Unit-4: TIME SERIES

1. INTRODUCTION

A set of ordered observations of a quantitative variable taken at successive points in time is known as 'Time Series'. In other words, arrangement of statistical data in Chronological order, i.e., in accordance with occurrence of time, is known as 'Time Series'. Time, in terms of years, months, days, or hours, is simply a device that enables one to relate all phenomenon to a set of common, stable reference points.

Such series have a unique important place in the field of Economic and Business Statistics since the data relating to prices, consumption and production of various commodities; money in circulation; bank deposits and bank clearings; sales and profits in a departmental store, agricultural and industrial production; national income and foreign exchange reserves; prices and dividends of shares in a stock exchange market, etc., are all time series data spread over a long period of time. A time series depicts the relationship between two variables, one of them being time, e.g., the population (y_t) of a country in different years (t); temperature (y_t) of a place on different days (t), etc.

Mathematically, a time series is defined by the functional relationship

$$y_t = f(t)$$

where y_t is the value of the phenomenon (or variable) under consideration at time t. For example, (i) the population (y_t) of a country or a place in different years (t), (ii) the number of births and deaths (y_t) in different months (t) of the year, (iii) the sale (y_t) of a departmental store in different months (t) of the year, (iv) the temperature (y_t) of a place on different days (t) of the week, and so on, constitute time series. Thus, if the values of a phenomenon or variable at times $t_1, t_2, \ldots, t_n$ are $y_1, y_{2,} \ldots, y_n$ respectively, then the series

t	:	t_1,	t_2,	t_3,	….,	t_n
y_t	:	y_1,	y_2,	y_3,	….,	y_n

constitute a time series. Thus, a time series invariably gives a bivariate distribution, one of the two variables being time (t) and the other being the value (y_t) of the phenomenon at different points of time. The values of t may be given yearly, monthly, weekly, daily or even hourly, usually but not always at equal intervals of time.

If the data are segregated by time (days, months, years, etc.) the value of the variable under consideration changes from time to time. These fluctuations are affected not by a single force but are due to the net effect of multiplicity of forces pulling it up and down and if these forces were in a state of equilibrium, the series would remain constant. For example, the retail prices of a particular commodity are influenced by a number of factors, viz., the crop yield which further depends on weather conditions, irrigation facilities, fertilizers used, transportation facilities, consumer demand, etc.

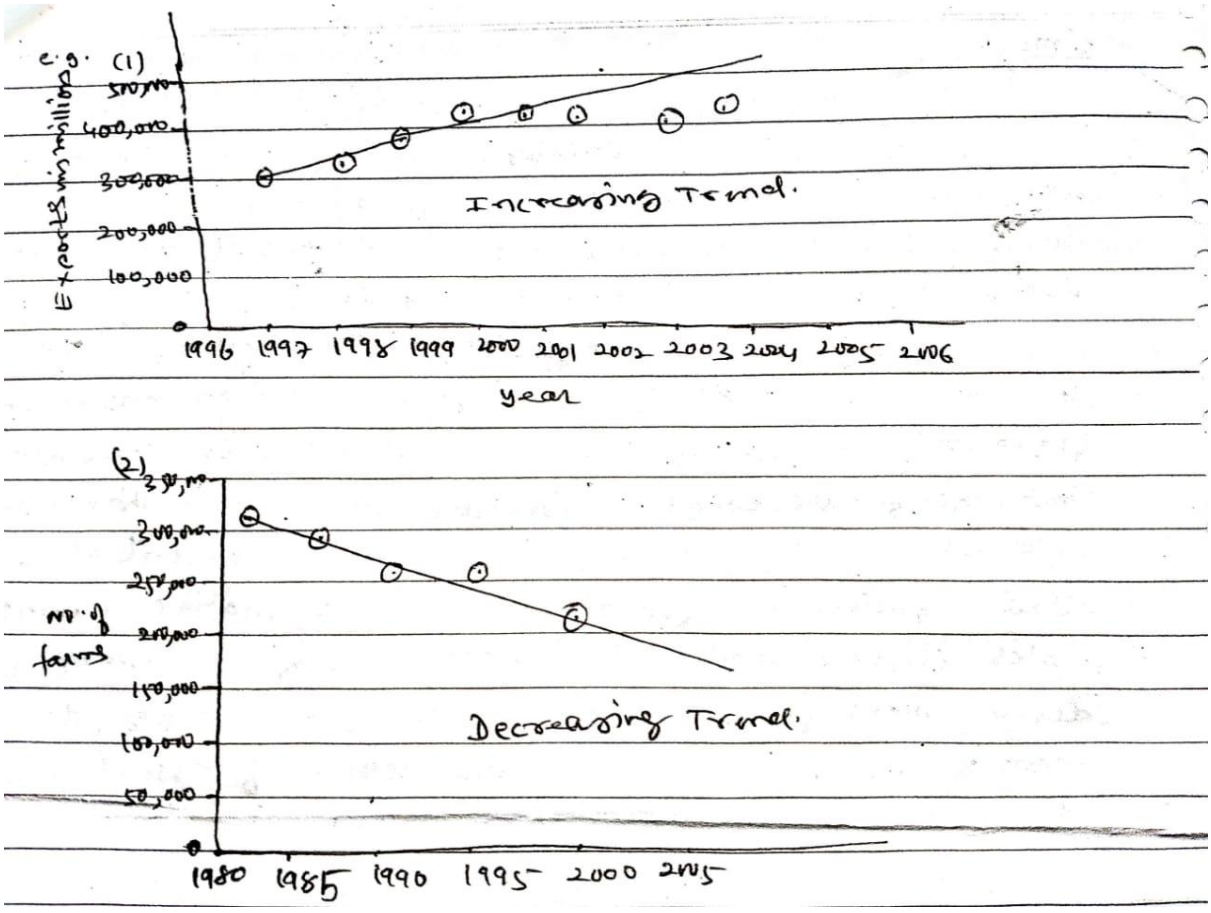
2. Components of a Time Series

There are four components to a time series viz.

(1) Secular Trend or Long-term Movement or Simply Trend
(2) Cyclical variation
(3) Seasonal variation
(4) Irregular variation

(1) Secular Trend

The long term trends of sales, employment, stock prices and other business and economic series follow various patterns. Some move steadily upward, others decline and still others stay the same over the time. Thus, secular trend is the long term direction of a time series.



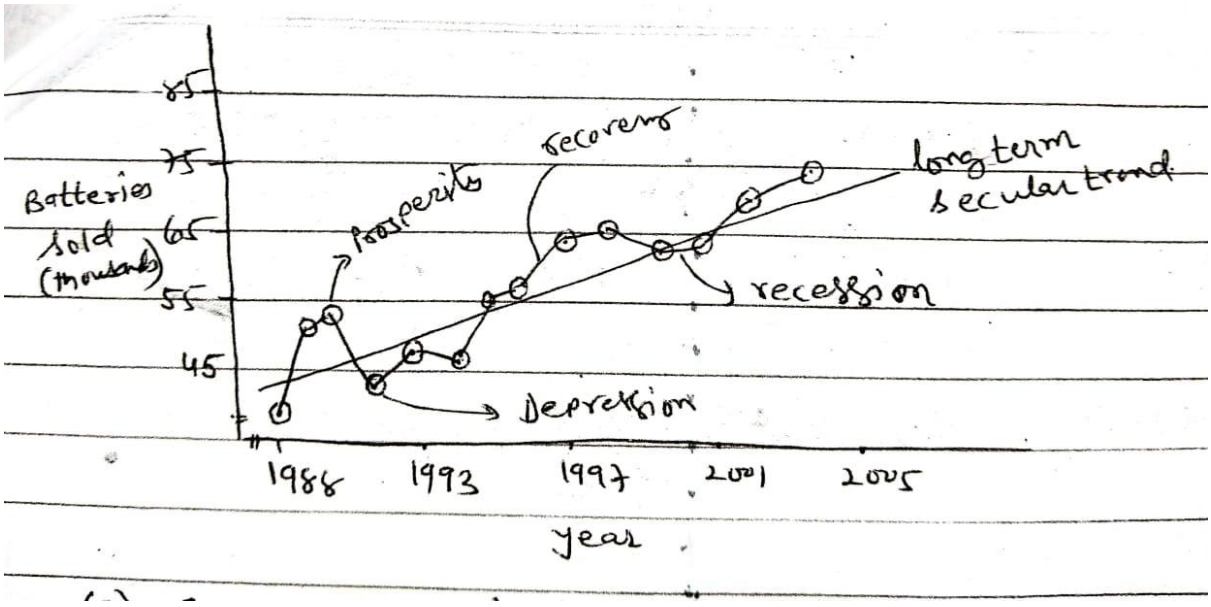
It should not be inferred that all the series must show an upward or downward trend. We might come across certain series whose values fluctuate round a constant reading which does not change with time, e.g., the series of barometric readings or the temperature of a particular place.

Linear and Non-linear (Curvi-linear) Trend. If the time series values plotted on graph cluster more, or less, round a straight line, then the trend exhibited by the time series is termed as Linear otherwise Non-linear (curvi-linear). In a straight line trend, the time-series values increase or decrease more or less by a constant absolute amount, i.e., the rate of growth (or decline) is constant. Although, in practice, linear trend is commonly used, it is rarely obtained

in economic and business data. In an economic and business phenomenon, the rate of growth or decline is not of constant nature throughout but varies considerably in different sectors of time. Usually, in the beginning the growth is slow, then rapid which is further accelerated for quite some time, after which it becomes stationary or stable for some period and finally retards slowly.

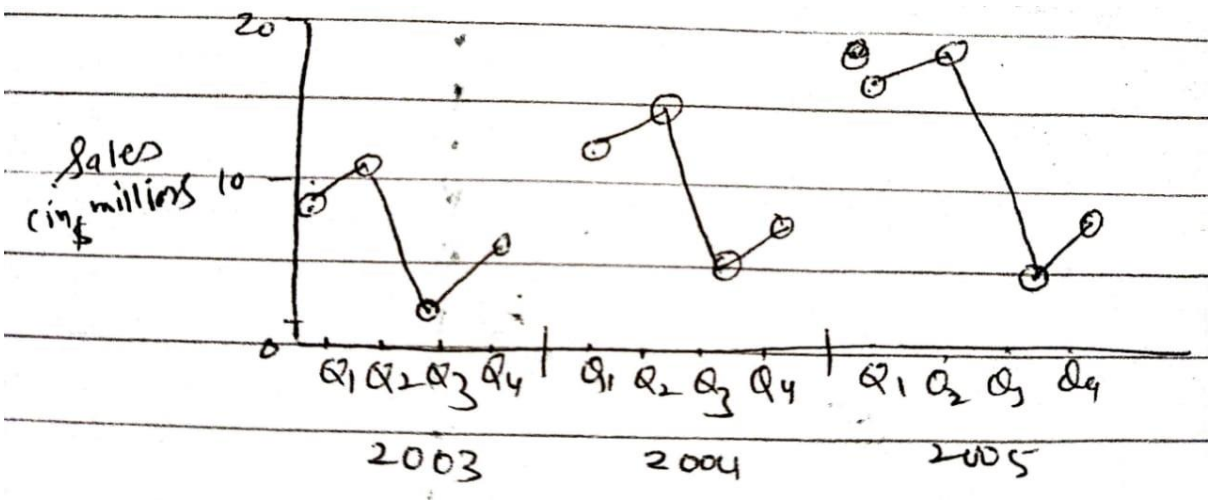
(2) Cyclical variation:

The second components of a Time Series (TS) is cyclic variation. A typical business cycle consists of a period of prosperity followed by periods of recession, depression, and then recovery with no fixed duration of the cycle. There are sizable fluctuations unfolding over more than one year in time series and below the secular trend. In recession, for example, employment, production and many other business and economic series are below the long term trend lines. Conversely, in periods of prosperity, they are above their long term trend lines. Thus, cyclic variations are the rise and fall of a TS over periods longer than one year.



(3) Seasonal variation:

The third component in a TS is the seasonal component. Many sales, production, and other series fluctuate with the seasons. The unit of time reported is either monthly, or quarterly. Thus, the seasonal variation are the patterns of charge in a TS within a year. These patterns tend to repeat them shelves each year e.g. ready-made garments have extremely high sales just prior to big festivals like Diwali, Christmas etc. and relatively low sales just after that and during the summer toy sale have an extreme seasonal pattern



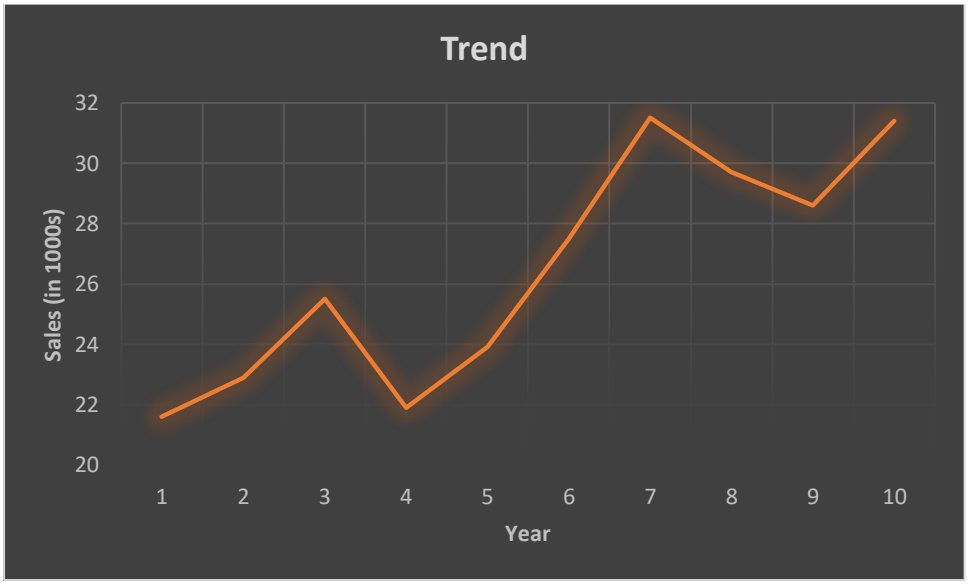
(4) Irregular variation:

Many analysists prefer to subdivide the irregular variation into episodic and residual variations. Episodic fluctuations are unpredictable, but they can be identified. The initial impact on the economy of a major strike or a war can be identified, but a strike or war cannot be predicted. After the episodic fluctuations have been removed, the remaining variations is called 'the residual variation'. The residual fluctuations, often called 'chance fluctuations' are unpredictable and they cannot be identified. Of course, neither episodic nor residual variations can be projected in the future.

3. Examples on components of Time series:

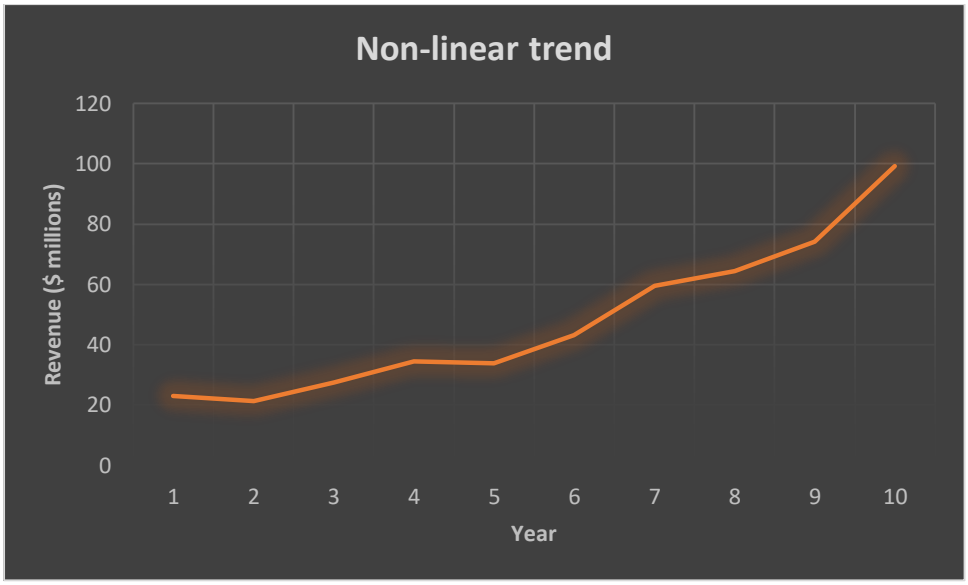
Example-1:

Year	1	2	3	4	5	6	7	8	9	10
Bicycle sales (in 1000s)	21.6	22.9	25.5	21.9	23.9	27.5	31.5	29.7	28.6	31.4



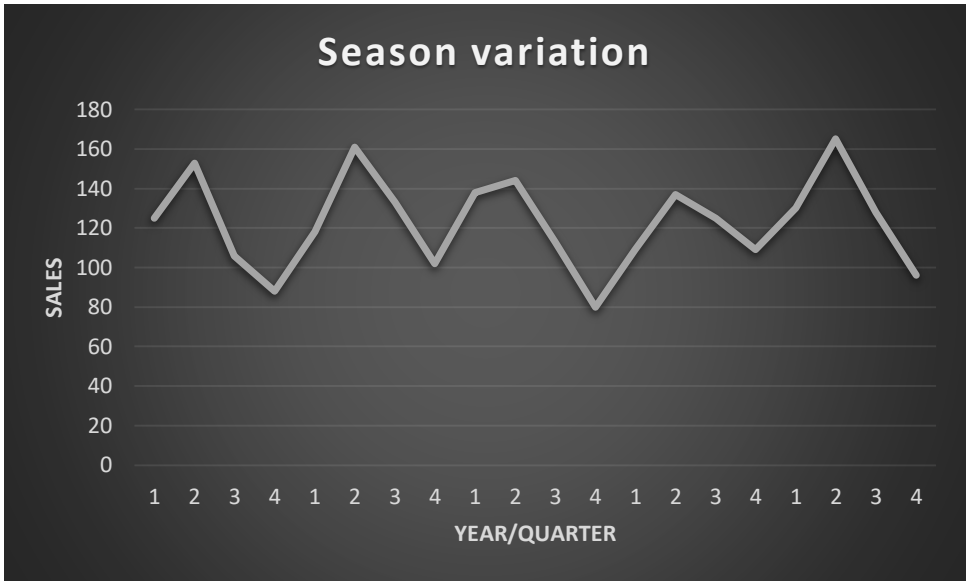
Example-2:

Year	1	2	3	4	5	6	7	8	9	10
Cholesterol Revenue sales ($ millions)	23.1	21.3	27.4	34.6	33.8	43.2	59.5	64.4	74.2	99.3



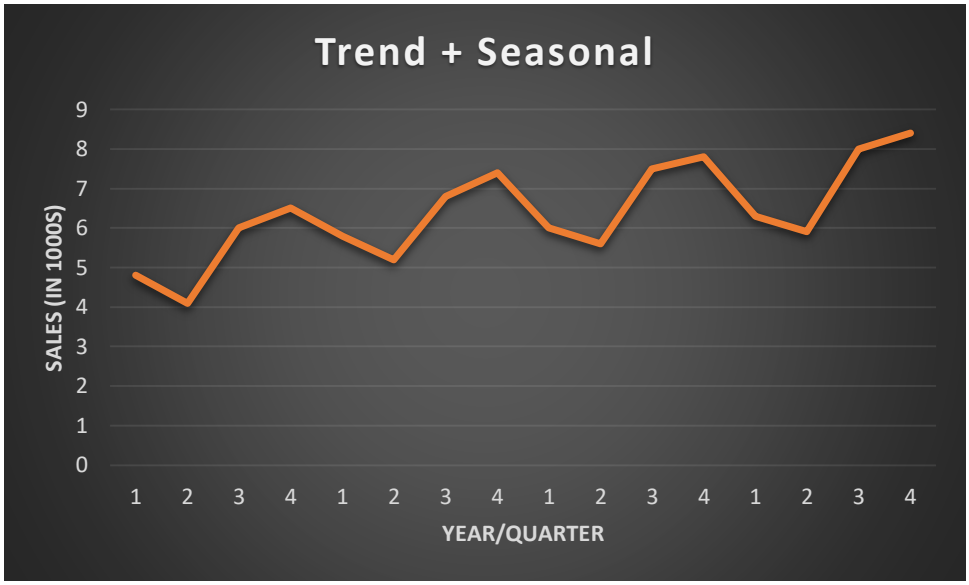
Example-3:

Year	**Quarter**	**Umbrella Sales**
1	1	125
	2	153
	3	106
	4	88
2	1	118
	2	161
	3	133
	4	102
3	1	138
	2	144
	3	113
	4	80
4	1	109
	2	137
	3	125
	4	109
5	1	130
	2	165
	3	128
	4	96



Example-4:

Year	Quarter	TV Sales (in 1000s)
1	1	4.8
	2	4.1
	3	6
	4	6.5
2	1	5.8
	2	5.2
	3	6.8
	4	7.4
3	1	6
	2	5.6
	3	7.5
	4	7.8
4	1	6.3
	2	5.9
	3	8
	4	8.4


Trend + Seasonal
SALES (IN 1000S)
9
8
7
6
5
4
3
2
1
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
YEAR/QUARTER