A time series is a set of observations arranged in chronological order.

Examples:

1. The hourly series of temperature recorded by the Meteorological observatory.

2. The daily series closing price of shares in the Stock Exchange.

A time series shows that the observed values of the variable fluctuate from time to time. Thus, an analysis of time series involves an examination of the past observations and estimation of future values. The variations in the time series are due to various factors like change in population, weather conditions and many others. The object of time series analysis is to identify and isolate these factors. These variations of time series are broadly grouped into four types called components of time series.

Components

1. Secular trend
2. Seasonal variation
3. Cyclical variation
4. Irregular variation

Secular trend

The increase or decrease in the movements of a time series is called Secular trend.

A time series data may show upward trend or downward trend for a period of years and this may be due to factors like increase in population, change in technological progress, large scale shift in consumer tastes etc. This does not include short term changes but only includes steady long term movements.

Example

- population increases over a period of time, price increases over a period of years, production of goods on the capital market of the country increases over a period of years. These are the examples of upward trend.
- The sales of a commodity may decrease over a period of time because of better products coming to the market. This is an example of declining trend or downward.

Seasonal variations

Seasonal variations are short-term fluctuation in a time series which occur periodically in a year. This continues to repeat year after year. The major factors that are responsible for the repetitive pattern of seasonal variations are weather conditions and customs of people. Series of monthly and quarterly data are ordinarily used to examine these seasonal variations.

Cyclical variations

Cyclical variations are recurrent upward or downward movements in a time series but the period of cycle is greater than a year. Also these variations are not regular as seasonal variation. There are different types of cycles of varying length and size. The ups and downs in business activities are the effects of cyclical variation.

Irregular variations

Irregular variations are fluctuations in time series that are short in duration, erratic in nature and follow no regularity in the occurrence pattern. These variations are also referred to as residual variations since by definition they represent what is left out in a timeseries after trend ,cyclical and seasonal variations. Irregular fluctuations results due to the occurrence of unforeseen events like :
Floods
Earthquakes
Wars
Famines

Measurement of trends

Some of the methods of finding trend in a time series:

1. Graphic method
2. Semi average method
3. Moving average method
4. Method of least squares

Graphical Method

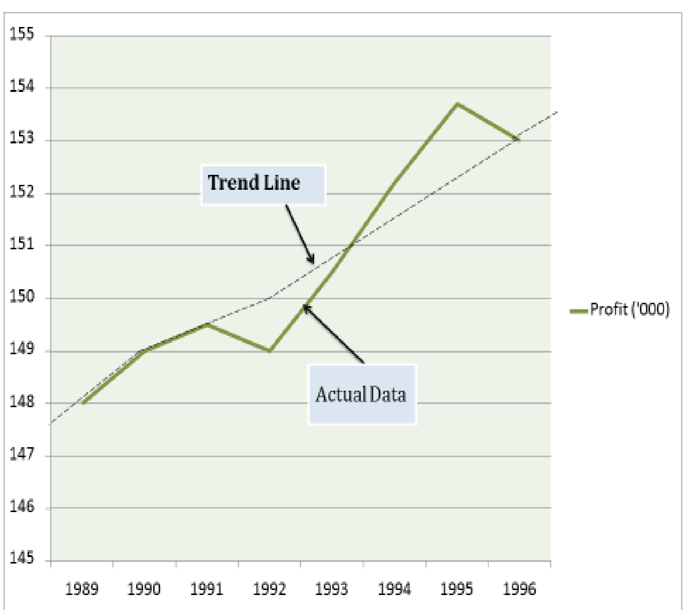
In this method the actual time series data is plotted on a graph paper by taking the time t along the horizontal axis and the values y along the vertical axis. A straight line is drawn to the data. As far as possible straight line must be drawn in such a way that there are equal number of points on either side of it. The straight line so obtained is called the trend line. The vertical component of any point on the line gives the trend corresponding to the year.

Example

Draw a free hand curve on the basis of the following data

Years	1989	1990	1991	1992	1993	1994	1995	1996
Profit	148	149	149.5	149	150.5	152.2	153.7	153

Sol:



Semi average method

In this method the given data are divided in two parts, preferable with the equal number of years.

- For example, if we are given data from 1991 to 2008, i.e., over a period of 18 years, the two equal parts will be first nine years, i.e.,1991 to 1999 and from 2000 to 2008. In case of odd number of years like, 9, 13, 17, etc.., two equal parts can be made simply by ignoring the middle year. For example, if data are given for 19 years from 1990 to 2007 the two equal parts would be from 1990 to 1998 and from 2000 to 2008 - the middle year 1999 will be ignored.

Moving average method

This method indicates the trend of the given values over a period of time. Moving averages are usually calculated for 3 years, 4 years, 5 years etc. Determining the period of a moving average is an important factor in finding the trend values

1. Using three year moving averages, determine the trend and short term fluctuations

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production	21	22	23	25	24	22	25	26	27	26

Sol:

Year	**Production**	**Three year moving total**	**Three year Moving average**	**Short term fluctuation**
2000	21	-	--	
2001	22	66	22	0
2002	23	70	23.33	-0.33
2003	25	72	24	1
2004	24	71	23.67	0.33
2005	22	71	23.67	-1.67
2006	25	73	24.33	0.67
2007	26	78	26	0
2008	27	79	26.33	0.67
2009	26	--		

2. For the following data, calculate the four year moving average and determine the trend values. Find the short term fluctuations.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009

Values	50	36.5	43	44.5	38.9	38.1	32.6	41.7	41.1	33.8

Sol:

Year	**Production**	**Four year moving total**	**Two period moving total**	**4 centred moving average**	**Short term fluctuation**
2000	50	-	--		
2001	36.5				
		17.4			
2002	43		336.9	42.11	0.89
		162.9			
2003	44.5		327.4	40.93	3.57
		164.5			
2004	38.9		318.6	39.83	-0.93
		154.1			
2005	38.1		305.4	38.18	-0.08
		151.3			
2006	32.6		304.8	38.1	-5.5
		153.5			
2007	41.7		302.7	37.84	3.86
		149.2			
2008	41.1				
2009	33.8	--			

Least Square Method

This method is most widely in practice. When this method is applied, a trend line is fitted to data in such a manner that the following two conditions are satisfied:-

The sum of deviations of the actual values of y and computed values of y is zero.

The sum of the squares of the deviation of the actual and computed values is least from this line. That is why method is called the method of least squares. The line obtained by this method is known as the line of `bestfit`.

The Method of least square can be used either to fit a straight line trend or a parabolic trend.

The straight line trend is represented by the equation:-

$\mathbf{Y_c = ax + b}$ where Y = trend value to be computed : x – unit of time (Independent variable) ;

a = constant to be calculated and b = constant to be calculated

1. Fit a straight line trend to the following data

x	71	68	73	69	67	65	66	67
y	69	72	70	70	68	67	68	64

Sol:

x	**y**	**x^2**	**xy**
71	69	5041	4761
68	72	4624	5184
73	70	5329	4900
69	70	4761	4900
67	68	4489	4624
65	67	4225	4489
66	68	4356	4624
67	64	4489	4096
Σx = 546	Σy = 548	Σx^2 = 37314	Σxy = 37578

Normal equations are $\Sigma y = a\Sigma x + nb$

$$\Sigma xy = a\Sigma x^2 + b\Sigma x$$

Substituting the values in the normal equation

$$548 = 546a + 8b$$

$$37578 = 37314a + 546b$$

Solving the above two equations, we get

$$a = 0.424 \text{ and } b = 0.394$$

Hence the trend line is $y = 0.424x + 0.394$

2. Fit a parabola, by the method of least squares to the following data; also estimate y at x = 6.

x	1	2	3	4	5
y	5	12	26	60	97

Sol: Let $y = ax^2 + bx + c$ be the best fit.

Then, the normal equations are $a\Sigma x^2 + b\Sigma x + nc = \Sigma y$

$$a\Sigma x^3 + b\Sigma x^2 + c\Sigma x = \Sigma xy$$

$$a\Sigma x^4 + b\Sigma x^3 + c\Sigma x^2 = \Sigma x^2 y$$

x	y	x^2	x^3	x^4	xy	x^2y
1	5	1	1	1	5	5
2	12	4	8	16	24	48
3	26	9	27	81	78	234
4	60	16	64	256	240	960
5	97	25	125	625	485	2425
$\Sigma x = 15$	$\Sigma y=200$	$\Sigma x^2 = 55$	$\Sigma x^3 = 225$	$\Sigma x^4 = 979$	$\Sigma xy = 832$	$\Sigma x^2y = 3672$

Hence the normal equations are $55a + 15b + 5c = 200$

$$225a+ 55b + 15c = 832$$

$$979a + 225b + 55c = 3672$$

On solving the above equations for a, b and c we get

$a = 5.7143$; $b = -11.0858$ and $c = 10.4001$

Hence, the parabola is $y = 5.7143x^2 - 11.0858x + 10.4001$

$$y\ (x=6) = 149.6001$$