Decision Making with Spreadsheet
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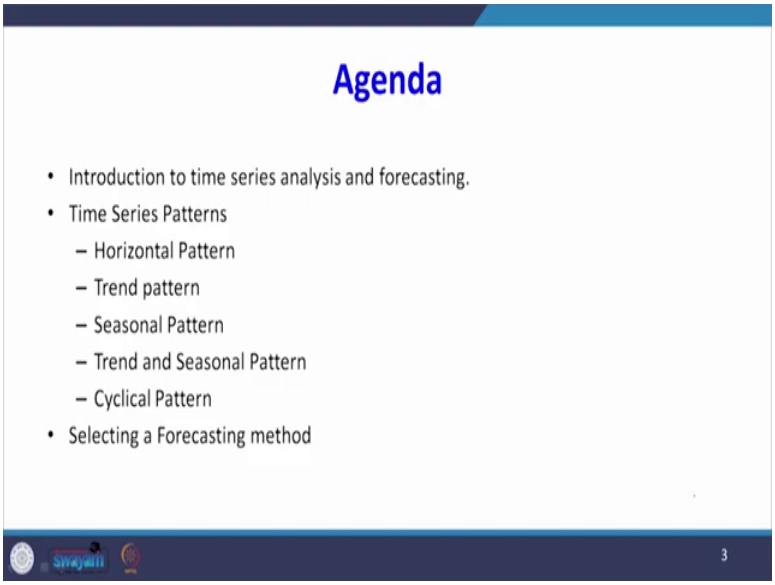
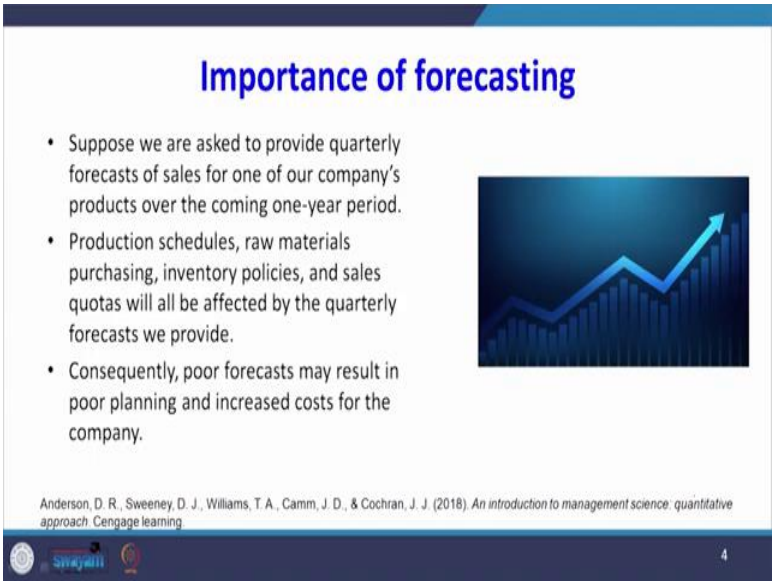
Lecture – 56
Time Series Analysis and Forecasting – I

In this lecture, I am going to discuss time series forecasting; mainly, I will explain different types of patterns of time series data. Finally, I will explain how to choose appropriate forecasting techniques. So, the agenda for this lecture is an introduction to time series analysis and forecasting and time series patterns.

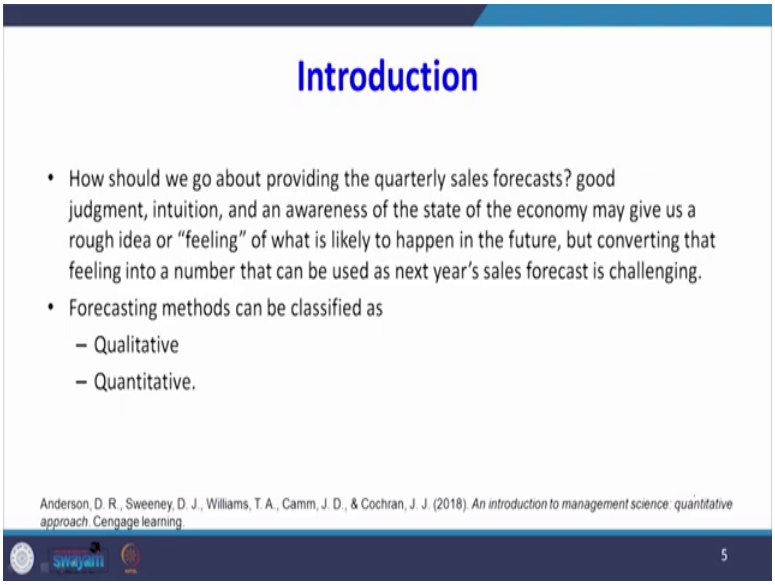


There are five types of patterns. One is a horizontal pattern, trend pattern, seasonal pattern, trend and seasonal pattern, and cyclic pattern. Finally, after looking at different patterns, I will explain how to select the correct forecasting method.



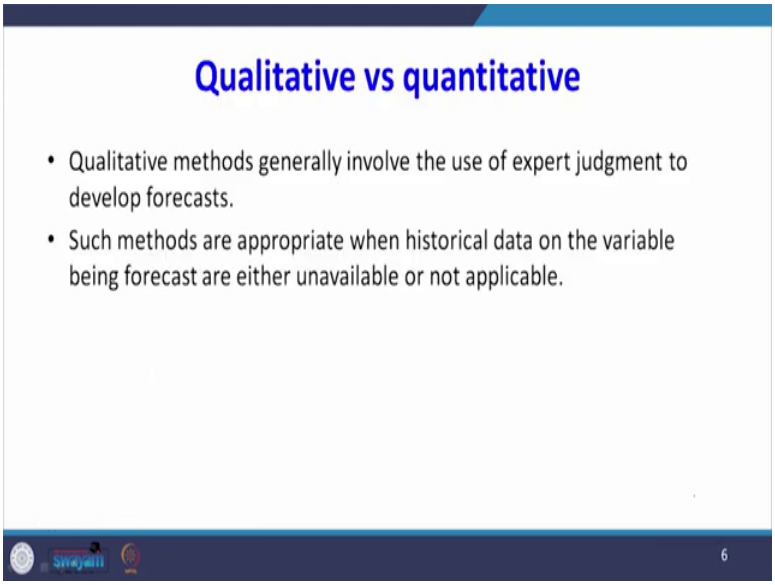
First, we can see the importance of forecasting; suppose we are asked to provide a quarterly forecast of sales for one of our company's products over the coming one-year period. Production schedules, raw materials purchasing, inventory policies, and sales quotas will all be affected by the quarterly forecasts we provide. That is why forecasting is important.

All other planning activities are based on forecasting if there is any problem in forecasting that may affect all our planned activities. So, what will happen? Consequently, poor forecasts may result in poor planning and increased costs for the company.

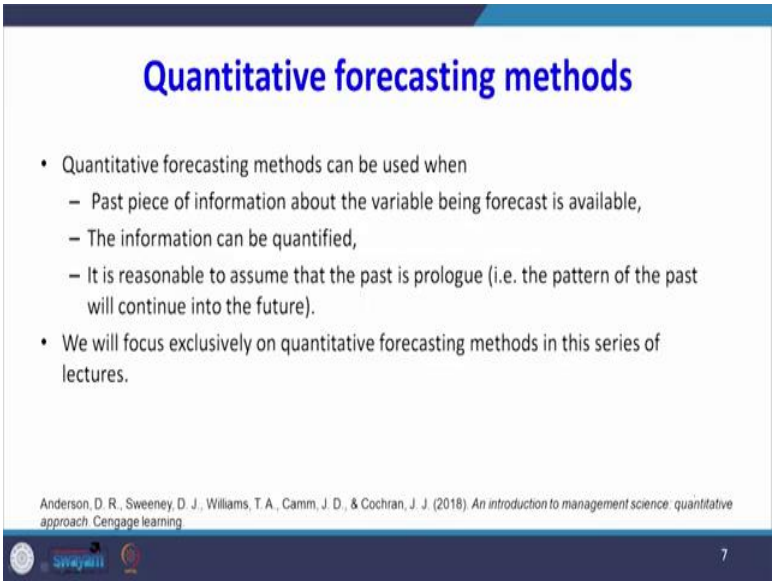


How should we go about providing the quarterly sales forecasts? We can provide sales forecasts through good judgment, intuition, and an awareness of the state of the economy, which may give us a rough idea or feeling of what is likely to happen in the future but converting that feeling into a number that can be used as a next year's sales forecast is

challenging. We can classify forecasting methods into two categories: qualitative and quantitative.



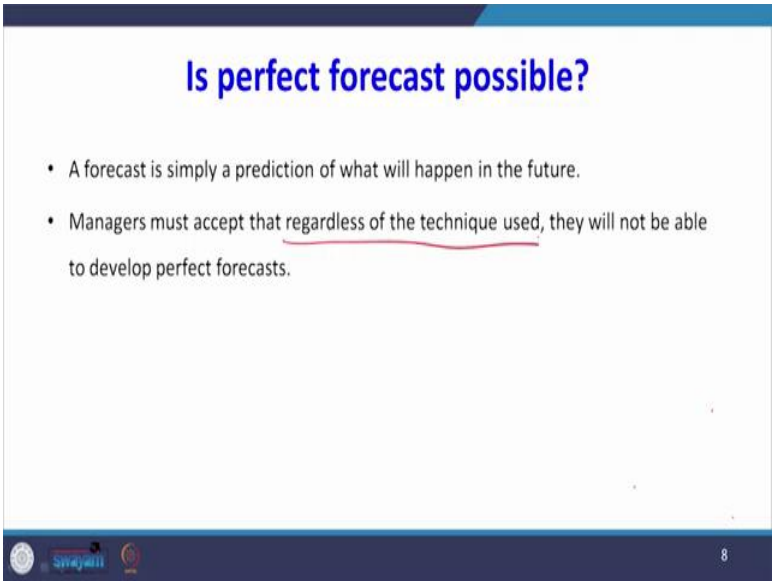
Qualitative methods generally involve the use of expert judgment to develop forecasts. When are qualitative methods most appropriate? Qualitative methods are appropriate when historical data on the variable being forecast is either unavailable or not applicable. Many times, we may not have historical data. If you do any innovative products, we cannot predict sales. At that time, we need to go for judgment. So, that type of forecasting technique is called qualitative forecasting.



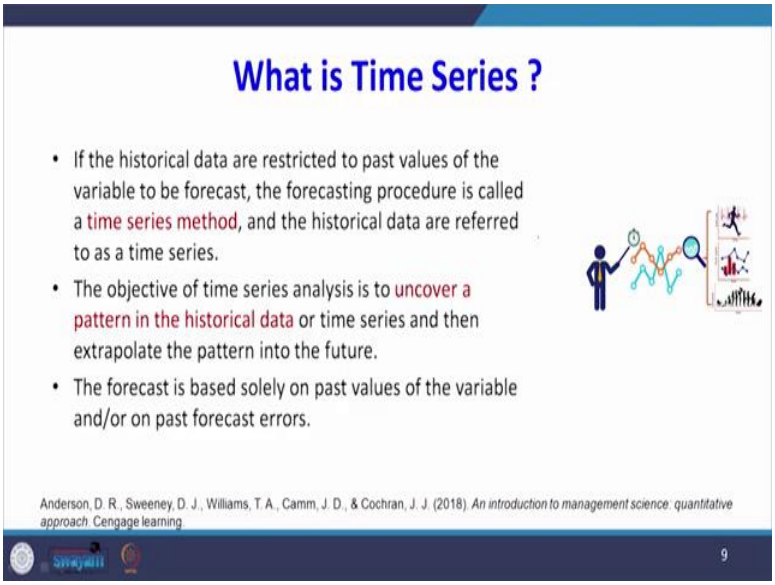
Then quantitative forecasting methods, when quantitative forecasting methods can be used. Past pieces of information about the variable being forecast are available. If you have enough information on the historical data, then we can go for the quantitative forecasting method.

The information can be quantified, it can be easily measurable. It is reasonable to assume that the past is prologue and that the pattern of the past will continue in the future.

In these situations, we can only use quantitative forecasting. But in coming lectures, we exclusively focus on quantitative forecasting methods, not on the qualitative.



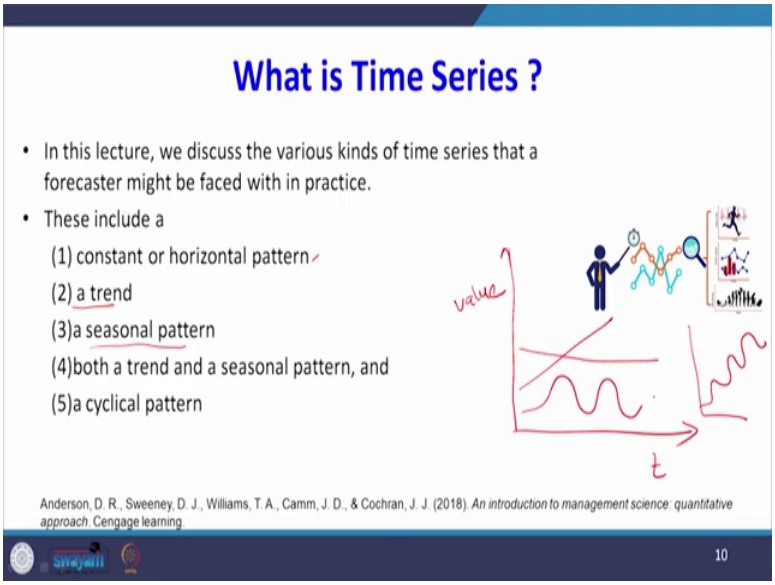
Is a perfect forecast possible? A forecast is simply a prediction of what will happen in the future. So, managers must accept that regardless of the technique used, they will not be able to develop a perfect forecast. So, the manager should understand that a perfect forecast is not possible.



Now, we will go back to the time series. What is time series? If the historical data are restricted to past values of the variable to be forecast, the forecasting procedure is called a time series method. The historical data are referred to as a time series. If the data changes

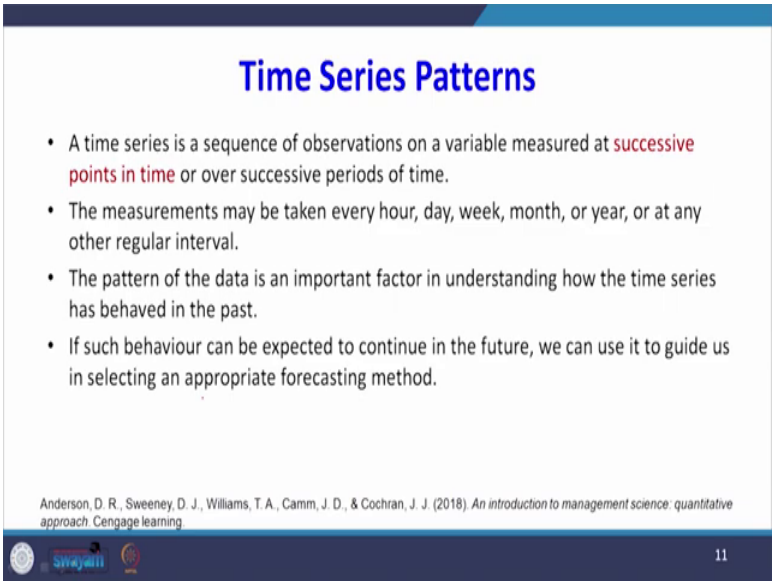
over a period, then that type of data is called time series data. Time series analysis aims to uncover a pattern in the historical data or time series.

And then extrapolate the pattern in the future. The forecast is based solely on past values of the variable and/or on past forecast errors.



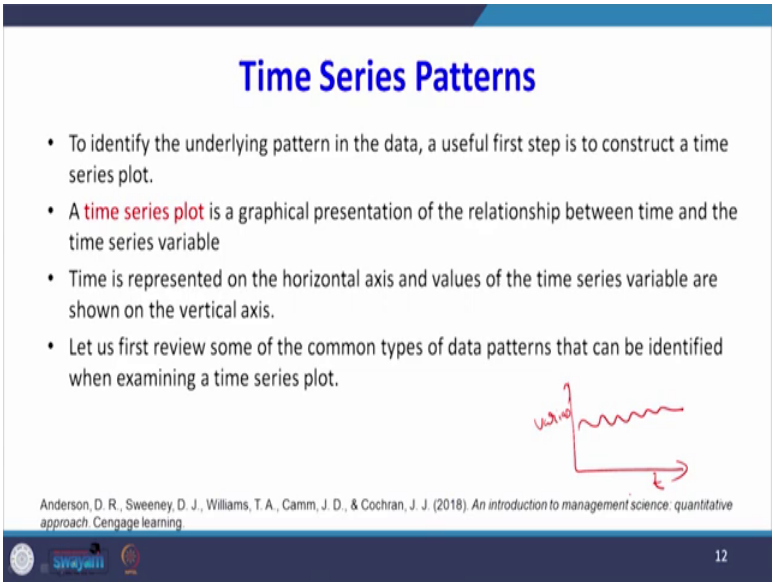
In this lecture, we discuss the various kinds of time series that a forecaster might face in practice. This includes constant or horizontal patterns. The time series may follow the trend. The time series may follow a seasonal pattern or both a trend and a seasonal or a cyclic pattern. So, generally, if you say time, the series in the x-axis is the time in the y-axis is the value. So, we assume that the value differs only based on the time.

We are not considering any other variable. That kind of data is called time series data if you plot the time series data, there are five possibilities possible. Sometimes, the data may follow a horizontal pattern. It may be like this, or there may be a trend, it may be like this, or there may be a seasonal, or sometimes there may be a trend also. See that there is a trend, and the seasonality also will be there or there may be a cyclic pattern also.



So, we are going to discuss the five patterns. Time series patterns: a time series is a sequence of observations on a variable, measured at successive points in time or over successive periods of time. The measurement may be taken every hour, day, week, month, or year or at any other regular interval. The pattern of the data is an important factor in understanding how the time series has behaved in the past.

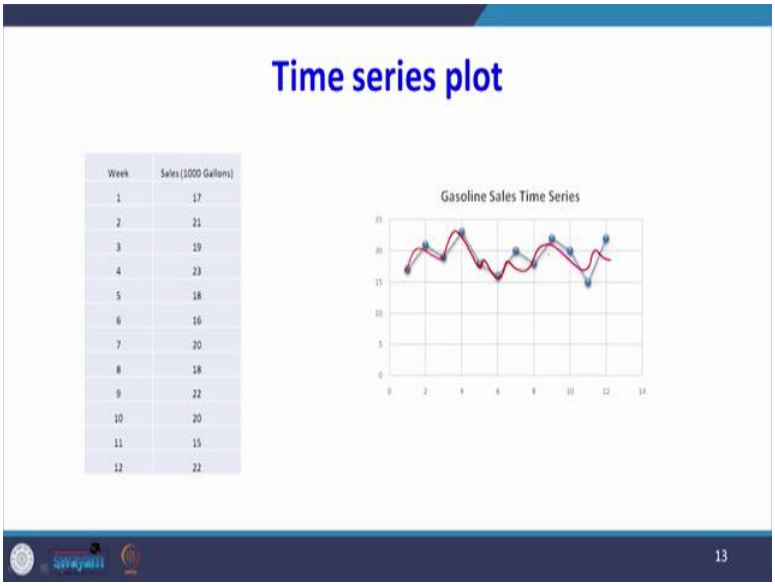
So, based on the pattern of the data, we will use appropriate forecasting techniques. If such behavior can be expected to continue in the future, we can use it to guide us in selecting appropriate forecasting methods. That is the reason we want to see the patterns that are present in the time series.



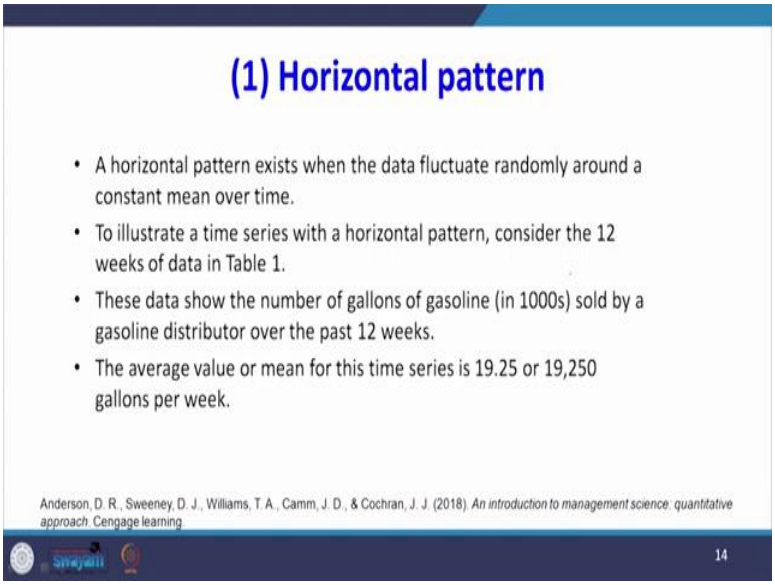
A useful first step in identifying underlying patterns in the data is to construct a time series plot. What is a time series plot? A time series plot is a graphical presentation of the

relationship between time and the time series variable. So, in the x-axis, it will be time in the x-axis variable. So, when you plot it with this data, this figure is called a time series plot. Time is represented on the horizontal axis, and the value of the time series variable is shown on the vertical axis.

Let us first review some of the common types of data patterns that can be identified when examining a time series plot. As I have previously mentioned, why do we have to see the different types of patterns? Only by analyzing the pattern can we choose the right forecasting techniques.

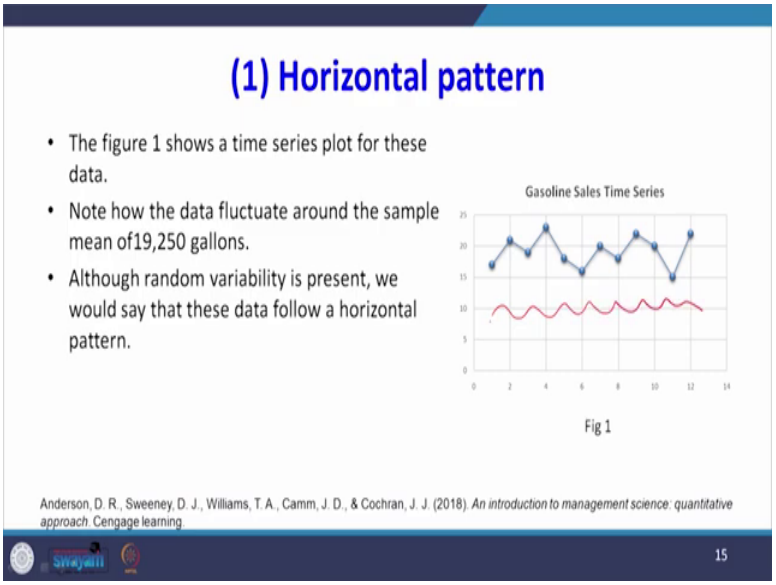


Suppose I have data, say weeks 1 to 12. I have sales in thousands if we plot it. So this plot is called a time series plot.

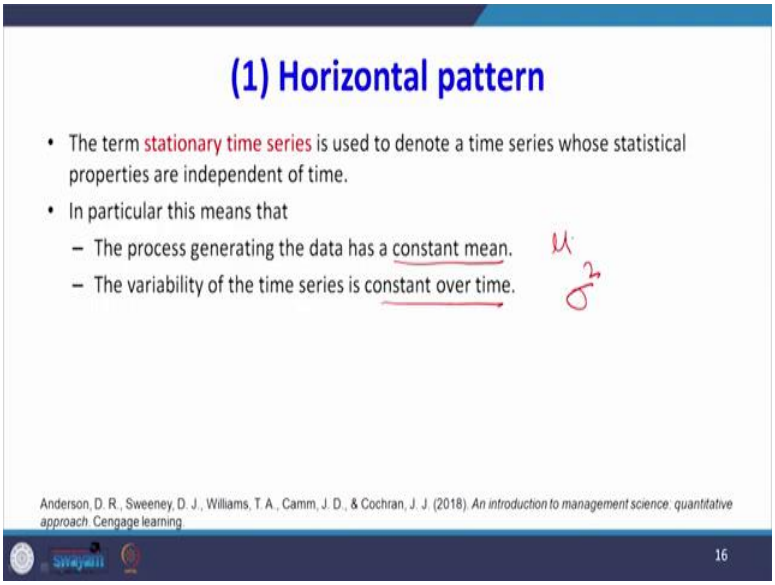


The first pattern is a horizontal pattern. In the previous slides, I have shown you a data set where there is a horizontal pattern. What is the meaning of a horizontal pattern? There are ups and downs, but it is. There is a variation, but we can say the mean is centered. That type of pattern is called the horizontal pattern. So, a horizontal pattern exists when the data fluctuates randomly around a constant mean over time.

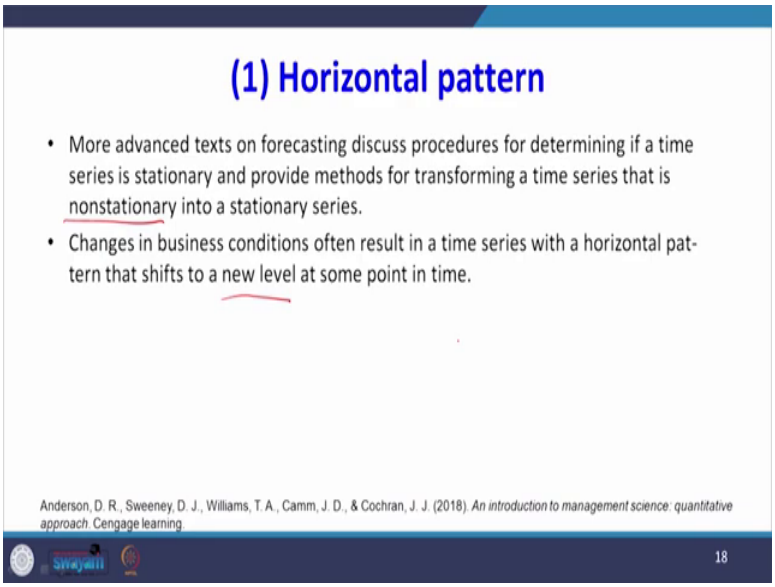
To illustrate a time series with the horizontal pattern, consider the 12 weeks of data that I have provided, which I have shown in Figure 1. This data shows the number of gallons of gasoline in terms of thousands sold by gasoline distributors over the past 12 weeks. So, the average value or mean of this time series is 19.25. The actual is 19,250 gallons per week.



See, I have shown this picture. The figure shows the plot of the time series of these data. Note that the data fluctuates around the sample mean of 19,250 gallons. Although random variability is present, we would say that these data follow a horizontal pattern. There is a slight randomness, but it is a horizontal pattern.

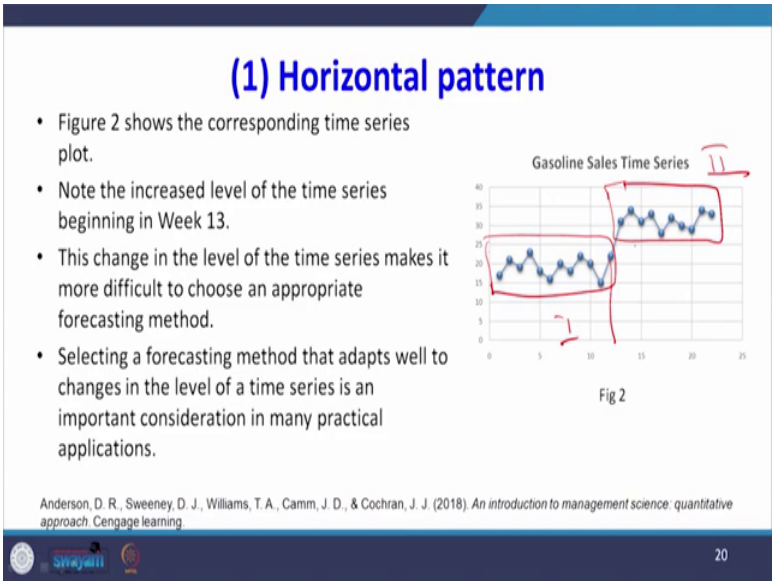


The term stationary time series is used to denote a time series whose statistical properties are independent of time. When we say stationarity, that means the process generating the data has a constant mean, the mean is the same, and the variability of the time series is also constant over a period of time. So, if the mean and the variance are the same, then we can say that time series data has the property called stationarity.



A time series plot for a stationary time series will always exhibit a horizontal pattern with random fluctuations. However, simply observing a horizontal pattern is not sufficient evidence to conclude that the time series is stationary. So, we have shown that when we plot the data set, there is a stationary pattern. However, only by looking at the figure is it not enough to decide whether there is a property of stationarity.

More advanced text on forecasting discusses the procedure for determining if your time series is stationary. And provide methods for transforming a time series that is nonstationary into a stationary series, but we are going to discuss those procedures. So, changes in business conditions often result in a time series with a horizontal pattern that shifts to a new level at some point in time.

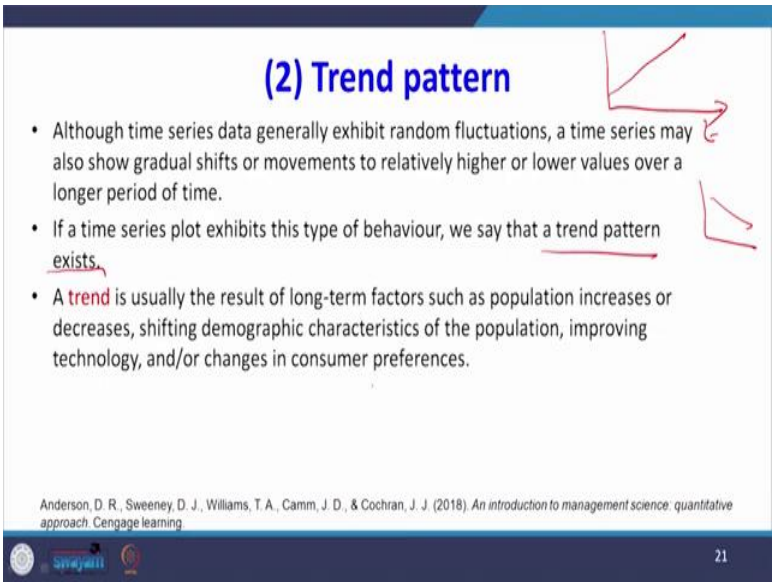


For instance, so far, we have drawn up to 12 weeks. We found there is a level; level means that the mean is fixed. For instance, suppose the gasoline distributor signs a contract with a customer in week 13. With this new contract, the distributor naturally expected to see a substantial increase in weekly sales starting from week 3. Look at this from week 3 to week 13.

So, from week 13 onwards, there is an increase in sales. So, the table shows the number of gallons per gasoline sold for the original time series and the 10 weeks after signing the new contract. So, there is a drastic improvement. So, now, Figure 2 shows the plot of the corresponding time series after the agreement. Note that the increased level of the time series began in 13. See this up to this, there is no problem, so, up to this, there is no problem.

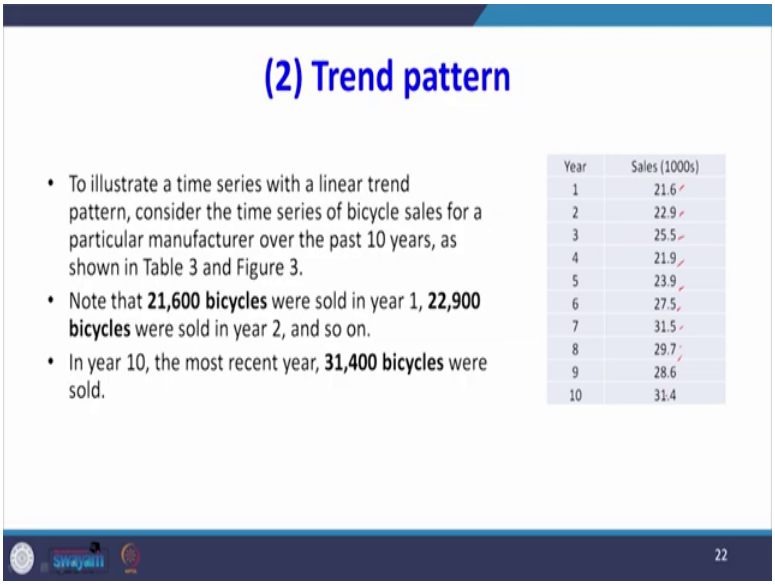
But from 13 weeks onwards, there is an increase in level. Say, for example, the mean is approximately 19, and the mean may be approximately only for this level; this level 2, level 1, may be around thirty. This change in the level of the time series makes it more difficult to choose an appropriate forecasting method. Selecting a forecasting method that adapts well to changes in the level of a time series is an important consideration in many practical

applications. So, the forecasting techniques which you use have to incorporate the change in level.

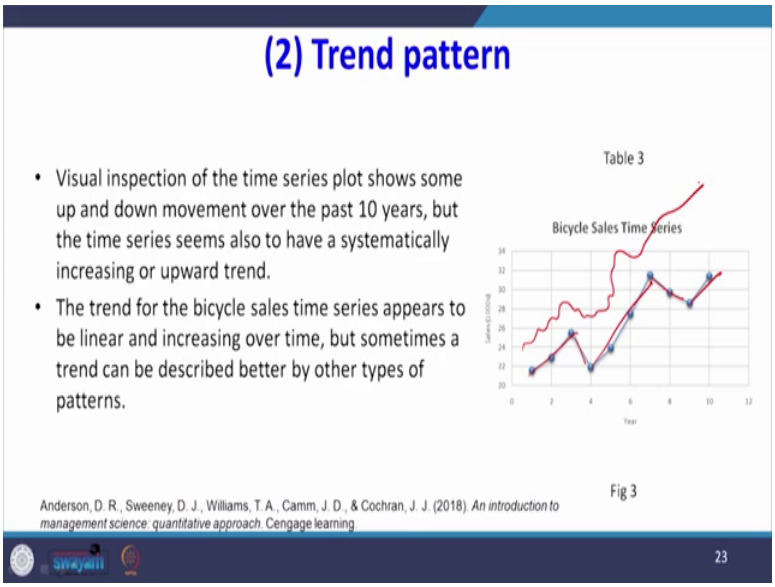


Although time series data generally expect random fluctuations, a time series may also show a gradual shift or movement to relatively higher or lower values over a longer period of time. If a time series plot exhibits this behavior, we say a trend pattern exists. Previously, we talked about horizontal patterns. Now, we are going to talk about another type of pattern called trend pattern.

What will happen? There will be a suppose, this is a time there will be a trend, it may be an increasing trend, or there may be a decreasing trend. A trend is usually the result of long-term factors, such as population increases or decreases, shifting population demographic characteristics, improving technology, or changes in consumer preference. If you plot this kind of data set, you may find a trend. The trend may be increasing or decreasing.

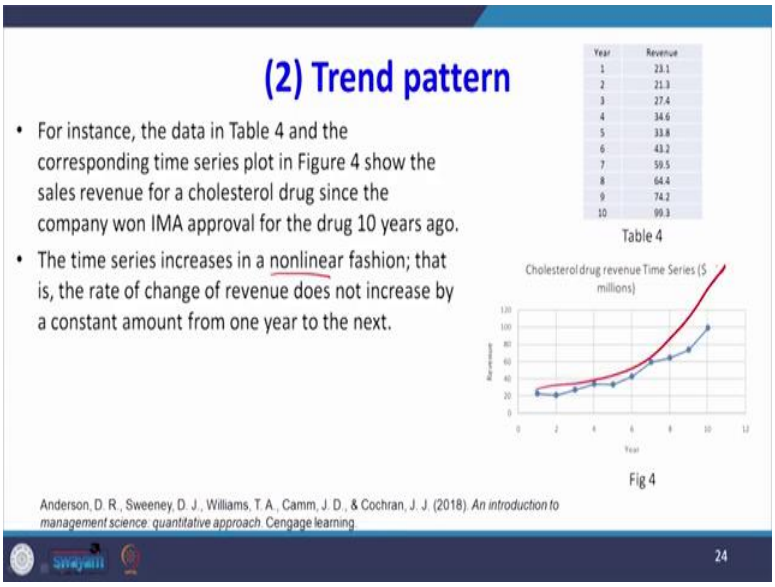


To illustrate a time series with a linear trend pattern, consider the time series of bicycle sales for a particular manufacturer over the past 10 years. Note that 21,600 bicycles were sold in year one, and 22,900 bicycles were sold in year two. You see 21.6, 9, 5, 9, 9, 5. After that, this is 31. So, in year ten, the most recent year, we have 31,400 bicycles sold. So, there seems to be an increase in trend.



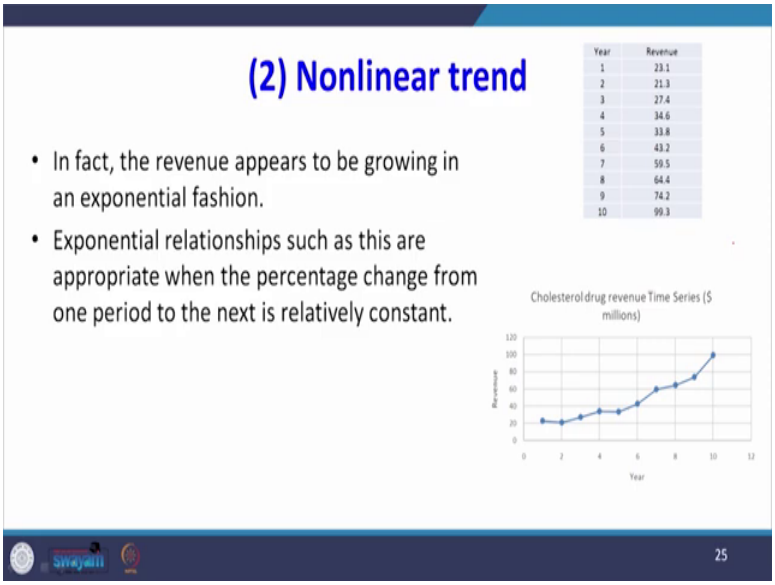
So, visual inspection of the time series plot, please look at it on the right-hand side, shows some up and down movement over the past 10 years. But the time series seems also to have a systematically increasing or upward trend. See, initially, it is increasing, there is decreasing, there is increasing, there is decreasing, then it is increasing. The trend for the bicycle sales time series appears to be linear and increasing over time.

But sometimes, a trend can be described better by other types of patterns. That may be a non-linear also. So, what is the meaning of non-linear? Maybe like this? There is this non-linear. So, here we are, seeing some linear patterns.

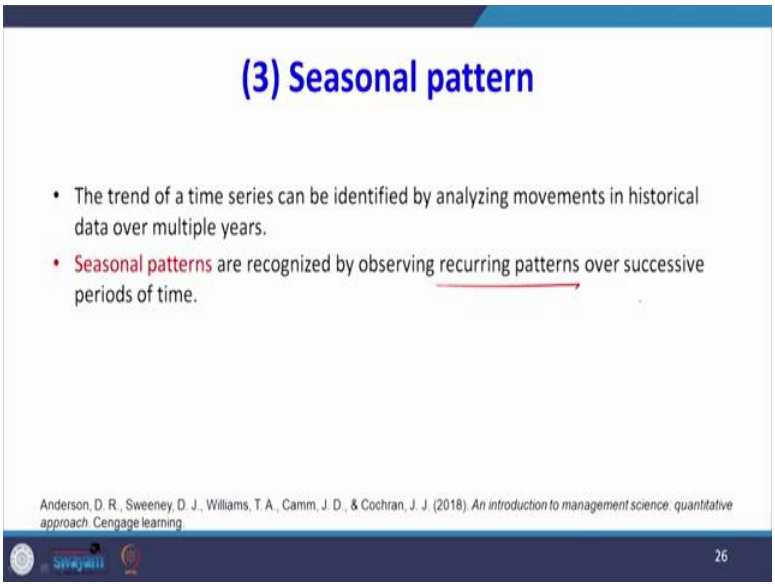


For instance, the data here looks at the year and revenue. The data in the table shows the plot of the corresponding time series in the figure. 4 shows the sales revenue for the cholesterol drug since the company won, say, Indian Medical Association approval for the drug 10 years ago. The time series increases in non-linear fashion. That is, the rate of changes in revenue does not increase by a constant amount from one year to the next year.

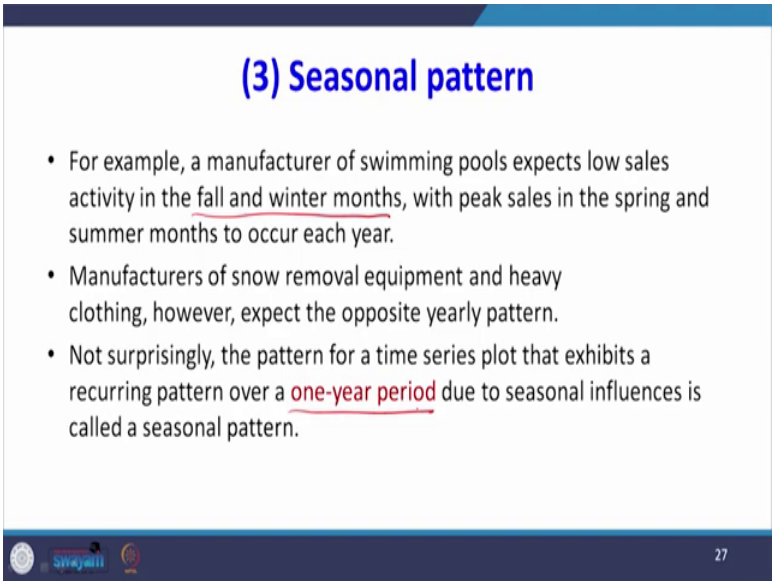
So, there is an increase in trend. So, this is not a linear trend or a non-linear one.



In fact, the revenue appears to be growing in an exponential fashion. Exponential relationships such as this are appropriate when the percentage change from one period to the next is relatively constant.

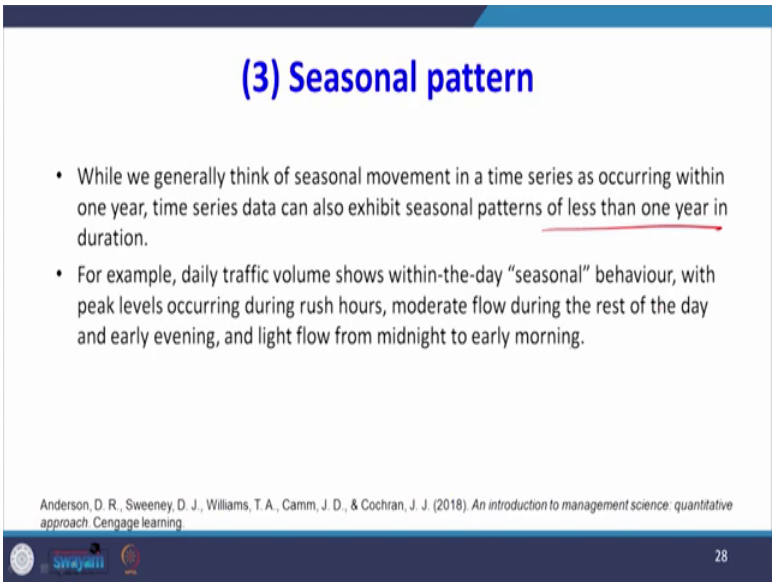


The third type of pattern is the seasonal pattern. The trend of the time series can be identified by analyzing movement in the historical data over multiple years. That is what you have seen in the trend. However, the seasonal patterns are recognized by observing recurring patterns over a successive period of time. Seasonality, winter, summer, winter, summer, sales of AC during summer will be more, during winter it will be less. That type of pattern is called the seasonal pattern.

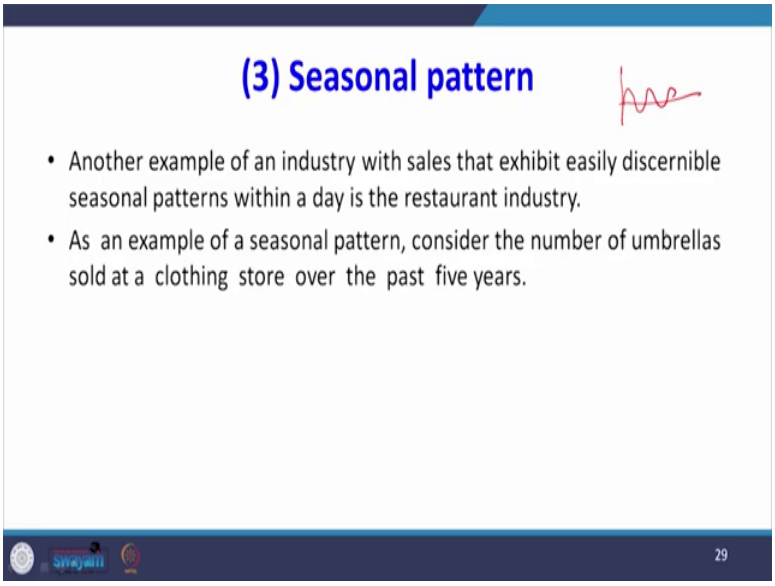


For example, a manufacturer of swimming pools expects low sales activity in the fall and winter months and peak sales in the spring and summer months to occur each year, And this variation is within the year. Manufacture of snow removal, equipment, and heavy clothing,

however, expect the opposite yearly pattern. Not surprisingly, the pattern for a time series plot that exhibits a recurring pattern over a one-year period due to seasonal influences is called a seasonal pattern.



While we generally think of seasonal movement in a time series as occurring within one year, time series data can also exhibit seasonal patterns less than one year in duration. For example, daily traffic volume shows with-in-the-day seasonal behavior, with the peak levels occurring during rush hours, moderate flow during the rest of the day and early evening, and light flow from midnight to early morning. So, within the day also there may be a seasonal variation.



Another example of an industry with sales that exhibit easily discernable seasonal patents within your day is the restaurant industry. In the restaurant industry also, you can see there is a seasonality. As an example of a seasonal pattern, consider the number of umbrellas sold at the clothing store over the past 5 years. We can see there is a seasonal. What will happen

during the rainy season is that there will be more sales. During the summer season, there will be fewer sales.

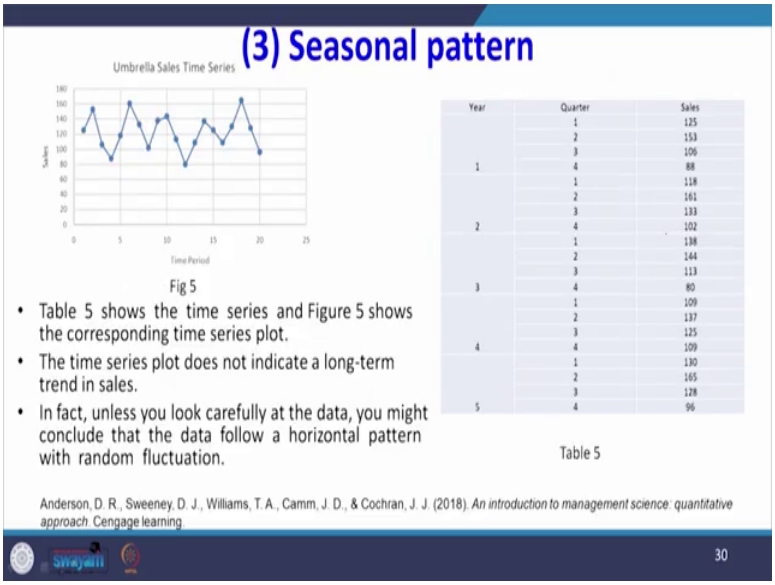
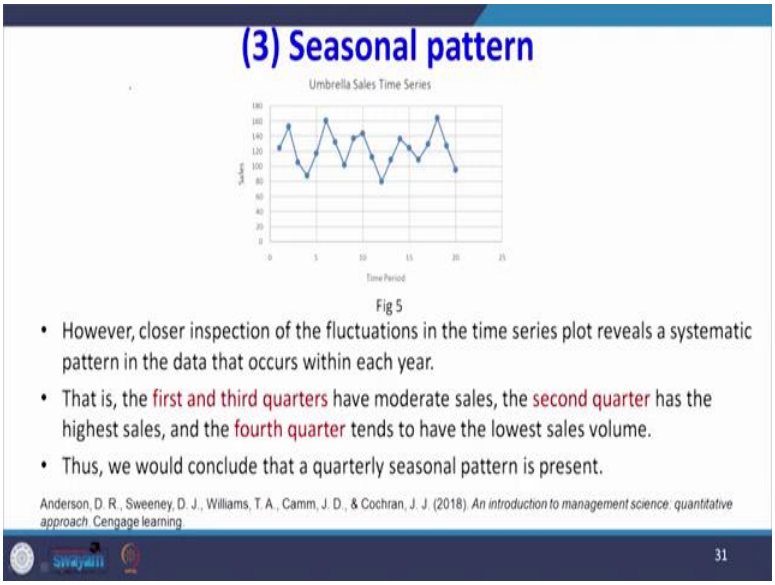


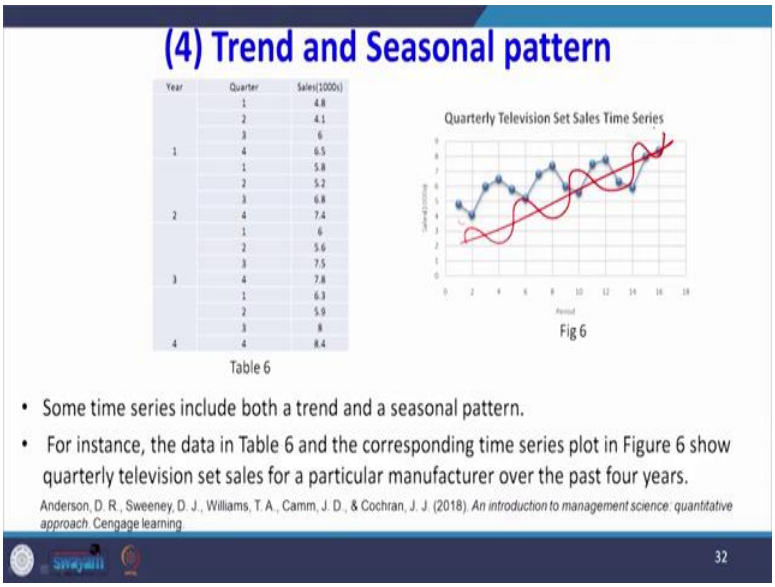
Table. 5 shows the time series, and Figure 5 shows the corresponding time series plot. You see that here there are 4 season, 1, 2, 3, 4 quarters. Then we can see there are sales figures, table 5 shows the time series, and Figure 5 shows the corresponding time series plot. The time series plot does not indicate a long-term trend in sales. In fact, unless you look carefully at the data, you might conclude that the data follows a horizontal pattern with random fluctuation.

You see that in quarters 1 and quarter 2, it is higher; in quarter 3, it is low; and in quarter 4, again, it is low. Then, in quarter 1, it is low, and in quarter 2, it is high, so there is a pattern.



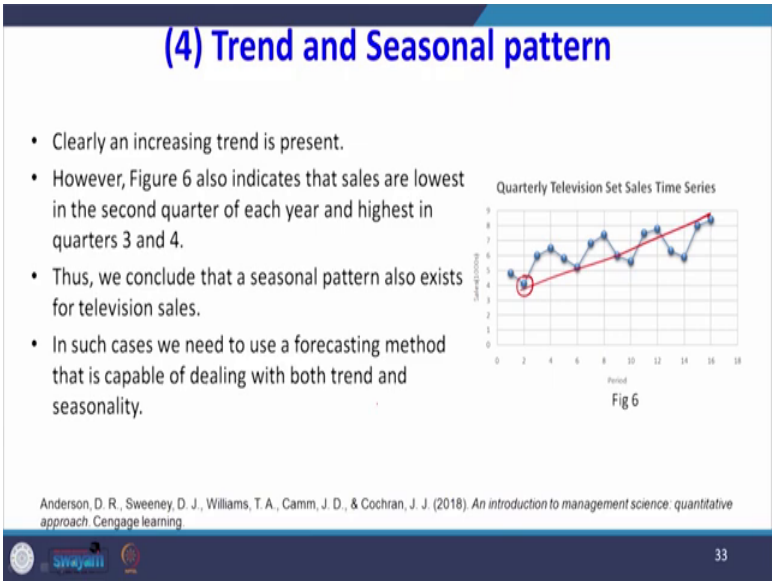
However, closer inspection of the fluctuation in the time series plot reveals a systematic pattern in the data that occurs within each year. That is the first and third quarters have moderate sales, this one. This is the first, second, third, and fourth see 1 and 3 have moderate sales. The second quarter has the highest sales see here it is the second highest. That is, the first and third quarters have moderate sales.

The second quarter has the highest sales, and in the 4th quarter tends to have the lowest sales volume. Thus, we would conclude that the quarterly seasonal pattern is present.

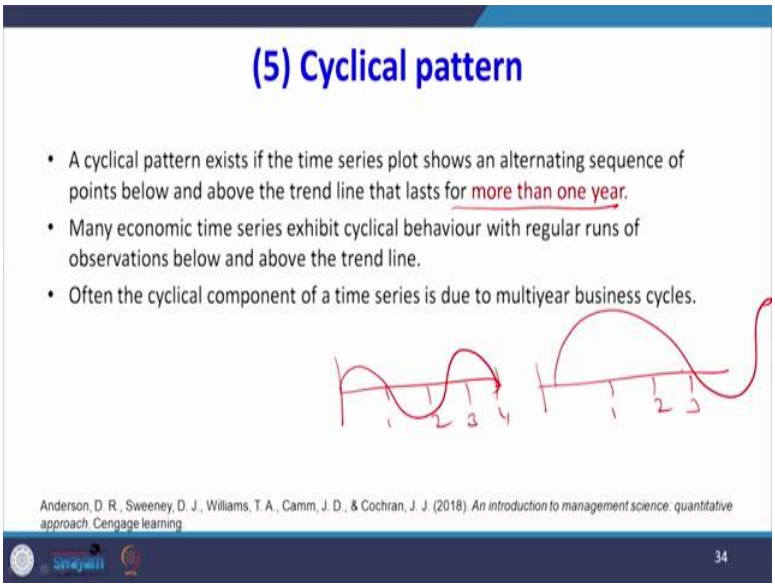


Now, we are going to see another type of pattern, that is trend and seasonal pattern. We have studied trends separately. We have studied seasonality separately. Now, there may be a data set that may have both patterns. Look at the data set and corresponding figure. Some time series include both trend and seasonal patterns. Why am I saying trend? You see that there is seasonality but there is an increase in trend. So, we can say it is this way.

So, the trend component is there, and the seasonal component is also there. For instance, the data in Table 6 and the corresponding time series plot and Figure 6 show quarterly television set sales for a particular manufacturer over the past 4 years.

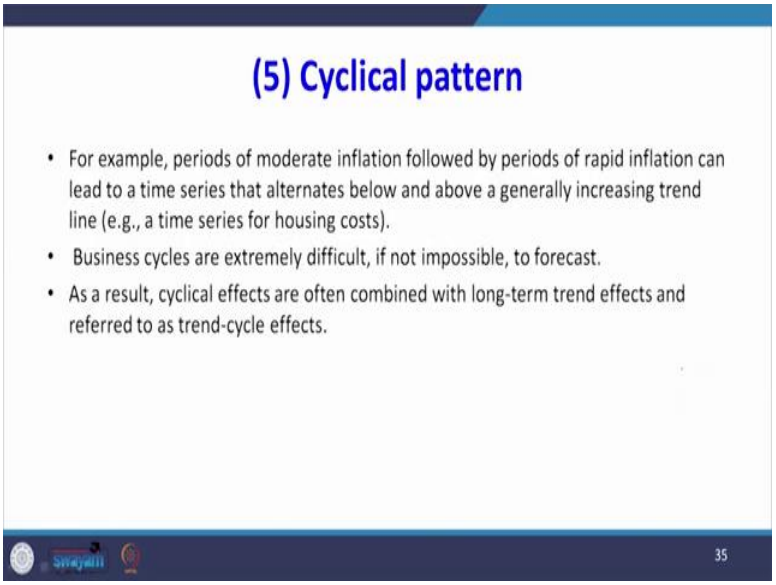


Clearly, an increasing trend is present. This one, however, figure 6, also indicates that sales are lowest in the second quarter, see that this is the lowest of each year and highest in quarters 3 and 4. Thus, we conclude that a seasonal pattern also exists for television sales. There is a trend at the same time, there is a seasonal pattern. In such cases, we need to use a forecasting method that is capable of dealing with both trend and seasonality.



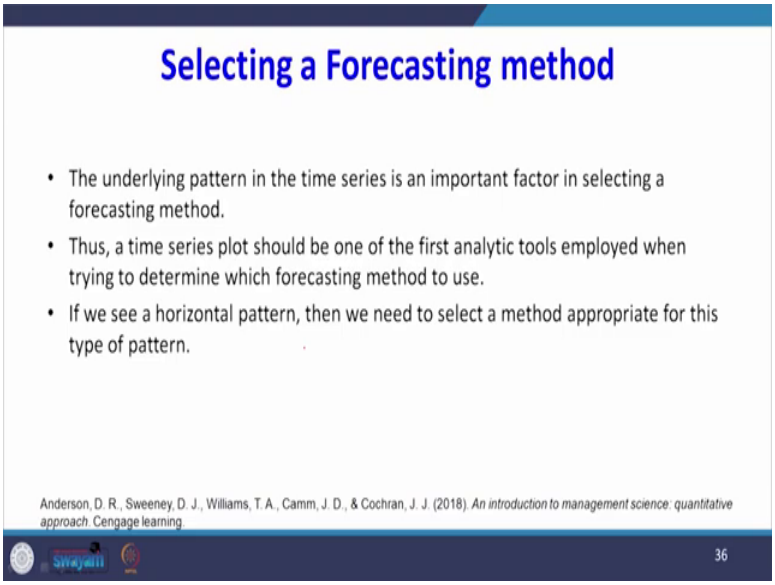
The next type of pattern is a cyclic pattern. A cyclic pattern exists if the time series plot shows an alternative sequence of points below and above the trend line that lasts for more than one year. You may ask what the difference is between a seasonal pattern and a cyclic pattern. In the seasonal pattern, the variation is within the year. For example, say this is quarter one, quarter 2, quarter 3, or quarter 4, so there may be seasonality like this.

But the cyclic pattern in the sense is year 1, year 2, and year 3. So, in some years, there may be a high, and after some years, it will be low, so that type of pattern is called the cyclic pattern. Many economic time series exhibit cyclic behavior with regular runs of observation below and above the trend line. Often the cyclic component of your time series is due to multilayer business styles.



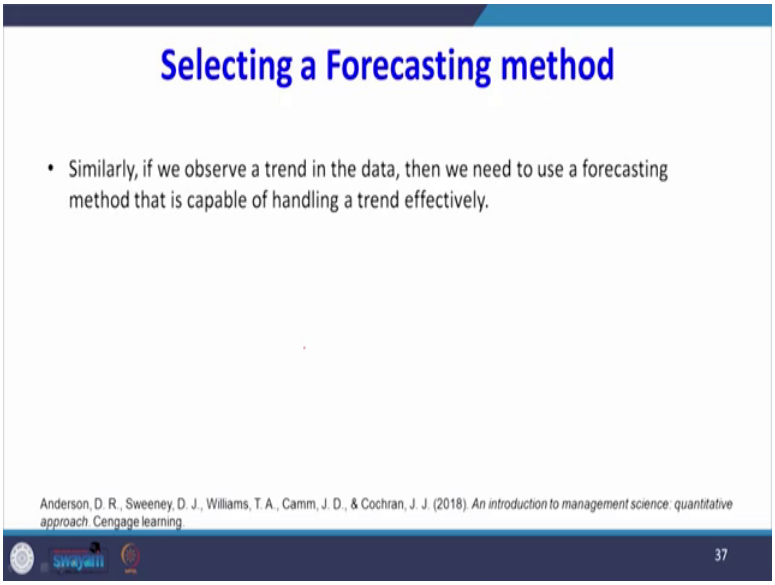
For example, periods of moderate inflation, followed by periods of rapid inflation, can lead to a time series that alternates below and above a generally increasing trend line. For example, the time series for housing costs may sometimes be higher for 2 or 3 years after some time. The housing and real estate costs may go down, so business cycles are extremely difficult, if not impossible, to forecast. Because it is, the duration is more than one year as a result.

The cyclic effects are often combined with the long-term trend effect and referred to as the trend cycle effect. Previously we have seen trend seasonal. So, similarly, we can have trends and cycles together.



Finally, selecting a forecasting method, we have seen 5 types of patterns. So, the underlying pattern in the time series is an important factor in selecting a forecasting method. The reason why we have studied this pattern is that? So, the type of pattern will guide us to choose appropriate forecasting techniques. Thus, a time series plot should be one of the first analytic tools employed when trying to determine which forecasting method to use.

If we use a horizontal pattern, then we need to select a method appropriate for this type of pattern.



Similarly, if we observe a trend in the data, then we need to use a forecasting method that is capable of handling trends effectively. Dear students, in this lecture, I have discussed time series forecasting. I have given an introduction to time series data, and then I have explained different types of patterns in time series data. The purpose of studying these different types of

patterns. In the time series data is to choose appropriate forecasting techniques. So, at the end I have explained how to choose appropriate forecasting techniques.