

ANALYSIS OF TIME SERIES

- **Time Series**

An arrangement of data by successive time period is called time series. For example, the total monthly sales receipts in a departmental store, the annual yield of a crop in a country for a no of years, hourly temperature recorded at a locality for a period of years, the weekly prices of wheat in Lahore, the monthly consumption of electricity in a certain town, the monthly total of passengers carried by rail, the quarterly sales of a certain fertilizer, the annual rainfall at Karachi for a number of years, the enrolment of students in a college or university over a number of years and so forth.

- **Signal and Noise**

Signal: The systematic component of variation in time series is called signal.

Noise: An irregular or random component of variation in the time series is called noise.

- **Analysis of Time Series**

The analysis of time series consists of the description, measurement, and isolation of the various components present in the series, this analysis helps the economists, businessmen and Planner etc.

The value of the time series (Y) is the product effects of four components trend (T) , Cyclical (C), Seasonal (S) and Irregular (I) Movements. $Y = T \times C \times S \times I$

But some statistical; consider the components of a time series follow and additive law.

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

- **Components (Movements) of a Time Series**

A typical time series has four types of movements usually called components for a time series.

- a. Secular Trend (**T**)
- b. Seasonal Movements or Seasonal Variation (**S**)
- c. Cyclical Movements or Cyclical Variation or Cyclical Fluctuation (**C**)
- d. Irregular, Accidental or Random Movements (**I**)

- a. **Secular Trend (T)**

These movements refer to long term variation which shows any tendencies of growth or decline over a long period approximately 30 to 40 years. These are smooth, steady and regular in nature for example, a continually increasing for more food due to population increase, a decline in death rate due to advance in science.

- b. **Seasonal Movements (S)**

These movements refer to short-term variations which generally occur due to seasonal effects within a period of one year. Climatic conditions including rainfall, heat and wind directly effect the time series for example, the demand of Woolen cloths increases in winter, the sale of shoes increase before EID, the price of wheat which fall after harvesting season and rise before the sowing time, the sales of soft drinks which are high in the summer and low in the winter, investments in Savings Certificates which are high in the months of May and June and low in other months, and so forth. The concept of seasonal variation is customarily broadened to include the more or less regular fluctuations of shorter duration occurring within a day, a week, a month, a quarter and so forth. Examples of such variations are the daily variations in temperature or the monthly variations in Bank deposits.

- c. **Cyclical Movements or Cyclical Variation or Cyclical Fluctuation (C)**

Statistical data in a number of cases show up and down movement periodically, there are swings from prosperity through recession, depression and recovery and back to prosperity, which is know as four phases of a business cycle (Depression, Revival or Recovery ,

Prosperity or Boom , Contraction or Recession) and very important example of cyclical movements. These changes are repeated at intervals ranging from 7 to 10 years.

d. **Irregular, Accidental or Random Movements (I)**

These movements are irregular and unsystematic in nature and happen as a result of abnormal events such as floods, earthquakes, wars and strikes etc. For example, Prices rise during war time, the production of industries goes down due to labour strikes.

• **Analysis the Secular Trend (T)**

There are four methods to measure the secular trend.

- 2) The Freehand Curve Method
- 3) The Method of Semi Averages
- 4) The Method of Moving Averages
- 5) The Method of Least Square

1) The Freehand Curve Method

In this method the data are plotted on a graph measuring the time units (year, months, etc) along X-axis and the value of the time series variable along the Y-axis. A trend line or smooth curve is drawn through the graph in such a way that it shows the general tendency of the values. The trend values for different years (or months) are read from the trend line or curve.

2) The Method of Semi Averages

The freehand curve method, as we have seen, depends too much on personal judgment and gives subjective results. Another simple method for measuring secular trend is the method of Simple Averages. In this method the data is divided into two equal parts. (If the number of values is odd, either the middle value is left out or the series is divided unequally). The averages for each part are computed and placed against the centre of each part. The averages are plotted and joined by a line. The line is extended to cover the whole data. Trend values corresponding to different time periods can be read from this trend line.

3) The Method of Moving Averages

We have seen that the Freehand Curve Method is subjective because it is based too much on individual judgment. The method of Semi Average is appropriate only when the trend is linear. Another simple method which can also be used to eliminate seasonal, cyclical and irregular movements is the method of moving averages. In this method, we find the simple average successively taking a specific number of values at a time.

For example, if we want to find 3-Year moving average, we shall find the average of the first three values, then drop the first value and include the fourth value. The process will be continued till all the values in the series are exhausted. The averages so obtained are placed in the middle of the group for which the average is calculated. When we find the moving average taking an even number of values, the middle of the group will lie b/w two years. In the order to make the average coincide with a particular year, we centre the averages by calculating further a 2-year moving average of the even order moving averages. The averages obtained are called moving averages (Centre).

4) The Method of Least Square

The principle of least square states "the sum of squares of the deviations of the observed values from the corresponding estimated values should be least" in this method a straight line $Y = a + bX$, Second degree parabola $Y = a + bX + cX^2$ and a Third degree parabola $Y = a + bX + cX^2 + dX^3$ are fitted to the observed time series by the method of least squares

a. **Linear trend line**

$$Y = a + bX$$

Normal Equations

$$\sum Y = na + b \sum X$$

$$\sum XY = a \sum X + b \sum X^2$$

We get the value of "a" and "b" solving the above equations simultaneously.

b. Second Degree Parabola \ Second Degree Trend Line

$$Y = a + bX + cX^2$$

Normal Equations

$$\sum Y = na + b \sum X + c \sum X^2$$

$$\sum XY = a \sum X + b \sum X^2 + c \sum X^3$$

$$\sum X^2Y = a \sum X^2 + b \sum X^3 + c \sum X^4$$

We get the value of "a", "b" and "c" solving the above equations simultaneously.

c. Third Degree Parabola \ Third Degree Trend line

$$Y = a + bX + cX^2 + dX^3$$

Normal Equations

$$\sum Y = na + b \sum X + c \sum X^2 + d \sum X^3$$

$$\sum XY = a \sum X + b \sum X^2 + c \sum X^3 + d \sum X^4$$

$$\sum X^2Y = a \sum X^2 + b \sum X^3 + c \sum X^4 + d \sum X^5$$

$$\sum X^3Y = a \sum X^3 + b \sum X^4 + c \sum X^5 + d \sum X^6$$

We get the value of "a", "b", "c" and "d" solving the above equations simultaneously.

Coding of X:

Origin at beginning (X)	Origin at Middle		
	Odd Numbers	Even Numbers	
		Half Unit	One Unit
0	.	.	.
1	.	.	.
2	.	.	.
3	-3	-7	-3.5
.	-2	-5	-2.5
.	-1	-3	-1.5
.	0	-1	-0.5
.	1	1	0.5
.	2	3	1.5
.	3	5	2.5
.	.	7	3.5
.	.	.	.
.	.	.	.

- **Analysis the Seasonal Variation or Seasonal Indices (S)**