2	9.7	9.4

27. Find Karl Pearson's co - efficient of correlation between the values of X and Y given below. Also find probable Error and interpret.

X :	78	89	96	69	59	79	68	61
Y :	125	137	156	112	107	136	123	108

Assume 69 and 112 as the mean values for X and Y respectively.

28. The following table gives the distribution of the total population and those who are wholly or partially blind among them. find out if there is any relation between age and blindness.

Age → :	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80
No. of persons in '000 :	100	60	40	36	24	11	6	3
Blind → :	55	40	40	40	36	22	18	15

[Hint : Blindness = (No. of blind people ÷ Total number of people) × 100

29. If r = 0.8 and N = .81, find out the probable error of the coefficient of correlation.

30. Find the probable error, if r = 0.6 and n = 64. Also calculate the standard error and interpret the result.

31. In a question on correlation, the value of r is 0.64 and its P. E = 0.1312. Find the value of N.

32. In an aptitude test two judges rank the 10 competitors in the following order

Individual :	1	2	3	4	5	6	7	8	9	10
Ranking by Judge I :	6	4	3	2	1	7	9	8	10	5
Ranking by judge II:	4	1	6	7	5	8	10	9	3	2

Is there any concordance between the two judges ?

33. The ranking of 10 students in two subjects A and B are as follows.

A :	3	5	8	4	7	10	2	1	6	9
B :	6	4	9	8	1	2	3	10	5	7

Find the rank correlation coefficient.

34. Ten competitors in a beauty contest are ranked by three judges in the following order:-

First judge :	1	5	4	8	9	6	10	7	3	2
Second judge:	4	8	7	6	5	9	10	3	2	1
Third judge:	6	7	8	1	5	10	9	2	3	4

Use the rank correlation coefficient to discuss which pair of judges have the nearest approach to common tastes in beauty.

35. Quotations of index numbers of security prices of a certain joint stock company are given below:

Year	:	1	2	3	4	5	6	7
Debentures (Price)	:	97.8	99.2	98.8	98.3	98.4	96.7	97.1
Share (Price)	:	73.2	85.8	78.9	75.8	77.2	87.3	83.8

Find the rank correlation between the two prices.

36. Judge X and Y given the marks of 10 candidates in beauty contest. Find the rak correlation coefficient.

Candidate	:	A	B	C	D	E	F	G	H	I	J
Judge X	:	50	60	70	65	80	85	90	92	40	96
Judge Y	:	60	70	75	60	80	82	86	90	50	95

ANSWERS

(22) –0.96 **(23)** 0.88 **(24)** 0.79 **(25)** 0.98 **(26)** 0.42 **(27)** 0.95, .023, significant **(28)** 0.899 **(29)** 0.027 **(30)** 0.054, 0.08 **(31)** N = 10 **(32)** r = 0.25, poor **(33)** –0.3 **(34)** I & II = .55, I & III = 0.05, II & III = .73 ∴ II & III have nearest approach **(35)** –0.11 **(36)** 0.97