1. Introduction

Welcome to the series of E-learning modules on components of time series.

By the end of this session, you will be able to:

- Explain the following components of time series:
    - Secular trend
    - Seasonal variation
    - Cyclical variation and
    - Irregular variation

Introduction

The first step in making estimates for the future consists of gathering information from the past. In this connection, one usually deals with statistical data, which are collected, observed or recorded at successive intervals of time. Such data are generally referred to as 'time series'.

It may be very difficult to study the effect of various factors that either have led to an increase or decrease in sales. The statistician, therefore analyze the effect of the various factors under the following broad heads:

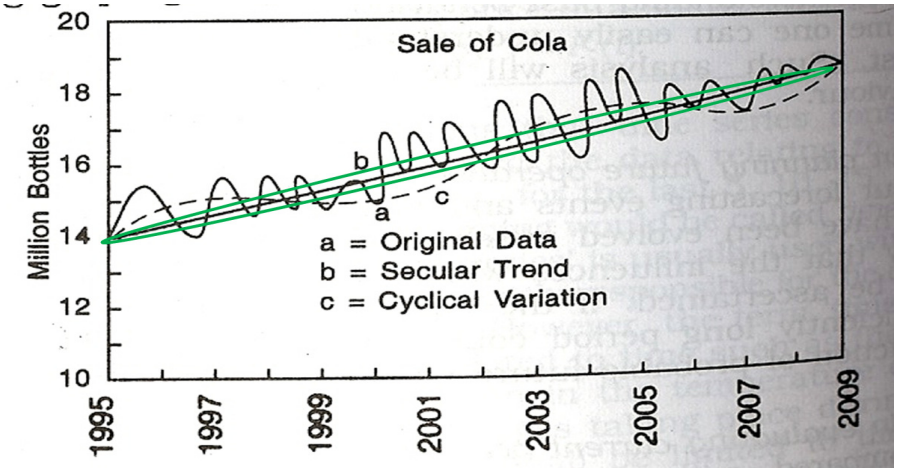
- Changes that have occurred as a result of general tendency of the data to increase or decrease, known as 'secular movements'
- Changes that have taken place during a period of 12 months as a result of change in climate, weather conditions, festivals, etc. such changes are called as 'seasonal changes'
- Changes that have taken place as a result of booms and depressions. Such changes are classified under the head 'cyclical variations'
- Changes that have taken place as a result of such forces that could not be predicted like floods, earthquake, famines, etc. such changes are classified under the head 'irregular or erratic variations'

It is customary to classify the fluctuations of the time series into four basic types of variation, which are superimposed and acting all in concert, account for the changes in the series over a period of time. These four types of patterns, movements, or, as they are often called components or elements of time series, are:

- Secular trends
- Seasonal variation
- Cyclical variation and
- Irregular variation

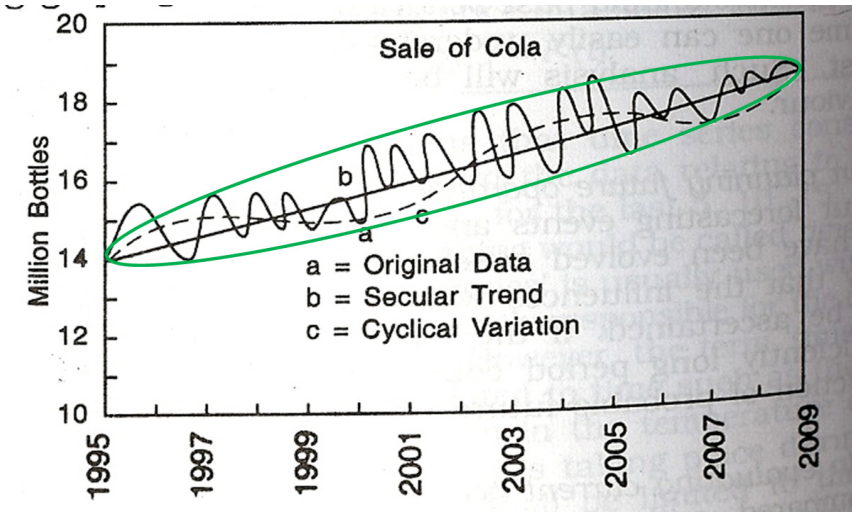
Let us observe the diagram representing the sale of a product for the past five years represented graphically. We will see that the original data in the graph is represented by a curve. The general movement persisting over a long period of time represented by the diagonal line drawn through the irregular curve is called the secular trend (T).

Figure 1



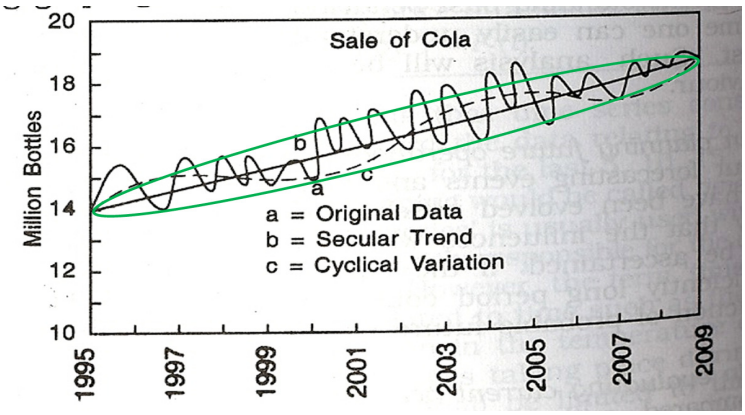
Next, if we study the irregular curve year by year, we see that in each year the curve starts with a low figure, reaches a peak about the middle of the year, and then decreases again. This type of fluctuation, which completes the whole sequence of change within the span of a tear and has about the same pattern year after year, is called a seasonal variation (S).

Figure 2



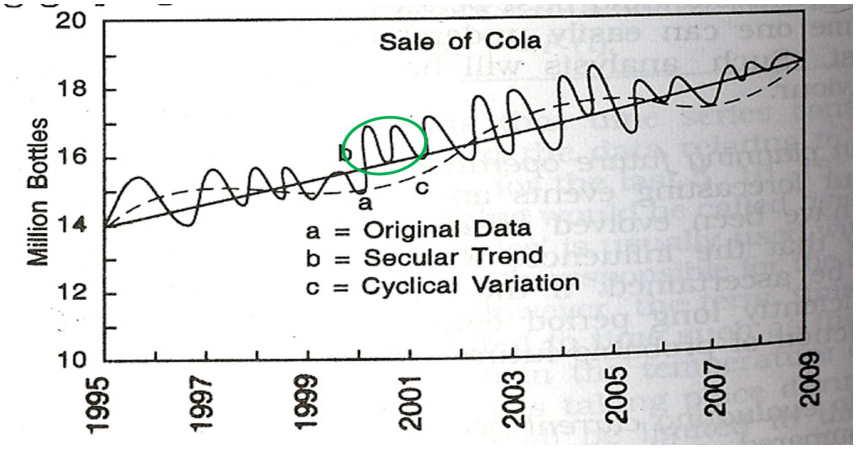
Furthermore, looking at the broken curve super imposed on the original irregular curve, we find pronounced fluctuations moving up and down every few years throughout the length of the chart. These are known as business cycles or cyclical fluctuations n (C) because they comprise a series of repeated sequences just as wheel, goes round and round.

Figure 3



Finally, the little saw-tooth irregularities on the original curve represents what are referred to as irregular movements (I).

Figure 4



In traditional or classical time series analysis, it is ordinarily assumed that there is a multiplicative or additive relationship between these four components. Hence, there are various models represented in the multiplicative form or the additive form or the combining of both the forms.

In the multiplicative model, it is assumed that any particular value in a series is the product of factor that can be attributed to the various components. It is symbolically represented as Yc the time trend is equal to the product of trend into seasonal variation into cyclical variation into irregular variation.

It needs to be noted that in the above model, the seasonal, cyclical and random items are not viewed as absolute amounts, but rather as relative influencers. Thus, a seasonal index of 110 percent would mean that the actual value is 10 percent higher than it otherwise would be because of seasonal variation. This particular model is appropriate for those situations in which percentage changes best represent the movement in the series.

Another approach is the additive model, where we treat each observation of a time series as the sum of the four components. Symbolically represented as Yc the time trend is equal to the sum of the trend, seasonal, cyclical and irregular movements.

In this relationship, it is assumed that the major aim of time series analysis is to isolate those parts of the overall variation of a time series, which are traceable to each of these four components and each part is measured independently.

There are numerous variations of these basic models. Two of such variations models are: Yc is equal to product of trend, cyclical and seasonal plus irregular variation and the other model is Yc is equal to trend into cyclical plus seasonal into irregular variation. Where, it is a combination of the multiplicative and additive model.

There is little agreement amongst experts about the validity of the different assumptions – some feel that the given classification is too crude and there are more than four types of movements. Nothing specific is really known about how the components are related, how they combine to produce particular effects, or whether they are really separable.

The effects of the various components might be additive, multiplicative or they may be combined in any one of the infinitely large number of other ways. Different models will lead to different results. Although the additive assumption is undoubtedly true in some cases and the multiplicative assumption characterizes the majority of economic time series.

Consequently, the multiplicative model is not only considered as the standard or traditional assumption of time series analysis, in fact, it is more often employed in practice than all other possible models combined. The task of performing a time series analysis is to operate on the data to bring out each of the present components separately.

2. Secular Trend

Secular trend:
The term ‘secular trend’ or simply “trend” is very popularly used in day-to-day conversation. For example, we often talk that the population, prices, production, etc. which are showing an upward trend. Thereby, what we really mean is that, we observe such variables over a long period of time and we find an increasing tendency.

Similarly, we find that over the last several years, the death rate in our country is declining and hence we say that death rate is showing a declining trend. In a dynamic economy, where a downward or constant tendency is observed is rare, most of the variables show an upward trend.

The general tendency of the data to grow or decline over a long period of time is called ‘Secular Trend’. Trends are classified in to 2 main categories namely:

- Linear / Straight Line methods
- Non-Linear Trends

As we are aware, secular trend means the tendency of data to grow or decline over a long period of time, what determines the period of time is the nature of data. In case, we are studying about the population growth between 2000 and 2005, then the duration is in terms of years. However, if you take the case of growth of virus that multiplies so fast, the duration of the trend would be in the order of minutes.

However, in any statistical analysis, longer the period, better is the trend. In order to compute the trend, it is ideal to have at least three to four complete cycles of the trend.

It is important to note that the upward or downward trend of the data must happen in the same direction throughout the period of the trend. For example, if the price of an item has been showing increasing trend over the last decade except for a couple of years, we can call it as a secular trend.

Factors affecting Trend:
In cases of increasing trend, the main factor responsible for such a trend is the population and demand. In cases of declining trends in the series, the reasons could be due to technological, cultural and political.

For example, the declining trend in death rate can be attributed to technological advances in the field of medical sciences, but the same can result in increased birth rate. The key objective of the study of trend is to bring about predictability of future behaviour of the data.

If the trend can be determined, the rate of change or progress can be ascertained. This would help a firm to make a reasonably good estimates of the future demand to plan its production, sale, investment, inventory and staffing.
However, we need to be aware that such forecasts always have some element of assumptions, which are dependent on many factors, and a change in any of those factors might lead to a change in the estimation or forecast.

3. Seasonal Variations

Seasonal Variations:
Seasonal variations can be attributed to periodic movements in business activity. Such activities can be predicted accurately. However, any business is impacted by seasonal changes but the degree of impact varies.

Seasonal does not necessarily align to the different seasons in a year but to certain kind of variations that are periodic in nature and where the cycles repeat. Some of the factors that affect the seasonal variations are climate, weather, customs, tradition and habits.

Customs and Traditions
For example, certain religious event or festival creates huge demand for certain commodity leading to the increased spending of money and shopping or handing over gifts during Christmas or New year.

Similarly, you can also see increased spending during the first half of a month and reduced spending in the latter half of the month, which is directly linked to the spending habits of the people and the flow of money by way of salary/income.

For example, companies like Archies, reap maximum benefits during Christmas and New year by sale of greeting cards, which peak the maximum. It also affects the sale of stamps and revenue of postal department.

In addition, many retail outlets reap the rewards of festival seasons by organizing special discount sale leading to higher sale proceeds. This is true for fast moving consumer goods and also leads to maximum employment demand of contract labourers.

Weather and climate
Weather and climatic conditions do create a significant influence in the trends. For example, during winter, demand for warm clothing increases significantly and during summer, there is a rising trend for cold drinks, casual clothes. During rainy seasons, there is an increasing trend for water protective clothing and also for automobile body protections.

If you take in India, the demand for mango and grapes increases during summer season when the harvest is at its peak, while the demand for apples peaks during winter.

It is extremely important that the firm take into consideration the data and trends in planning for demand management, inventory and advertising to create maximum impact on consumers. This might help the firm to strategize upon various factors like introduce diverse products that cater to different seasonal peaks in demands.

Other options can consider manufacturing or accumulating stock in lean period to manufacture at a reduced rate and spending more on off-seasonal promotion of those products.

4. Cyclical Variations

Cyclical variations
The term Cycle refers to the recurrent variations in time series that usually last longer than a year but not regular in length or amplitude. Time series related to economies and business show some kind of cyclical variations.

Cyclical fluctuations are long-term movements that represent consistently recurring increase and decline in activity. A business cycle consists of recurrence of up and down movements of business activity from some sort of statistical trend or normal.

Business cycles consists of expansion occurring about the same time in many economic activities followed by similar general recessions, contractions and revivals, which merge into the expansion phase of the next cycle. These sequences of changes are recurrent but not periodic. In durations, business cycles vary from more than 1 year to 10-12 years. Normal means a kind of statistical average.

Any business cycle has four well defined period or phases, namely:

- Prosperity
- Decline
- Depression
- Improvement

Despite being able to classify series and data trends, there are some practical challenges in classifications. Seasonal variations are not uniform always in timing to increase certainty. Similarly, it is difficult to distinguish seasonal influences from cyclical factors. Sometimes a cyclical impact can affect the seasonal trend. Rapidly rising trend eliminates seasonal and cyclical variations.

Hence, it has been advised to make necessary adjustments to the following parameters before analyzing the time series. In the prosperity phase of business cycle, public demand is optimistic with increased business revenue, higher prices, increased demand and good level of profits being made by business houses. This also leads to potential expansion in scope of business, which leads to excess development of products.

However, on the flip side this leads to shortage in warehouse space, shortage of transportation facilities, difficulty in securing deliveries, leading to large inventories that get accumulated, increase in wage and decrease in labour efficiency. Strong demand for money causes increase in interest rates and possible situation of reduced loan disbursements from banks.

This situation causes the business houses to make price concessions in order to secure the necessary cash. As a result, the business firm resorts to price reduction of the products and leads to a declining situation. Hence, buyers wait for further reduction in anticipation leading to a decline in the situation and the situation changes from optimism to pessimism.

As a resultant situation, there could be business loss or even closure of business, widespread unemployment, wage reduction, lower prices creating a state of depression. This leads to restructuring, reorganizing, liquidation, accumulation of money, sale of non-performing assets and certain changes to cash flows and adjusting inefficiencies.

This phase is called the Improvement phase. The improvement phase is characterized by increasing prices, period of business improvement, recovery, rising prices. The Improvement phase normally rolls into the prosperity phase again and hence a business cycle is completed.

As discussed above, the movements are constantly repeated in the given order as the cycle completes.
The study of such cyclical variations is extremely useful in framing suitable policies for stabilizing the level of business activity and for avoiding periods of booms and depressions as both are bad for an economy – particularly depression that brings about a complete disaster and shatters the economy.

Though we can measure the cyclical variations and the associated impacts on the economy, it is very difficult to predict and measure the economic fluctuations. The reason being –

- Business cycles do not show regular periodicity as they differ in the timing, pattern
- Cyclical variations are mixed with erratic, random forces, which make it difficult to isolate separately the effect of cyclical and irregular forces

Business cycles are distinguished from seasonal variation in the following respects, where in the cyclical variations are of a longer durations that is more than a year. Typical business cycles could vary from 2 to 10 years. Moreover, they do not ordinarily exhibit regular periodicity as successive cycles vary widely in timing, amplitude and pattern.

Fluctuations in the 4 phases of business cycles are caused by multiple factors. The period of prosperity, decline, depression and improvement viewed as four phases of a business cycle are generated by factors other than weather, social customs and those, which create seasonal patterns.

5. Irregular Variations

Irregular Variations:
Irregular variations refer to variations in business activity that does not have a repetitive pattern. Irregular variations are largely random and hence difficult to predict. The category labelled irregular variations is really intended to include all types of variations other than those accounting for the trend, seasonal and cyclical movements.

Irregular movements are considered to be largely random, being the result of chance factors, which like those determining the fall of a coin are wholly unpredictable. Such variations could be caused due to events like wars, earthquakes, strikes. Since quantitatively it is difficult to separate out the irregular movements and cyclical movements, while analyzing the time series, the trend and seasonal variations are measured separately and cyclical and irregular variations are left.

Sudden changes in demand or technological advancements can be included in this category. Sudden spurt of internet and e-mail has led to a significant reduction in snail mail – leading to loss of revenues for the postal department.

The border disputes, war threats, or sudden civic unrests can lead to displacement /exodus of people of a certain sector that can cause disturbances in a section of the industries. For example, the cauvery riots caused most of the migrant Tamil speaking labourers leading to disruptions in constructions industry.

Similarly, a sudden exodus of people from NE states on the fear of counter attacks led to severe disruptions in hotel industry and security agencies, since these were managed by people from these states.

There are two reasons for recognizing irregular movements:

- One is to suggest that on occasion it may be possible to explain certain movements in the data as due to specific causes and to simplify further analysis
- Two is to emphasize the fact that prediction of economic conditions is always subject to degree of error owing to the unpredictable erratic influences

Here's a summary of our learning in this session, where we have understood the various components of time series like:

- The secular trend
- The seasonal variation
- The cyclical variation and
- The irregular variation