

Time Series Analysis

Time series is a series of observations recorded at different points or intervals of time. Most of the economic data are found to be dependent on time and they constitute a time series data. Mathematically, a time series is defined by function of relationship

$$Y_t = f(t)$$

where Y_t is the value of the variable under consideration at time t . For example,

- The population (Y_t) of a country in different years (t)
- The sale (Y_t) of departmental store in different months (t)
- The temperature (Y_t) of a place on different days (t)
- The closing price (Y_t) of share at a stock exchange on different days (t)

Thus if the values of a variable at time t_1, t_2, \dots, t_n are $Y_{t_1}, Y_{t_2}, \dots, Y_{t_n}$ respectively, then the series constitute a time series. So, there are actually two variable quantities, one is the study variable, say production of coal, rainfall, temperature, profit, sale, export, import, population etc. and the other variable is time. The variable time varies uniformly, always in the same direction. The value of t may be given yearly, monthly, weekly, daily or even hourly, but not always at equal interval of time.

- A time series is said to be continuous when observations are made continuously through time. For example temperature readings, flow of a river, concentration of a chemical process etc. can be recorded as a continuous time series. The adjective 'continuous' is used for series of this type even when the measured variable can only take a discrete set of values. E.g., a binary process at continuous time is a continuous time series.
- A time series is said to be discrete when observations are taken only at specific times, usually equally spaced. For example population of a particular city, production of a company, exchange rates between two different currencies may represent discrete time series. The term 'discrete' is used for series of this type even when the measured variable is a continuous variable.

Discrete time series can arise in several ways:

- Sampled: Given a continuous time series, we could read off the values at equal intervals of time to give a discrete time series, sometimes called a sampled series. The sampling interval between successive readings must be carefully chosen so as to lose little information.
- Aggregated: Aggregate the values over equal intervals of a continuous time series. E.g., monthly exports and daily rainfalls.

- **Two Main Goals**

There are two main goals of time series analysis: (a) identifying the nature of the phenomenon represented by the sequence of observations, and (b) forecasting (predicting future values of the time series variable). Both of these goals require that the pattern of observed time series data is identified and

more or less formally described. Once the pattern is established, we can interpret and integrate it with other data (i.e., use it in our theory of the investigated phenomenon, e.g., seasonal commodity prices).

Components of Time Series

▪ **Secular trend or Trend (T_t)**

The term “trend” is commonly used in day-to-day conversation. We often complain about the rising trend of population, prices etc. “Trend”, also called “Secular” or “long-term” trend is the basic tendency of production, sales, income, employment etc. to grow or decline over a period of time. It includes steady movements over a long time and excludes short-range oscillations.

Secular trend is attributable to factors such as population change, technological progress or large-scale shifts in consumer tastes. More populations call for more food, more clothing and more housing. Technological changes, discovery or depletion of resources, improvements in business organization and Government intervention in the economy are other major causes for the growth or decline of many economic time series.

Secular trends may be linear or nonlinear.

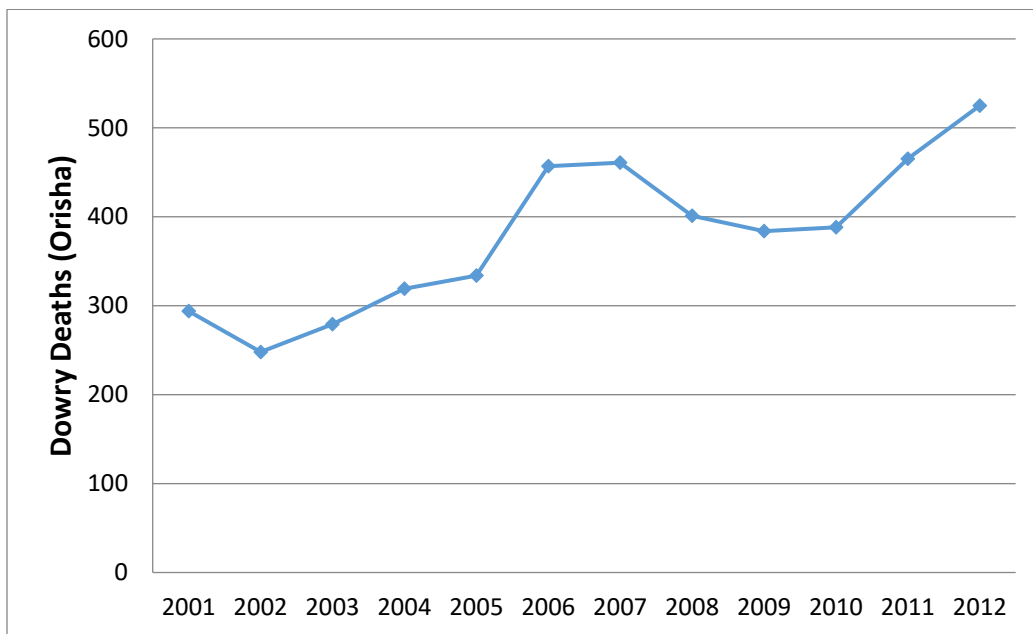


Fig 1: Dowry deaths in Odisha.

▪ **Seasonal variation (S_t)**

Seasonal variations are those periodic movements in business activity which occur regularly every year and have their origin in the nature of the year itself. Since they repeat over a period of 12 months, they can be predicted fairly accurately. Almost any type of business activity is subject to a seasonal influence to a greater or lesser degree and as such these variations are regarded as normal phenomena during every year. Although the word “seasonal” seems to connect with a season of the year, the term is meant to include any type of variation which is periodic in nature and whose repeating cycles are of a very short

duration. Seasonal variations become evident when the data are recorded at weekly, monthly or quarterly intervals. Although the amplitude of seasonal variations may vary, their period is fixed (one year). As a result, seasonal variations do not appear in series of annual figures.

Seasonal variations may be caused by

(i) Climate and weather conditions (natural forces): during winter there is a greater demand for woollen cloths whereas in summer, there is a greater demand for cool drinks and ice cream.

(ii) Customs, traditions and habits (manmade forces): since most students buy books in the first few weeks of the schools and colleges opening, the sale of books show seasonal swings, the sale and profit in departmental stores go up considerably during durga puja.

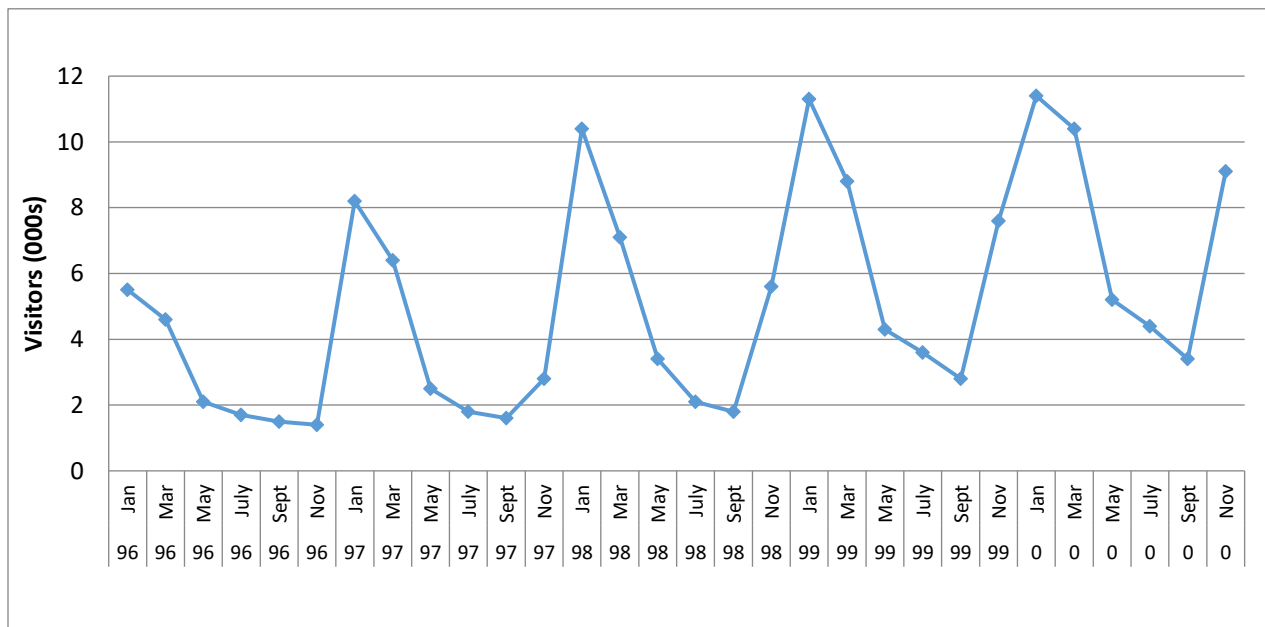


Fig 2: Abel Tasman National Park visitors in the year.

▪ **Cyclical variation (C_t)**

The term “cycle” refers to the recurrent variations in the time series that usually last longer than a year and are regular, neither in amplitude nor in length. Most of the economic and commercial series, e.g., series relating to price, production, wages etc., are affected by business cycle. One complete period is called a cycle. A cyclical variation is characterized by four phases – prosperity, decline (recession), depression and recovery and normally lasts from seven to eleven years.

A study of cyclical variations is extremely useful in framing suitable policies for stabilizing the level of business activity, that is, for avoiding periods of booms and depressions as both are bad for an economy - particularly depression which brings about a complete disaster and shatters the economy. Cyclical variation is the most difficult type of fluctuation to measure.

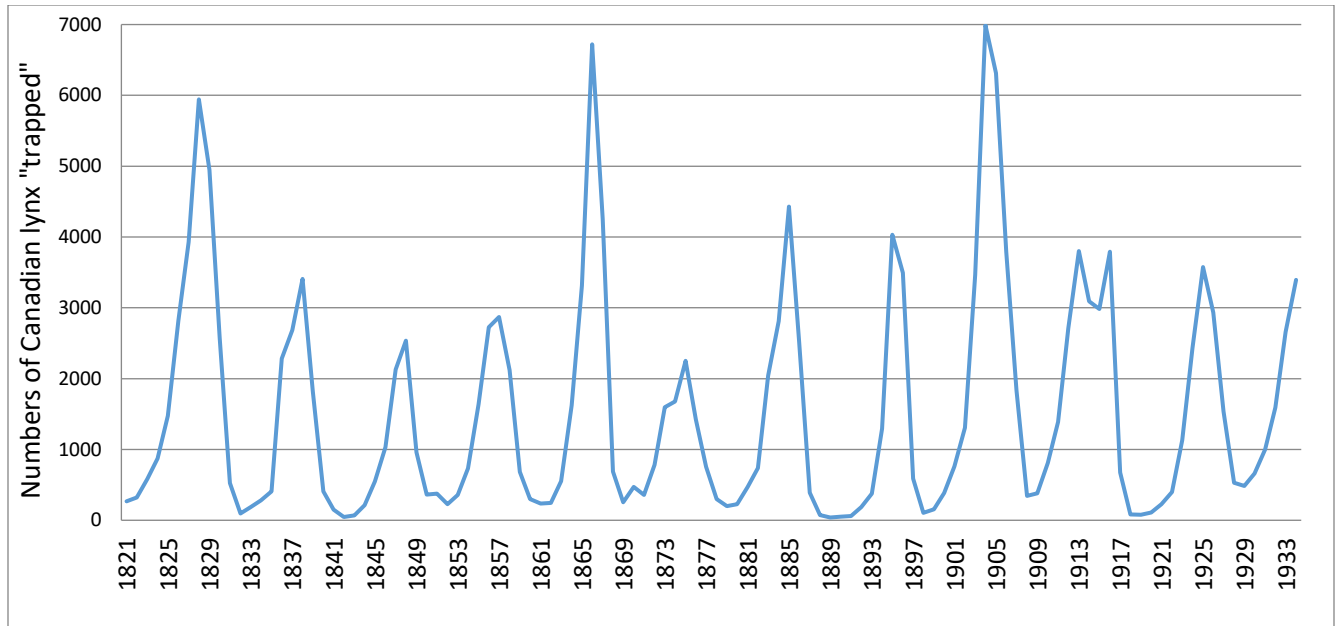


Fig 3: Number of the Canadian lynx "trapped"

▪ **Irregular or Random variation (I_t)**

Irregular variation, also called "erratic" "accidental" or "random" variations refer to such variations in business activity which do not repeat in a definite pattern. It includes all types of variations other than trend, seasonal and cyclical movements. The latter three, when they are actually at work, act in such a way as to produce certain systematic effects. Irregular movements on the other hand are largely random, being the result of chance factors.

Irregular variations are caused by such isolated special occurrences as floods, earthquakes, strikes and wars. Sudden changes in demand or very rapid technological progress may also be included in this category. Quantitatively it is almost impossible to separate the irregular movements from the cyclical movements. Therefore, in time series analysis the trend and the seasonal variations are measured separately, while the cyclical and irregular variations are accounted together.

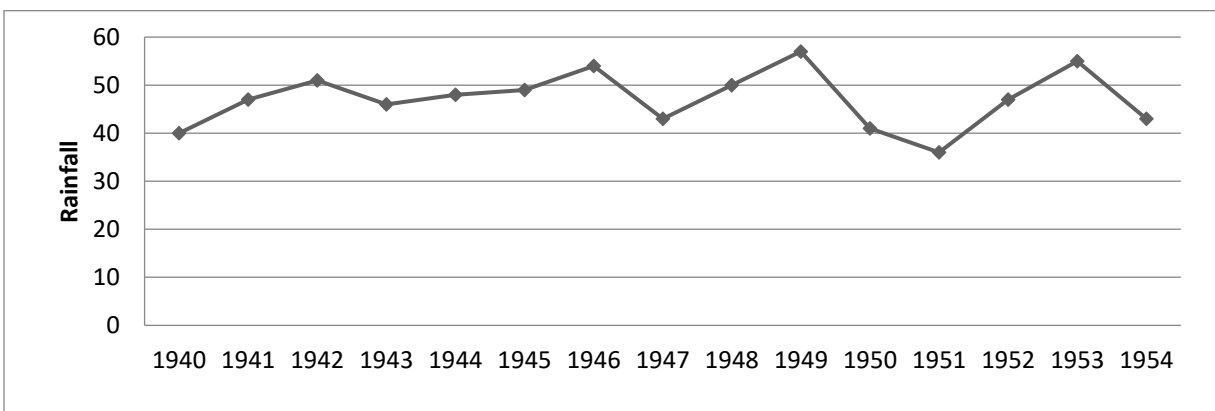


Fig 4: Annual rainfall in Bihar.