Economics, Management and Entrepreneurship
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Lecture – 04
Demand Forecasting

Welcome to the fourth lecture on the subject Economics Management and Entrepreneurship. If you recall in the last 3 lectures we were talking about economics in particular managerial economics and in which we started discussing about demand and supply of products and services and how in the market an equilibrium condition can exist and how equilibrium demand and equilibrium supply can be estimated.

In the last lecture we talked about demand elasticity, how demand changes with different factors and today we are going to discuss about demand forecasting. Demand forecasting is very important, particularly for an entrepreneur. To start with let me clarify that demand is not same as sales. Sales of an enterprise is the amount that is delivered to the customers and the amount of money realized from the customers that is the sales.

Whereas demand is the potential demand for the product in the market, therefore demand is always greater than or in the limit equal to sales. Estimating demand is what is forecasting. Forecasting is basically estimating the future value of the potential demand of your product or service that an enterprise offers. Anything that is to be estimated for the future is difficult. In particular, if there are large number of factors, that influence the value of the potential demand. Therefore, it is not surprising that there are a very large number of methods that have been provided in the literature.

And being practiced by the enterprises, throughout the world in making estimates of demand. Now, before I proceed further, let me say that demand is always difficult to estimate, because it is very uncertain and because there are large number of factors as I said, but whatever may be the accuracy of the demand, a decision has to be taken because it will be useful in many ways for many purposes. So in today's lecture we shall basically study different types of methods that are used popularly in academics and in practice and also say how they are useful in decision making.

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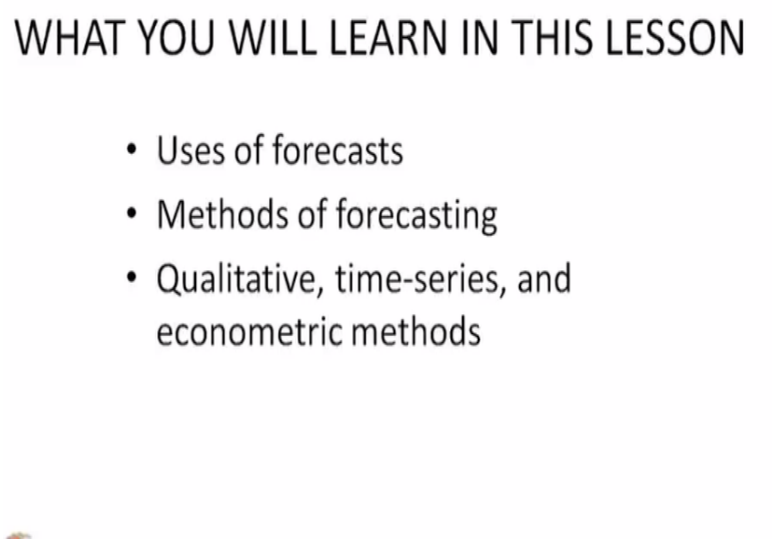

So, in this lecture, we shall first of all focus on uses of forecasts, methods of forecasting, and in particular, we shall discuss and highlight certain aspects of qualitative, time series, and econometric methods.

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First, need for demand forecasting or uses of demand forecasting. First thing for an entrepreneur particularly the one who is starting an enterprise newly capacity planning is very important and for that a long term projection of the demand is important and based on that, the capacity of the company can be planned. Once capacity is planned, the actual production plan will depend on the circum forecast.

Also, how much to inventory to hold so that no sale is lost, no demand is lost, forecast of demand is quite important. Once the production is planned, we would like to also purchase the input materials and services to actually produce those goods so that we will also depend on the forecast made. How many sales force to actually deploy so that we can sell the amount that we produce is actually planning distribution network to which market.

And by which means, by deploying how many sales persons, we will be able to sale our products will also depend on the demand forecast that is made right in the beginning. Management of working capital to deploy resources input material, the machines, the power that is required all that requires money and their working capital. Once we know or we can make an estimate of the demand, we can similarly make an estimate of the need for working capital to be able to be sustain in the business.

And finally if we know that our demand is so much accordingly we can also decide on the prices that we shall charge for our product. Now these are only a few areas, which we mention has the uses of forecasting. Basically, a forecast is an information for decision making and decision making for capacity planning, for production planning, for inventory building, for distribution etc. All these decision making requires an important input of forecasting. Therefore, forecast is important.

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Now there are different methods of demand forecasting. We would like to categorize them in 3 groups: Qualitative analysis and quantitative analysis. Quantitative analysis can be further divided, subdivided as time series analysis and econometric models. Now, there can be different ways in which the forecasts can be divided or grouped. This is one way in which I have grouped the demand forecasting methods.

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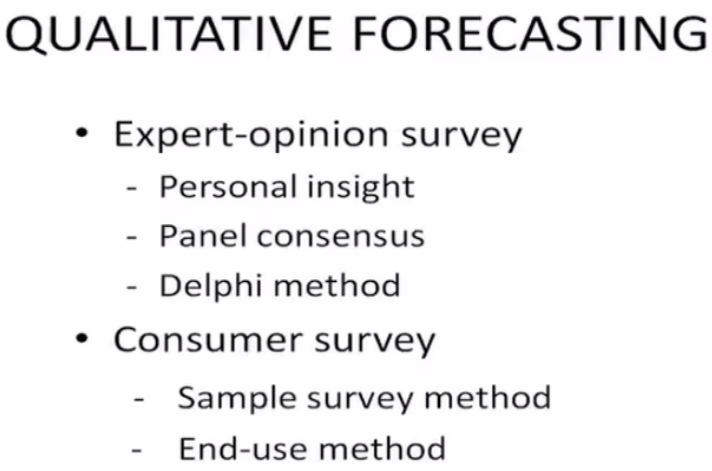

First, let us talk about qualitative forecasting. In qualitative forecasting, normally we do not deal with numbers. Quantitative forecasting uses numbers. Qualitative forecasting on the other hand does not rely so much on or does not use numbers. We divide qualitative forecasting methods into groups: Expert-opinion survey and consumer survey. Expert opinion survey can be further

subdivided into 3 individual items: Personal insights, panel consensus, and Delphi method, and the consumer survey method can be divided as sample survey method and end-use method.

Now let us study these 2 each one of these in more detail.

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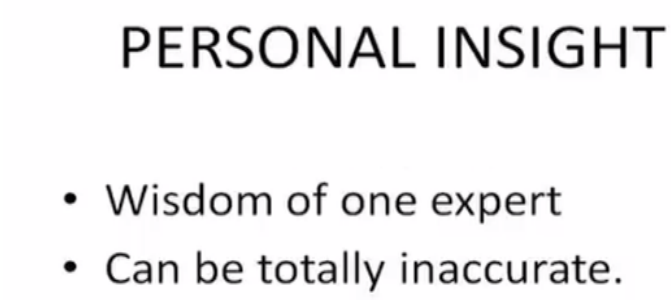

To start with we talk about the personal insight. Basically, it depends on an individual an expert who is extremely wise, highly experienced, he has lot of ideas, and the person can make a judicious estimate of the demand for the product in the market. So, naturally is very, very difficult to get hold of such a wise, knowledgeable, insightful, and experienced person to be able to make a good estimate of demand. He can be totally incorrect or he can be totally correct. It is very difficult to say to what extent the experts estimate is going to be accurate.

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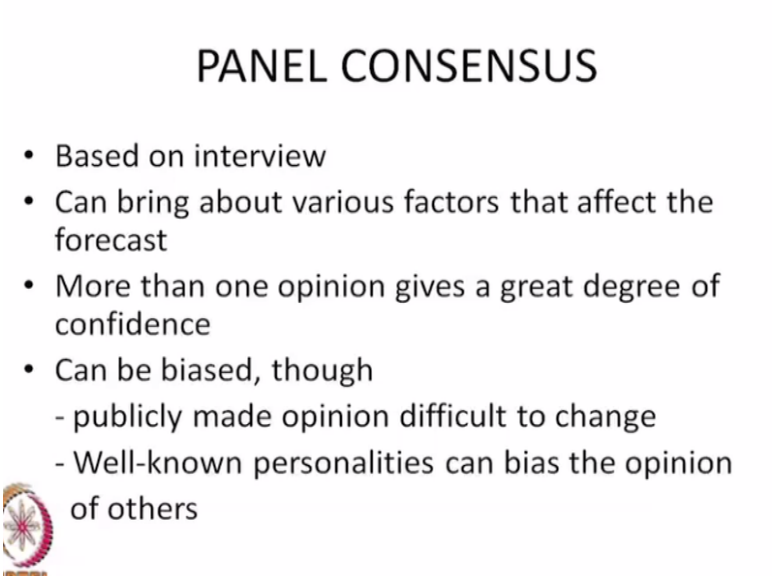

Therefore, in normal practice is to get a panel of experts, a group of experts and try to have an interaction among the panel experts, so that a consensus among them emerges. At that consensus would probably possibly would be more accurate than an individual expert's opinion. Now, there are different ways by which the panel of expert's ideas can be obtained and an interaction among them can be conducted. One is based on interview.

Now if it is a personal interview, then naturally no interaction is possible. Personal interview could be face-to-face interview or it could be even a telephonic interview. Now in such cases, because there are more than 1 expert, it is expected that different factors that one might overlook will surface and the effect of those factors on the estimates of the demand can actually be understood, estimated, and projected.

Therefore, it is expected that there is a greater degree of confidence that we can have on the estimate made by this panel of experts. Now, sometimes the panels are brought to a meeting, where its expert's opinion is collected. Now, the panel therefore, face each other and interact among themselves face to face. In such a case, also a consensus can come, but it can lead to a lot of difficulty. Particularly, if there is a senior person who publically makes his or her opinion then it is difficult for him or her to retrace it or to change it.

Similarly, if a powerful personality holding a senior position makes a statement is not impossible that the juniors will keep quite although they do not really a quiet agree with the statements or opinion made by the senior member. Like this, there are quite a lot of difficulties if meetings of experts take place and through a meeting the estimates are made. Because of these difficulties there are various other methods and in particular.

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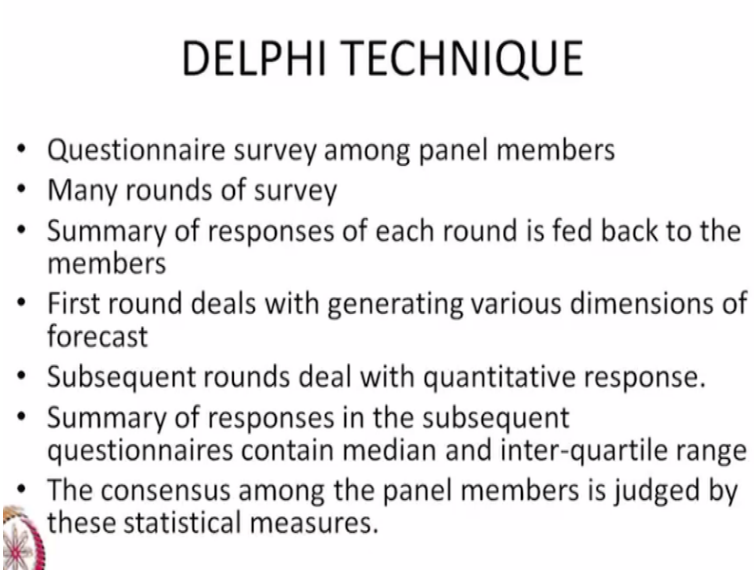

A method that has emerged in the last few years 2 to 3 decades in the Delphi technique. Delphi technique is basically a series of questionnaire surveys among panel members not 1 questionnaire survey, but a series of questionnaire surveys among the selected panel experts and the responses obtained in every round from the experts are summarized and the summary response is sent back to each individual member of the panel.

So that he or she can actually change his or her opinion on the basis of the group opinion that is available with him or her in the form of summary response of the previous round. Normally, in the second round or in the third round we have quantitative responses and in that case, what normally Delphi technique does is to find out the median of the responses and the inter-quartile range.

So median like mean is a measure of the central tendency and inter-quartile range is like standard deviation. So when a summary response is fed back to the members of the panel, the group

response is made available to each one of them in the form of the median value and the inter-quartile range value of the group responses and finally the reduction in the inter-quartile range as the number of rounds progresses is a measure of the extent to which consensus among the members of the panel takes place.

This in short is the Delphi technique. It has the advantage that a senior member of a panel cannot influence or buy as the opinion of a junior member. Yet they can have interaction. They have a chance to change their opinion, because of the multiple rounds of questionnaire survey anonymity is maintained. Nobody knows who the other members are therefore the estimates are unlikely to be biased.

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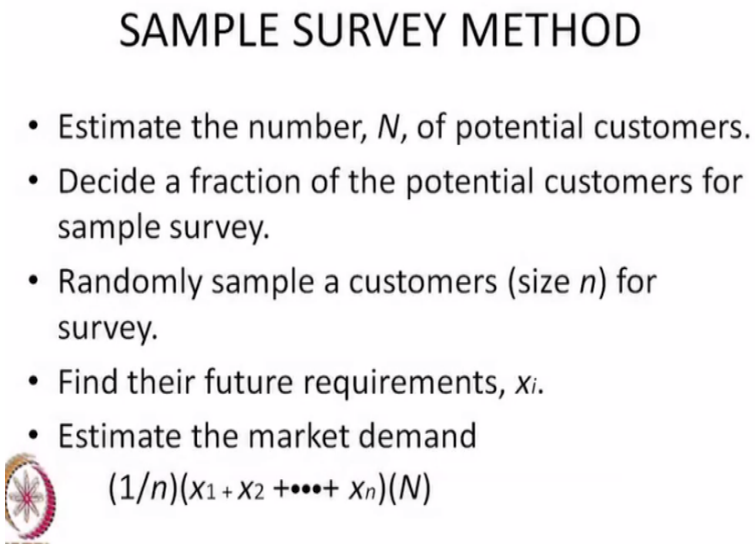

And now we take the case of the sample survey method. This is a very popular method used by enterprises to make forecast of demand. Here what is done is the number of potential customers is first estimated. Let the number be N. Then, randomly a sample of such potential customers is selected and let the size of these samples be n and then through a method of interview or a questionnaire survey their individual requirements is obtained to the survey method by meeting each one of them, by talking to each one of them.

Either through telephonic interview, or by sending questionnaire survey, or making face-to-face contacts. Then if there are n numbers of such customers with whom contacts could be made and

their individual requirements could be obtained, then the average requirement is x1 + x2 etc + xn/n. This is the average individual requirement that multiplied by the total number of estimated potential customers N is taken as the market demand. This is a very simple method, but this is a very powerful method, because it directly asks the potential customers to talk about their individual requirements.

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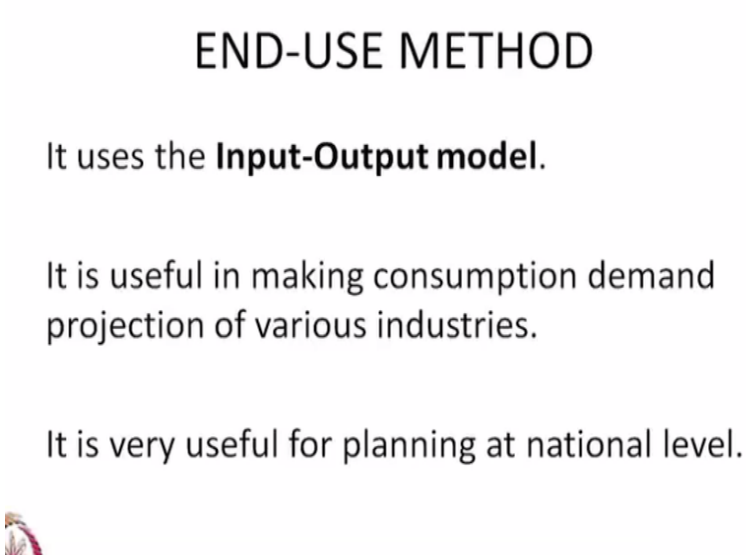

Now we go to the End-use method. Here, we include particularly the celebrated input-output model of Leontief. It is useful in making consumption demand projection of various industries at a national level and this is very useful for planning at the national level. So, at the enterprise level, it is not so much used, but at the national level, the input-output model is quite useful.

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INPUT-OUTPUT MODEL

Define

X_i: Output of industry i
X_{ic}: Consumption demand of industry i
X_{im}: Imports by industry i
X_{ie}: Exports by industry I
X_{if}: Final consumption demand of industry i
a_{ij}: Fraction of output of industry j consumed in industry i

Hence,

$X_{if} = X_{ic} + X_{im} - X_{ie}$

We will just have 2 or 3 slides on what this input-output model is. Let us first of all define Xi as the output of industry i, Xic as the consumption demand of industry i. Xim as the amount of goods imported by industry i, Xie as the amount of exports made by industry i, Xif as the final consumption demand of industry I and aij is the fraction of output of industry j consumed by industry i. Now from the above particularly these 4 things Xif the final consumption demand of industry I = its own consumption + imports - exports. This is the relationship therefore. Xif = Xic + Xim - Xie.

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$$X_1 = a_{11}X_1 + a_{12}X_2 + \bullet\bullet\bullet + a_{1n}X_{1n} + X_{1f}$$
$$X_2 = a_{21}X_1 + a_{22}X_2 + \bullet\bullet\bullet + a_{2n}X_{1n} + X_{2f}$$
$$\bullet\bullet\bullet$$
$$X_n = a_{n1}X_1 + a_{n2}X_2 + \bullet\bullet\bullet + a_{nn}X_{nn} + X_{nf}$$

It can be shown that

$$X_f = (I - A)^{-1} X$$

where

X_f : The vector of final consumption demand plus exports net of imports of various goods
I : The identity matrix
A : The matrix of input-output coefficients

Let us understand here we are trying to say the consumption demand of industry 1 is its own consumption, final consumption + the amount of goods produced in different industries, a

fraction of (()) (23:31) consumes for example steel industry consumes some coal, some iron ore, and things of that type. So each one of them is an industry exclude probably the coal industry iron ore X this industry, so a fraction of different industries is consumed by steel industry and similarly coal industry consume something from other industries so these are input output coefficients. a's are input output coefficients.

So we have if there are n number of industries we have n number of this equations and x1 contains a11X1 and therefore it we take it this side, it becomes 1 - a11 * X1 = this. So, therefore it can be shown that the final consumption demand vector, Xf is I - a inverse * x. X is this vector. Xf is the vector of final consumption demand + exports net of imports of various goods. I is the identity matrix containing once it is diagonal 0 elsewhere. A is the matrix of input-output coefficients a11, a12, an1, an2, ann. Now this model was used in many countries including there for a very large number of years.

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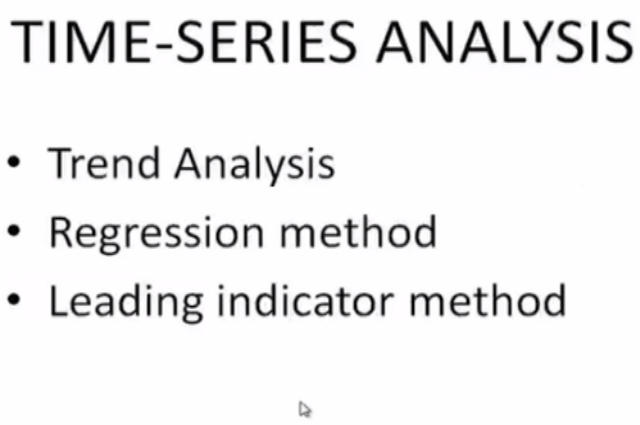

Now we talk about time-series analysis. Time-series analysis we can broadly group them under 3 headings: Trend analysis, regression method, and leading indicator method. Let us look at them one by one.

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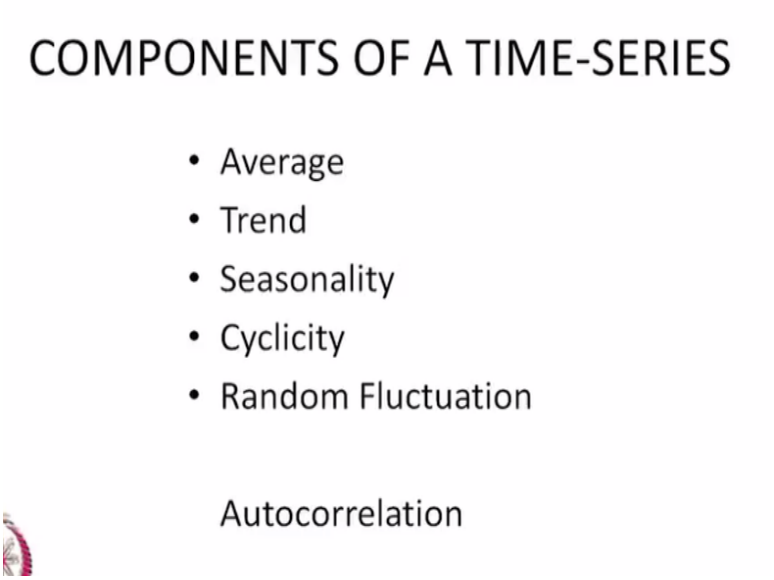

What we mean by a time series basically. When we consider a time series basically, we talk about only 1 variable, let us x.

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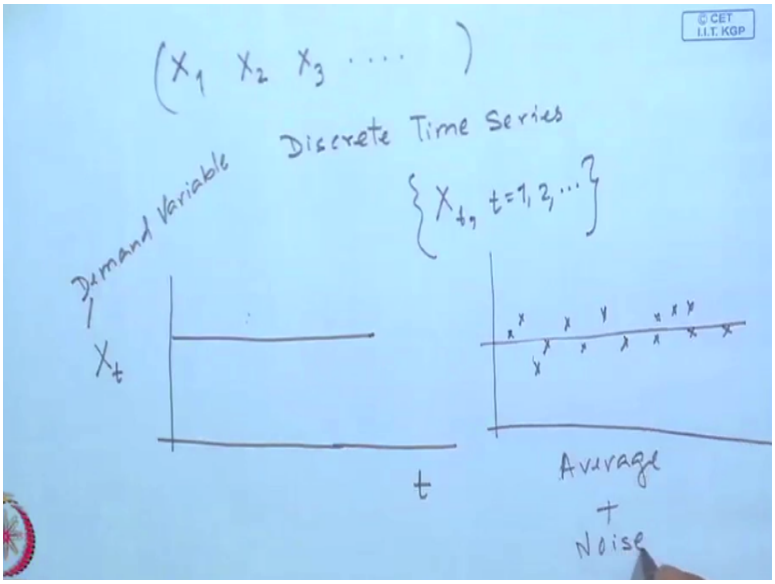

X1 at time 1, X2 at time 2, X3 at time 3, etc. So this is called a discrete time series, where our time T = 1 value of x is x1, at time T = 2 the value of x is x2 and so on so forth. This is called a discrete time series. Normally, it is written as Xt t equals 1, 2. Now it is time series can have different components. It will have a component analysis, a trend, a seasonality, a cyclicity, and random fluctuations. We can write it in this manner.

We can show it in this manner in a graphical form. So that this is time t and this is Xt. X versus t can take different steps. Suppose, it is exactly constant it is same at all times t, then we will say that this is the average value or a constant value, but this hardly happens. X is something like the demand variable whose forecast we will like to make and it is unlikely that it is constant at least we shall expect that there will be certain random fluctuations around this constant value.

So we might expect values such as this. So which means that there is an average value and there is a random fluctuation or an error term. So this is what I am trying to say that this is a case where there is an average, but this is a case where there is an average plus a noise. Let us take another case.

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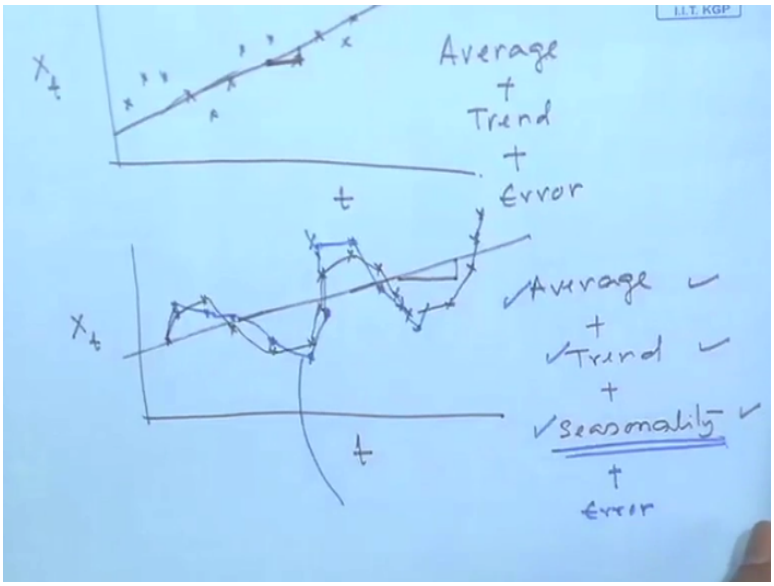

Now here is a case of Xt varying with t and we can say that it has an average. The average at the trend and there is a random fluctuation around it. So this is average plus there is a linear trend in this case, plus error, random fluctuation or an error around it. So there are 3 components of a time series present in Xt. Take up another case, where t, Xt shows now if you look at this, it has an average as a trend and it is associated with a seasonality, a perfect seasonality.

So this has an average + trend + seasonality. Seasonal products like fans, air conditioners. We will so average trend and seasonality, but it is unlikely that there is no random error present. So we might in fact come across cases where it is something like this. Now this blue colour

variation says that it has all the components of average, trend, seasonality, and also it has an error term. So this is the fourth component of a time series that we have shown here. Another component of the time series is cyclicity.

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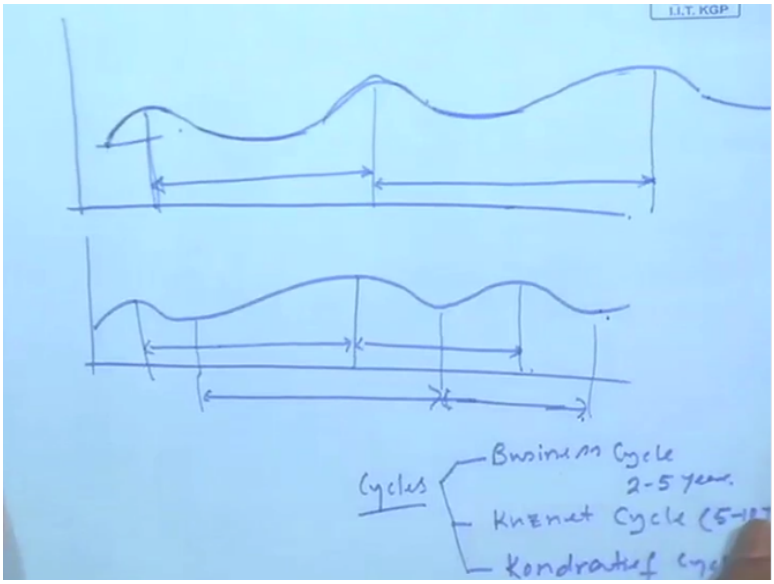

We have had business cycles where the demand shows not regular fluctuations, irregular fluctuations of different periodicity. So where we say that there is a rise in the value and there is a fall here and a fall here and fall here and a rise here. Now this periodicity may not be same unlike the case of seasonality where the periodicity exactly equal in this case it may not be equal. Another cycle could be of this nature.

So here you will see that differs. The values are different. The troughs are also different. So this is the case of cycles. We call business cycle 2 to 5 year and there are different other cycles such as Kuznet cycle, Kondratieff f cycle. Kuznet cycle periodicity is between 5 to 10 years, Kondratieff cycles are called long waves between 50 to 100 years. Basically, we are trying to say that if we are concentrating on a particular variable whose value in the future.

We would like to estimate then we can make an analysis of the past values of that particular variable x, that x in our case is demand and we can make an analysis of the time series data of the value of x. It has got 5 components average, trend, seasonality, cyclicity, and random

fluctuation as I have just told you and autocorrelation since we are dealing with only 1 variable Xt.

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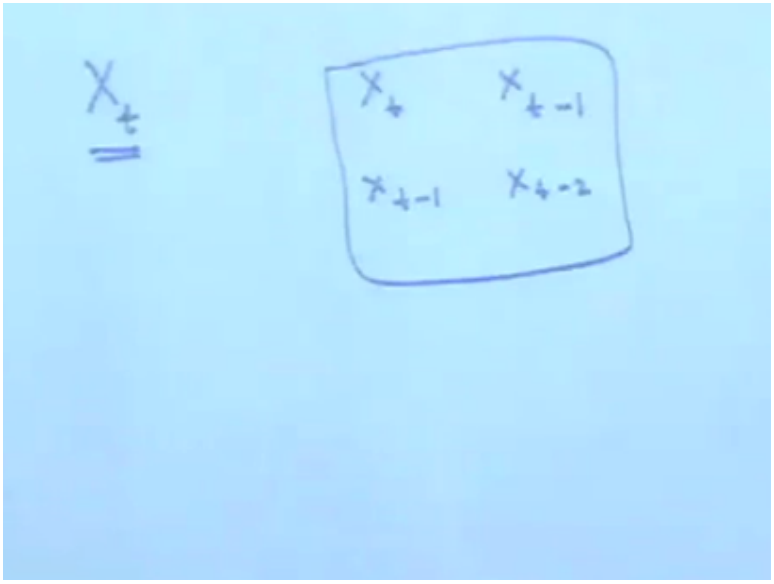

We can find how Xt is related to its lagged variable Xt - 1 or Xt - 1 is related with Xt - 2 etc. This is called autocorrelation and with the help of autocorrelation studies we can find out whether trend is present, seasonality is present, therefore autocorrelation holds a very important place in the time series analysis, but unfortunately we do not have time to discuss and go into the details, but I will give you some idea about what I am trying to say here.

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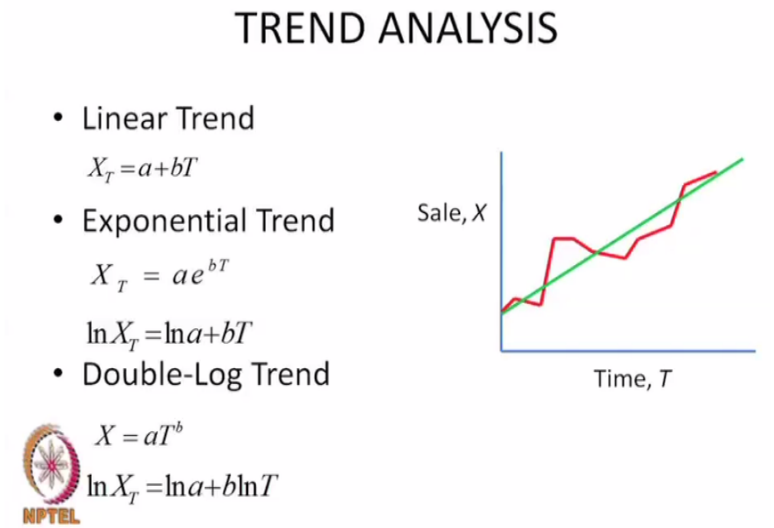

Trend analysis is a first thing that I am showing. Here I am trying to say that this diagram, this is the average value and that has a trend, but the actual data and has had no fluctuations. So suppose we are assuming a linear trend, then the equation of Xt is nothing by a + bT + there is a random fluctuation, but at least we are able to find out an estimate of the average value at any time T so given the pass data, we can basically make a projection of the pass data, but assuming a linear fit to the pass data.

The linear fit is given by the equation Xt = a + bt. So given a time T, we can find out the value of Xt and normally we use the least square estimates meaning that we actually take the data. This error at different time points we find out and we find out the intercept value of this a and b, trend. We estimate on the basis of a criterion of minimizing the square of the error. Now there can be different types of trend analysis.

Suppose we assume exponential trend that means we take Xt = a * e to the power bT we can make a log transformation. We can say ln Xt equals ln a + bT. Now this then becomes linear in the parameter just as it is in the case of liner trend. We can even assume a double-log or a log-log relationship between x and T in this manner, suppose that x = a * T to the power b taking ln, we get ln X = ln a + b of ln T. This once again is linear in parameter.

So by making suitable transformations we can convert a nonlinear relationship as this or this into a linear relationship in parameter and thereby we can use the simple regression techniques to find out the values of a and b and therefore to find a relationship between x T and T which is what can be done.

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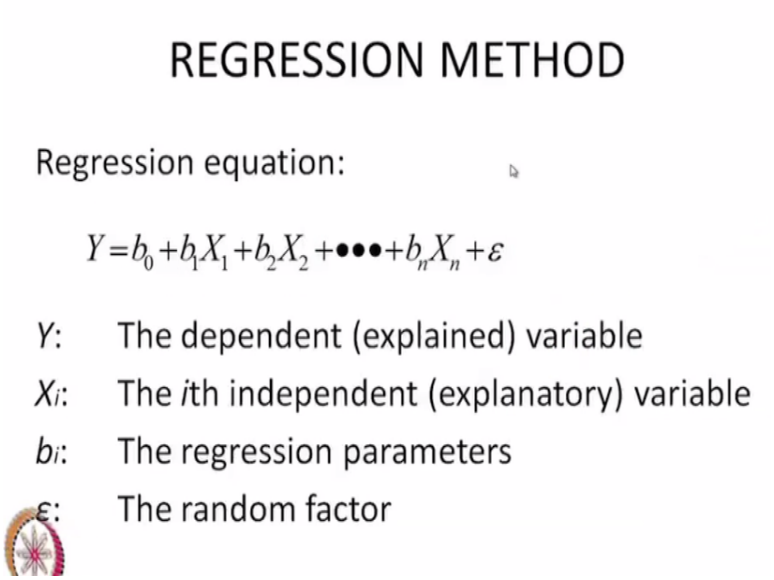

Now we not only use time, not just use time as the independent variable, but we take different other variables as the independent or explanatory such as X1, X2, and Xn. Suppose that we are assuming that there are different other variables such as X1, X2, and Xn that determine the value of y and then we call this a multiple regression equation. This is that error term about which I was talking.

And we will like to find out the estimates of the values of the parameters b0, b1, b2, and bn to be able to find out y. Once again we tried to minimize the least square error, minimize the square error and xi is the ith independent variable. We are not discussing here the methods of regression analysis, but we just trying to tell you the methods that are normally used.

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ARMA METHODS

AR(*k*):

$$Y_t = a + b_1 Y_{t-1} + b_2 Y_{t-2} + \bullet\bullet\bullet + b_k Y_{t-k} + e_t$$

MA(*l*):

$$Y_t = a + b_1 e_{t-1} + b_2 e_{t-2} + \bullet\bullet\bullet + b_k e_{t-l} + e_t$$

ARMA (*k*, *l*):

$$Y_t = b_1 Y_{t-1} + b_2 Y_{t-2} + \bullet\bullet\bullet + b_k Y_{t-k} + a + e_t + b_1 e_{t-1} + b_2 e_{t-2} + \bullet\bullet\bullet + b_l e_{t-l}$$

Next, we just expose to you certain advance topics in time series analysis we call them autoregressive moving average methods, autoregressive, AR standing for autoregressive, MA standing moving average method. We are talking about time series analysis. So let us say that y is the time series data Y and this is 1 period lagged value Y t - 1, e period lagged value Y t - 2, k period lag value is Y t - k and this is the error term. Now if Yt is related to its past value in this manner then it is called AR of the order k, autoregressive model of k.

Moving average model of order l on the other hand is related to et in this manner a + b1 et - 1 + b2 et - 2, bk et - l + et is called the moving average model of order l sometimes both are joined to give ARMA model of order k and l. k for autoregressive part of ARMA model, l for the moving average part of the ARMA model. So Yt = taking from here b1 Y t - 1 + b2 Yt - 2 etc bk Yt - k + a + et+ extra fit which is b1 et - 1 etc. Now this looks quite complicated in actual practice one can just have k = 1 and l = 1 in which case if this becomes much simpler.

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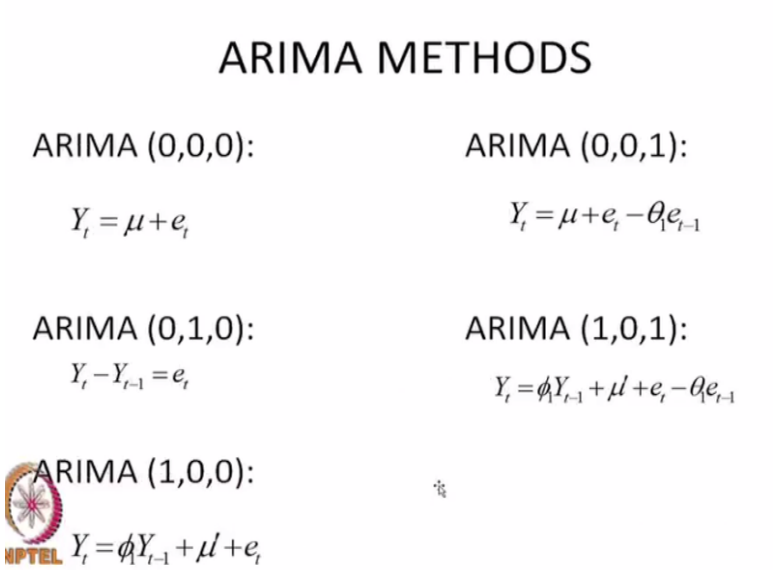

Now sometimes say for example here what we have done, we are showing here that the difference of 2 individual adjacent time series data is stationary. So Yt - Yt - 1 is et. So we take a difference the value and work with the difference value. This is called ARIMA. I standing for integrated. Autoregressive integrated moving average methods. So when we difference. We difference to make nonstationary data stationary.

Now here let us say this is same as an AR model. An average value error term and this is a Y related with Y t - 1. This is a case of a MA1, you can see this is a constant. This error term and this is the moving average term. Here both AR and MA are present without differencing. so this is a case of ARIMA 1, 1 which is this part is autoregressive this part is moving average and this is constant and this is error term.

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LEADING INDICATOR METHOD (BAROMETRIC METHOD)

X is the leading indicator or the barometer for *Y*

$$Y_t = a + bX_{t-k}$$

Next we talk about the leading indicator method. Basically leading indicator method is like saying that find out if Y is the demand which we would like to estimate for a product find out some other indicator for Y, for example if cars sale more in the market then wheels with change more therefore if you are interested to project the demand of wheels you see how Y is changing. If Y is rising, it is expected that X will rise, but not exactly in the same phase with a phase difference that is why we say the demand of Y is a + b Xt - k. So this is also called a barometer because x is acting like a barometer for Y.

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ECONOMOTRICS METHOD

- Single regression equation
- Simultaneous-equation model

$$C_t = a + bY_t + u_t$$
$$Y_t = C_t + Z_t$$

where

Zt: Non-consumption expenditure (govt spending) at period *t*
Ct: Consumption expenditure at period *t*
Yt: Income (GNP) at period *t*
ut: Error term at period *t*

We now come to econometrics method. basically econometrics methods can be single regression equation such as the one that we have already discussed or it can be simultaneous equations such

as the 2 equations that I have written you will see here that Ct the consumption expenditure at period t is a function of Yt, the income, but Yt in term is also related to Ct therefore it contains 2 equations and there is a circular polarity between Y and C as you will see here. Now econometrics itself is a very important and difficult topic to discuss. This is just to expose to you the fact that forecast models can be quite complex.

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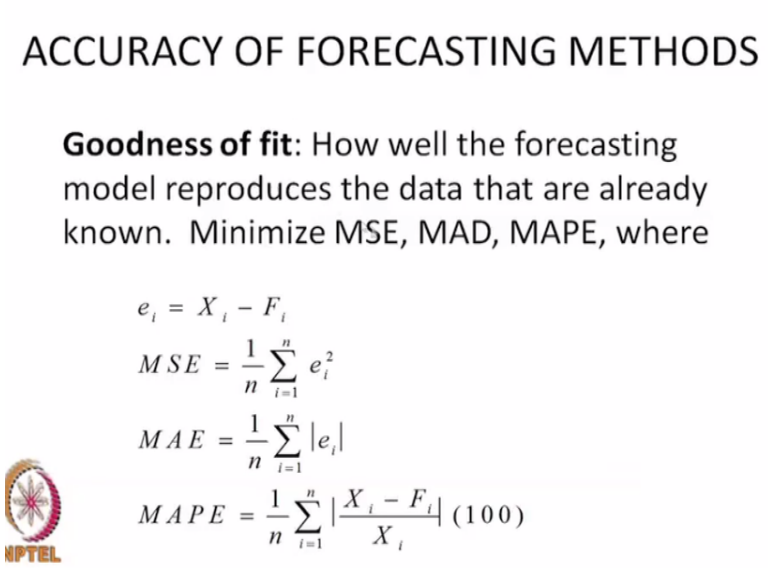

Now here we are trying to say that there are different forecasting methods and that normally we use to find out which forecasting method is the best we use different criteria. To use different criteria, we first of all find out the forecast error ei this is called forecast error. Suppose that the value available with us for the variable x at time I is Xi and using the method we can find out we can estimate or we can see that the forecast value of x at time I is Fi.

Then the difference between the 2 is taken as the forecast error and the criteria that we can use can be many, I have just listed 3 of them. This is mean square error which is all the squares over n terms average value dividing by n mean square error. It can be mean absolute error, absolute values at this and the average is this. It can also be mean absolute percentage error. Percentage error is basically Xi - Fi/Xi * 100.

Absolute value is taken here and average so one can use any one of these 3. There are many other methods also and one can use them to find out which forecasting method should be use.

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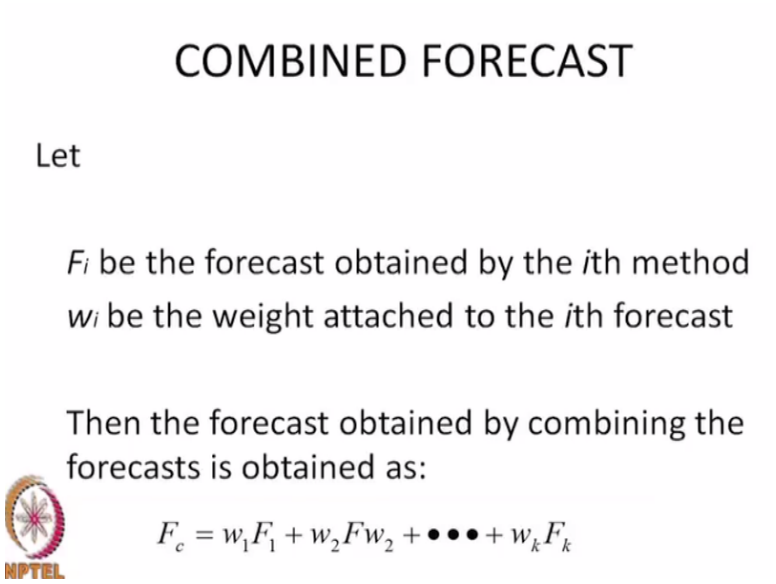

Finally, we come to the case of some many forecasting methods are available, which forecasting method to use? Now this is a difficult task. There are once again many ways by which the different forecasts can be used to have the best possible forecast. What is suggested here is that one can make forecasts using different forecasting methods. Let us say that there are cases forecasting methods and each one of them yields different forecasts for the same time period.

Let us say that the forecasts are F1, F2, F2, etc up to Fk. What is suggested is there you give certain weightages, weightages W1, W2 etc Wk indicating the importance and the confidence you are associating or attaching to each individual forecast. Then sum the (()) (50:41) average that is W1 * F1 + W2 * F2 there is a mistake here it should be F2 and + Wk Fk all that should be added.

These words should sum up to 1 if that happens, this forecast is taken as the best forecast. Now friends, as you must have seen I have (()) (51:13) over the topic of forecasting is quite involving. it can be highly mathematical, but the fact remains that one never knows unless the actual time in the future happens one does not know whether your demand is accurate or correct. In the absence of such future information, the only way there are 2 ways I would say 1 to use the expert analyze or to use the pass data.

If you use expert analyze one should use a panel of experts, find out what they have to say about the future demand and other consensus. If on another hand you are using pass data, there is a large number of mathematical methods, regression methods, econometric methods, time-series methods, they can always give some estimates, but finally you can always give them certain weights and take a (()) (52:34) average value of the forecast of the demand. Thank you very much.