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Analysis of Time Series

In every sphere of human activity, especially in financial, commercial and occupational areas, fluctuations always take place. Time series is the periodical analysis of that changes and fluctuations. The changes may relate to any area or activity such as daily, weekly, monthly, quarterly, six monthly or yearly fluctuation in the figures of production, sale, import, export, employment, weather or prices of bullion, etc. any type of chronological or periodical measurement is called as time series or historical variables.

According to **W. Z. Hirsch**, " A time series is the sequence of values of some variable corresponding to successive points in time." **Ya-lun-chou** has defined time series as, "A time series may be defined as a collection of reading belonging to different time periods of some economic variable or composite of variables." On the other hand **Spiegel** has defined time series as a mathematical function depended upon time. According to him, "Mathematically, a time series is defined by the values of y_1, y_2..... of a variable y at time t_1, t_2..... Thus, y is a function of t. Symbolised y = f(t)."

It can be said, conclusively that a time series is an arrangement or composition of statistical data in accordance with the time of its occurance, i.e. arrangement in chronological order. Census after gap of ten years, or yearly figures of foodgrain production for a period of ten years, or monthly or weekly price index number are the example of time series.

Importance of time series

The analysis of time series is very helpful in practical life. Its importance can be judged from the following points:

(1) Information of various sphere of life especially in the areas of Economics and Commerce can be ascertained easily.

(2) On the basis of knowledge of these changes, trends for future can be ascertained and forecasting can be made accurately.

(3) Analysis of time series helps in analysis and interpretation of past behaviour of a variable which reveals the circumstances and reasons influencing the movement of data.

(4) Analysis of time series helps in identifying the causes for change and efforts may be made to correct the causes for adverse changes.

(5) Analysis of time series helps in making comparison between data of two or more related periods.

(6) Proper and critical evaluation of achievements become possible with the help of time series.

(7) Fluctuation of trade cycles, can be estimated on the basis of cyclical fluctuation and related persons can plan strategy accordingly.

It is important to emphasise that utility of time series is not only confined to economics, trade and commerce, but these techniques can be applied in any area of human activity or pure sciences.

Components of Time Series

By components we mean the kinds or categories of fluctuations. Fluctutions can be seen when the values of a phenomenon are observed at different periods of time. These variations or fluctuations are not caused by a single factor but by the cumulative effect of multiplicity of factors. The factors for variations or fluctuations can be classified into two categories:

1. Long Term Changes or Secular Trends

Changes in time series usually take place at intervals. In short period the changes may take place in any direction but in long term these changes take place in a definite direction. Long term changes indicate towards the increase or decrease in a series. According to **Simpson & Kafka** , "Trend also called secular or long-term trend is the basic tendency of production, sales, income, employment or the like to grow or decline over a period of time. The concept of trend does not include short-range oscillations but rather, steady movements over a long time." In other words, despite various periodical fluctuation, there will be an inherent tendency of movements in a particular direction. This tendency is known as long tern trend. The increase may be due to joint action of various factors like change of tastes and habits of people, population growth and advent of new techniques, etc. The declining movements may be due to availability of better substitutes, or decline in demand, etc. For example, the study of agricultural production since independence shows a fairly regular increase in production. On the other hand declining trends is noticed in the data of birth and death or epidemics. The basic features of secular or long term trend are that (a) the secular movement continues in the same direction for a considerable period of time, (b) it does not change its direction too frequently and, (c) in the long period in a year or two there may be fall in figures but the overall trend maintains its direction.

For practical purpose the long term should be period of fifteen to twenty years in which a characteristic or change can be defined conclusively.

2. Short-time oscillations

Fluctuations which may be in either direction in a time series are known as short-time oscillations. They influence the time series for very short period of time. They either boost the speed of growth or enhance the causes of decline or temporarily obstruct the rate of growth. It depends upon the fact that whether the long term trend and short-time oscillations are in the same direction or in opposite direction. Short-time oscillations are of two types : (a) Regular Fluctuations and (b) Irregular Fluctuations.

(a) Regular Fluctuations :

Regular fluctuations occur in a time series regularly, they are repeatative in nature. Regular fluctuations are classified into following two types:

(i) Seasonal Variations : Seasonal variations are regular and repeatative which occur in a periodic manner over a time span of less than one year, i.e. a

day, week, month, quarter or half-yearly etc. They manifest due to change in customs and traditions, or change in season etc. These type of changes are witnessed in economic data. Production, consumption, sale or prices of food grains and other commodities, rates of interest, and changes in prices of shares etc. are some of the examples of seasonal variations or fluctuations. These variations emanate in a definite order. Thus the forecasting about them can be made easily. Fall in prices of foodgrains at the time of harvesting, increase in sales in the first week of month and increase in prices of Jwellery in the season of marriages etc. are some of the examples. The significant thing about them is that they are influenced to a great extent by seasons and customs.

The objective behind measurement of seasonal variation is to isolate them from the trend and analyse their effects. Identifying and studying the seasonal patterns is useful to businessmen, business managers, share brokers, middlemen and consumers. In the absence of knowledge of seasonal variations, confusions may prevail. Analysis of seasonal variation or fluctuation is necessary to understand the behaviour of a phenomenon properly.

(ii) Cyclical Variations : Cyclical fluctuations, like seasonal variation also occur in a definite interval, but the difference is that the interval or period of time is more then one year. They originate mainly due to "trade cycles". Because of certainity and regularity in their order of occurance, they are called cyclical variations. Each cycle consists of four stages : (a) Prosperity or boom, (b) Recession (c) Depression and (d) Recovery. Unlike seasonal variations there is no definite period of cyclical fluctuations. Generally the period ranges from three to eleven years.

(b) Irregular Fluctuations :

Irregular or random fluctuations occur accidently or by happening of chance. There does not exist any possibility of their occurance, they manifest themselves due to above mentioned causes, hence they are called random or chance fluctuations. For example, fluctuations occuring due to war, earthquakes, flood, famine, strike, lockouts election, etc. Usually they are short term variations but some time their impact is so powerful that they may create new cycles or movements. Because of uncertainty in their character they can not be property analysed or forecasted upon. They have no definite pattern and their coverage is wider.

Measurement of long Term or Secular Trend

Measurement of long trend is useful to experts in forecasting for future, studying the past changes in time series and knowing the fluctuations. There are four methods for measuring the long term trend which are as follows :

(1) Free Hand Curve Method
(2) Semi Averages Method
(3) Moving Average Method
(4) Least Square Method

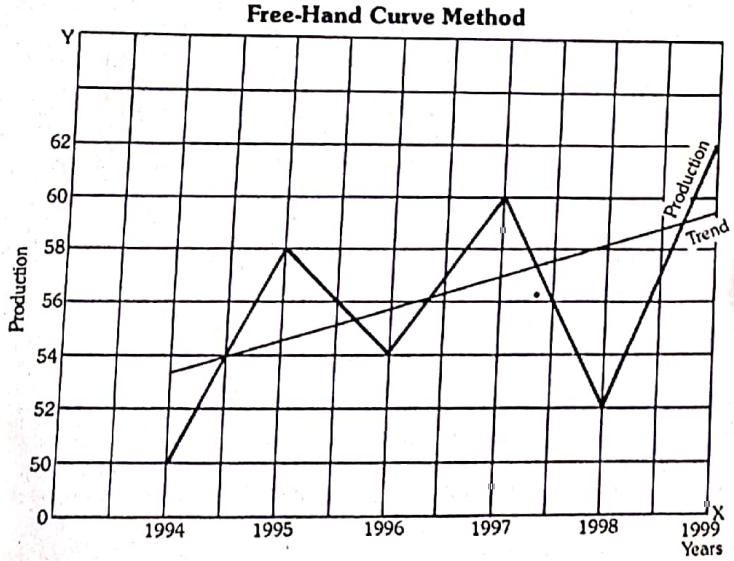
1. Free Hand Curve Method

This is the most simple and easy method for measuring long term trends. In this method the values of time series are plotted on a graph paper and a curve showing both descends and ascends emerges. Thereafter another smoothend curve is drawn in a manner that it may accurately describe the general long run tendency of the data. In this method an effort is made to draw such a smooth curve so that seasonal, cyclical and irregular fluctuation in the original data may be avoided. From the following example this method can be explained.

Exercise 1

Years :	1994	1995	1996	1997	1998	1999
Production :	50	58	54	60	52	62

Solution



Merits : Free-hand curve method has following advantages.

(i) It is most simple method of measuring the trend, it saves time and energy which is spent on mathematical calculations.

(ii) It is very flexible method as it can be applied to describe both linear and non-linear trends.

Demerits : This method has following disadvantages also:

(i) This method is subjective in nature, because the curve so obtained depends upon the bias of the person handling the data. Different type of curves may be drawn by different persons using the same data.

(ii) This method lacks accuracy which is evident in mathematical calculations.

(iii) It is disadvantageous to make predictions and forecasting on the basis of free hand curve.

2. Semi Average Method

In Semi Average Method trend is seen by dividing the series into two parts. In this method five basic steps are to be followed which are as follows:

(i) In the first step the series is divided into two equal parts. If the number of years are in odd number, the value of middle year is ignored and two equal parts are obtained.

(ii) In the second step the means or averages of both the parts are calculated. The means are called as semi-averages. The median points of the two parts are similarly calculated.

(iii) In the third step the original data is plotted on a graph paper.

(iv) In the fourth step, both the semi-averages are plotted on points against the middle point of their respective time periods or alternately, in front of median points semi averages are plotted.

(v) In the last step, a straight line is drawn by joining the points of semi averages. The line so drawn is known as "trend line by semi averages" showing trend.

This can be better explained by an example:

Exercise 2

Year :	1990	1991	1992	1993	1994	1995
Production :	20	24	22	30	28	32

Solution:

Semi Average = 22 and 30

Median years = 1991 and 1994

1986	18.9	1994	24.3
1987	19.2	1995	25.2
1988	19.3	1996	26.3
1989	18.1	1997	27.3
1990	20.2		

(Delhi B.Com.)

Solution:

Years	Production (in lakh tons)	3 Yearly Total	3 Yearly moving average, Trend
1983	17.2	—	—
1984	17.3	52.2	17.4
1985	17.7	53.9	18.0
1986	18.9	55.8	18.6
1987	19.2	57.4	19.1
1988	19.3	56.6	18.9
1989	18.1	57.6	19.2
1990	20.2	63.6	21.2
1991	25.3	70.4	23.5
1992	24.9	73.4	24.5
1993	23.2	72.4	24.1
1994	24.3	72.7	24.2
1995	25.2	75.8	25.3
1996	26.3	78.8	26.3
1997	27.3	—	—

Exercise 4

Calculate the five yearly moving average of acres under tea in India from the following data:

Years	Area in 1,000 acres	Years	Area in 1,000 acres
1987	672	1992	802
1988	679	1993	807
1989	690	1994	809
1990	702	1995	816
1991	712	1996	821

(Lucknow B.Com.)

Solutions:

Years	Area (in 1,000 acres)	5 Yearly Total	5 Yearly moving average trend
1987	672	—	—
1988	679	—	—
1989	690	3455	691.0
1990	702	3585	717.0
1991	712	3713	742.6
1992	802	3832	766.4
1993	807	3946	789.2
1994	809	4055	811.0
1995	816	—	—
1996	821	—	—

Exercise 5

Find the 4 yearly moving average for following time series data:

Year	1990	1991	1992	1993	1994	1995	1996
Production (in '000 tons) :	30	45	39	41	42	46	49

(Delhi B.Com.)

Solution

Year	Production (in '000 tons)	4 Yearly Total	2 Yearly Total of 4 Yearly Totals	4 Yearly moving Average Trend
1990	30		—	—
1991	45	155	—	—
1992	39	167	322	40.25
1993	41	168	335	41.88
1994	42	178	346	43.25
1995	46		—	—
1996	49		—	—

Exercise 6

The index number of annual production of a commodity (1940 = 100) are given below:

Year	Annual Average	Year	Annual Average
1972	165	1984	280
1973	178	1985	351
1974	236	1986	320
1975	213	1987	370
1976	180	1988	325
1977	163	1989	366
1978	180	1990	256
1979	187	1991	304
1980	210	1992	291
1981	237	1993	277
1982	203	1994	274
1983	215	1995	272

Assuming a ten-yearly cycle, find the trend values by the method of moving averages.

(Allahabad M.A)

Solution

Year	Annual Average	10 yearly Total	2 yearly Total of 10 yearly Totals	10 yearly Moving Average Trend
1972	165		—	—
1973	178		—	—
1974	236		—	—
1975	213		—	—
1976	180		—	—
		1949		
1977	163		3936	196.80
		1987		
1078	180		4011	200.55
		2024		
1979	187		4092	204.60
		2068		
1980	210		4274	213.70
		2206		
1981	237		4552	227.00
		2346		
1982	203		4899	244.95
		2553		
1983	215		5251	262.55
		2698		
1984	280		5575	278.75
		2877		
1985	351		5800	290.00
		2923		
1986	320		5913	295.65
		2990		
1987	370		6068	303.40
		3078		
1988	325		6218	310.90
		3140		
1989	366		6274	313.70
		3134		
1990	256		6189	309.45
		3055		
1991	304		—	—
1992	291		—	—
1993	277		—	—
1994	274		—	—
1995	272		—	—

Exercise 7.

Determine the period of the moving average for the following data and calculate moving average for that period: