Chapter 17

TIME SERIES

17.1 Introduction

Arrangement of statistical data with respect to time is called time series. Generally, the values of the various variables such as, series related to prices, consumption of commodities, bank deposits and credits, population etc are observed with respect to time. Such data falls under the study of time series analysis as the variable under consideration changes from time to time. A time series reveals the relationship between the two variables where the independent variable is time. The changes in the value of the variable with respect to time are called as fluctuations. Such fluctuations are the result of interaction between various forces, like changes in the taste and habits of the people, change in the prices of the commodities, weather condition, cost of production etc.

The main objective of time series analysis is to isolate and measure the extent in which the various components affect the time series. Such a study will help us to understand the past behaviour of the time series and in the prediction of future trends. Some of the definitions of time series are as follows –

"A time series is a sequence of values of the same variate corresponding to successive periods of time." –W.Z.Hirsch.

"A time series is a sequence of repeated measurements of a variable made periodically through time." – C.H.Meyers.

Advantages and Disadvantages of Time Series

17.2 Advantages

1. It helps to understand the past behaviour and would be helpful for future predictions.

2. Statistical techniques have been developed so that the time series can be analysed in such a way that the factor that influences the fluctuations of the series may be identified.
3. It helps to compare the performance of two different series of similar type for the same time duration.
4. The analysis of time series helps us to compare the present performance of the series with that of the past.

17.3 Disadvantages

1. The conclusion drawn from analysis of time series is not always perfect.
2. The various factors that affect the fluctuations of a series can not be fully adjusted by the time series analysis.
3. The various factors that influence the time series may not remain same for an extended period of time and so forecasting made on this basis may become unreliable.
4. Sometimes the increasing trend in the time series data may be due to the increase in population. So, unless necessary modification is made to the data it would be difficult to understand the trend.

Components of Time Series

If we look at a time series data or towards the graphical representation of it, we would see how the series changes over time. If the time series is studied critically, it would reveal that the changes are not haphazard but atleast a part of it can be explained properly. The variation in the time series that can be accounted for is called the explained variation of the time series. The explained variation results from any one, all or some combination of the following three broad factors viz. (a) Secular trend (b) Seasonal variation and (c) Cyclical variation. However, the part of the fluctuation in a time series that remains unexplained is called the irregular fluctuation. Let us now discuss various components of time series one by one.

(a)Long Time Trend or Secular Trend

The long time trend or secular trend is that component of the time series that looks the smooth, regular and long time movement of a series if observed for a considerable period of time. Thus, the general tendency of a time series to increase or decrease during a extensive period of time is called secular trend. This is true for most of the series in economics and business statistics. The growth or decline is due to some fundamental forces like changes in population, technology or productivity. However, it is not necessary that the growth or decline continues to occur at each and every time period, but we take into consideration the overall rise and fall in the time series. Even though there may be some occasional isolated time periods in which there are small fall or rise in the time series. Some examples of secular trend are given below –

An upward trend is noticed in time series related to population of a country, literacy rate, agricultural production, volume of bank deposits etc. Similarly, a downward trend is noticed in time series related to deaths due to epidemic, land for cultivation, infant mortality rate etc.

(b) Seasonal Variation

One rhythmic force that is found in most of the time series is called the seasonal fluctuation. Seasonal variations are short time fluctuations that are observed in a time series data particularly due to the climatic and weather conditions. Seasonal variation as the name indicates is the influence that the different seasons exert on a time series data. However, such variations, also may be due to the cultural or religious festivals that the people of a particular place celebrate during a particular time of the year. This type of variation is periodic and causes regular fluctuations in a time series with a time period of less than a year. For example, Sale of woolen cloth increases during winter, raincoats during rainy season, sale of dress materials increases during festival season like Durga puja, Diwali, Idd etc.

(c) Cyclical Variation

The oscillatory movements in the time series with a time period of more than a year is called as the cyclical fluctuation. The word ‘cycles’ refers to the period of affluence and depression, ups and downs, booms and slumps of a time series, most commonly seen in business cycles. These

cycles are not strictly periodic like that of the seasonal variation, but they generally occur in a time period of 3 to 12 years depending on the nature of the time series. Such type of variation does not have any definite trend. Some authors are of the opinion that seasonal variation is a particular type of cyclical variation where the period of cycle is 1 year. But the seasonal variations can be predicted much easily compared to cyclical variation because in the later case the period of cycle is uncertain. Some examples of cyclical fluctuations are found in the world of fashion, profits of business houses, demand for a particular brand of product etc.

(d) Irregular Variation

Irregular variation does not have any proper time, direction and magnitude of occurrence. Irregular variation is also called random variation. This type of variation occurs in the time series, if there is certain abnormal behaviour in the circumstances that affects the series. Irregular variation is caused due to factors such as wars, earthquake, floods, strike etc that are unpredictable in nature. The variation in time series that cannot be explained by secular or seasonal or cyclical fluctuation is known as by irregular variation. It is difficult to isolate this type of variation from time series as this type of fluctuation cannot be predicted. Examples: the variation in the production of a business house due to strikes, change in population of country due to epidemic, variation in the price of essential commodities due to war etc.

Different Methods of Measuring Trend

Moving Average Method

Moving average method is a simple device of reducing fluctuations and obtaining trend values with a fair degree of accuracy. Let us consider a time series of period k. This period k is called as the time interval of the moving average. In this method we start obtaining the simple average of each of the k successive observations of the series. We start with the first k observations and then we leave the first one and include the $(k+1)^{th}$ observation, so that for the second case also we have k observation which are averaged. The process is continued still we

reach the last observation of the series. Each of these means is then centered against the time which is the mid point of the time interval included in the computation of the moving average. If the time interval of the moving average is odd we can center the average against a given time value. But the problem arises if the time interval is even. In such a case the moving average falls midway between two tabulated values. Then we calculate a subsequent two item moving average values correspond to the tabulated time periods.

The interpretation of a moving average is simple. The procedure of taking averages for the k values actually eliminates the existence of abnormalities (as far an average can do) during that time period and estimates a value at the middle of the period. When all possible values are obtained from the moving average then we get the over all movement of the series or the trend eliminating the effect of all other components.

Advantages

1. The greatest advantage of this method is that it eliminates the short time fluctuation that may be present in the time series.
2. This method is simple to understand and does not require the use of any complex mathematical calculation.
3. If a few more values are added to the time series then it simply results into few more trend values which can be easily obtained without disturbing the previous calculations.
4. This method is not subjective because the choice of the period of moving average is determined by the oscillatory movements of the data and not by the whims of the statistician.

Disadvantages

1. The main disadvantage of this method is that it does not provide trend values for all the terms. There are no trend values for some time periods at the beginning and at the end of the series.
2. If the fluctuations in the time series are irregular then it is difficult to determine about the period of moving average.

3. The method of moving average is developed under the assumption that the trend is linear. Thus, for time series with linear trend (which is generally the case in economics and business), this method either over estimates or under estimates the trend values.
4. This method cannot be used for predicting or forecasting, which is the main objective for trend analysis because it does not put forward any mathematical relationship between the variate under study and time.

Experiments

Experiment No. 17.1

Question: Using 3-year moving averages, determine the trend of the fo1lowing time series

Year	Product ion ‘000 tons	Year	Production ‘000 tons
1968	21	1973	22
1969	22	1974	25
1970	23	1975	26
1971	25	1976	27
1972	24	1977	26

Plot the trend and actual values graphically.

Solution: For calculating the 3-year moving averages we construct the following table:

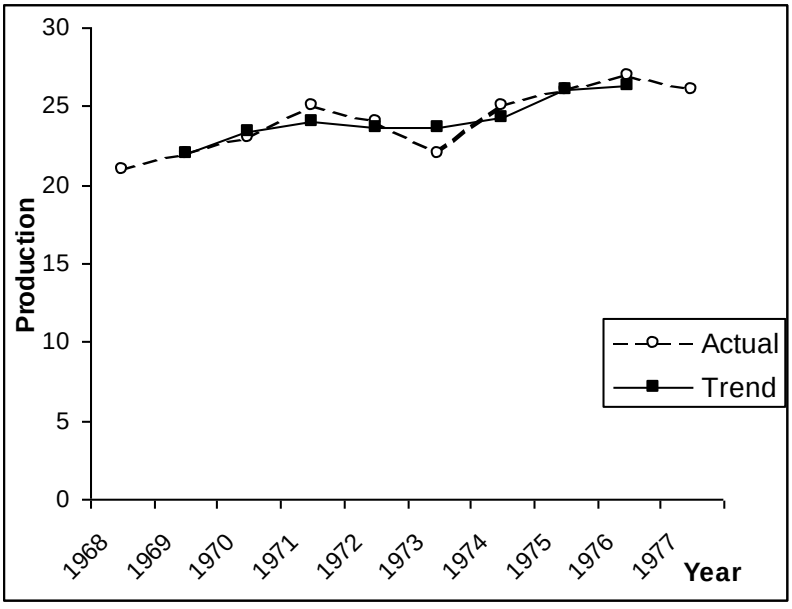
Year	Production	3 Yearly Moving Total	3 Yearly Moving Average
1968	21	-----	-----
1969	22	66	22
1970	23	70	23.33
1971	25	72	24
1972	24	71	23.67
1973	22	71	23.67
1974	25	73	24.33

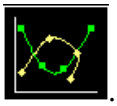
1975	26	78	26
1976	27	79	26.33
1977	26	-----	------

To compute this table in Excel we should proceed with the following formulae:

	A	**B**	**C**	**D**
1	Year	Production	3 Yearly Moving Total	3 Yearly Moving Average
2	1968	21	-----	-----
3	1969	22	=B2+B3+B4	=C3/3
4	1970	23	=B3+B4+B5	=C4/3
5	1971	25	=B4+B5+B6	=C5/3
6	1972	24	=B5+B6+B7	=C6/3
7	1973	22	=B6+B7+B8	=C7/3
8	1974	25	=B7+B8+B9	=C8/3
9	1975	26	=B8+B9+B10	=C9/3
10	1976	27	=B9+B10+B11	=C10/3
11	1977	26	-----	------

For the purpose of plotting we type the Year, Production and 3 Yearly moving average values in adjacent columns and then draw the scatter diagram. While drawing the scatter diagram we



activate the option  . On plotting the trend values obtained through the method of moving averages and the actual values we get the following graph.

Experiment No. 17.6

Question: From the data given below construct the 4- yearly moving averages.

Year: 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000

Prod('000 tons): 123 134 132 143 157 165 154 169 174 177 179 184 183

Solution: To construct the 4-yearly moving averages we construct the four yearly moving total and then using the usual procedure calculate the four yearly moving average. But the averages need to be centered, so a two yearly moving average is constructed in ordered to center them to corresponding year. These 4-yearly moving averages are then called as the centered 4-yearly moving averages.

Year	Prod.('000 tons)	4 Yearly Moving Total	4 Yearly Moving Average	4 Yearly Moving Average (Centered)
1988	123			
1989	134	532	133	
1990	132	566	141.5	137.25
1991	143	597	149.25	145.38
1992	157	619	154.75	152.00
1993	165	645	161.25	158.00
1994	154	662	165.5	163.38

1995	169			167.00
		674	168.5	
1996	174			171.63
		699	174.75	
1997	177			176.63
		714	178.5	
1998	179			179.63
		723	180.75	
1999	184			
2000	183			

1. For the following comment on (state the reasons) the type of fluctuation:

   (i) An era of prosperity

   (ii) Sale of rain coats

   (iii) Sale of fish

   (iv) Traffic density in the main road of a town

   (v) Price of vegetables

   (vi) Population of a country

   (vii) Population of a flood effected area

   (viii) Number of causalities in a hospital after a fire

   (ix) Production in an industry during a Bharat bandh

   (x) Yearly production in a firm.

Numerical Problems

1. Find out the short-term fluctuations of the following time series, assuming a five-yearly cycle:

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988
Annual values	239	242	236	252	257	250	273	270	268

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
Annual values	278	284	282	300	303	298	313	317	309

Year	1998	1999	2000	2001	2002	2003	2004
Annual values	329	333	327	345	344	343	362

Plot the trend values and the actual values graphically.

2. Calculate four yearly moving average from the following data

Year	*Production of Rice* in '000 tons	*Year*	*Production of Rice* in '000 tons
1990	100	1997	110
1991	95	1998	104
1992	105	1999	112
1993	90	2000	100
1994	94	2001	120
1995	102	2002	92
1996	108		

3. Following figures relate to output of cloth in a factory (output in lakhs of metres)

Year	*Output*	*Year*	*Output*	*Year*	*Output*
1977	72	1986	68	1995	84
1978	68	1987	68	1996	96
1979	64	1988	76	1997	92
1980	60	1989	80	1998	96
1981	68	1990	84	1999	100
1982	72	1991	80	2000	92
1983	72	1992	88	2001	96
1984	76	1993	88	2002	100
1985	72	1994	92	2003	84

Calculate four-yearly moving average.

4. Calculate 7-yearly moving average for the following data on number of commercial and industrial failures in a country during 1985-2000

Year	No. of failures	Year	No. of failures
1985	23	1993	9
1986	26	1994	13
1987	28	1995	11
1988	32	1996	14
1989	20	1997	12
1990	12	1998	9
1991	12	1999	3
1992	10	2000	1

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