Project and Production Management
Prof. Arun Kanda
Department of Mechanical Engineering
Indian Institute of Technology, Delhi

Lecture - 34
Forecasting

Today we are going to talk about some of the tactical and operational decisions which are relevant in production management. You will recall that till now our focus has been on strategic decision strategic decisions like choice of a product. Choice of a prose's, designing of the layout, fixing of the location of a plant all these decisions are essentially strategic decisions which are generally taken only once in the life time of a particular production system. But for a system to operate a large number of operational levels, decisions are required. Decisions regarding production planning, decisions regarding scheduling, decisions regarding materials planning, decisions regarding inventory and in fact all these decisions require that you have an estimate of the forecast of demand. We are going to be talking in today's lecture about forecasting and various methods of forecasting. We must remember that forecasting as far as we are concerned in production management is essential for a number of planning decisions.

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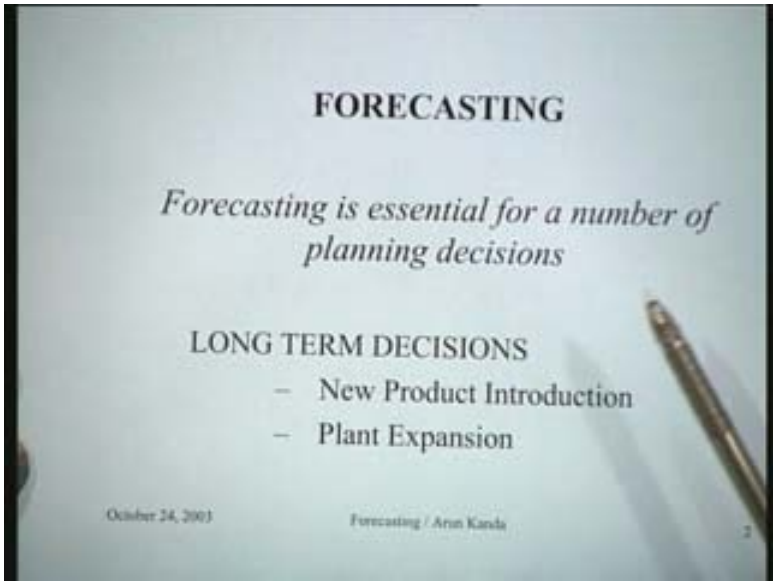

Forecast is essentially used not nearly for this purpose of making a forecast but for finding out taking more effective planning decisions. Here are some examples of planning decisions in which forecast play an important role. We can talk about long term decisions and in long term decisions like new product introduction or decisions like expansion of a plant. These decisions required that you know what the demand for the product is going to be in the long run, so that you can decide upon the kind of production capacities and which product to introduce with these kinds of decisions. We then may

talk about medium term decisions. By medium term decisions we need those decisions which have a planning arisen of let us say 6 months to 1 year or 2 years from now. So the category of decision which are more important in this category are aggregate production planning.

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Aggregate production planning decisions are basically decisions which tell how much you should be producing in each month to meet a fluctuating demand because demands often keep fluctuating whereas the production capacity is more or less constant. Of course you can have variations in production by varying the level that you operate on what should be the optimum level that you should operate upon for the next one year or so is basically an aggregate production planning decisions. Then you have decisions pertaining to man power planning. What should be the quantity of man power that you should recruit and how you should go about deploying this man power are again very vital decisions in the context of medium term decisions. Determining the inventory policy, how much should you stock? How much you should order and what should be the maximum permitted level of inventory? These kinds of decisions are again decisions govern to a very large extent upon the extent of the demand forecast for individual items. Besides this we have short term decisions in the context of a manufacturing plant where we are talking about decisions like production planning. How much to produce? There are 20 jobs to be done today in a particular job shop. What is the sequence in which the jobs should be done? Which job should be done, which should be left out or postponed for tomorrow. These kinds of decisions are production planning decisions, which are essentially concerned with deployment of resources for the various products. Scheduling of job orders, you might have number of job orders waiting to be processed. What sequence should they be processed on various machines and the equipment. What kind of priority dispatching rule to use, whether you use first in first out or whether you use SPT or LPT or you use any other processing rule that is in fact the part of this. This also governed to a very large extent upon the demand for various products.

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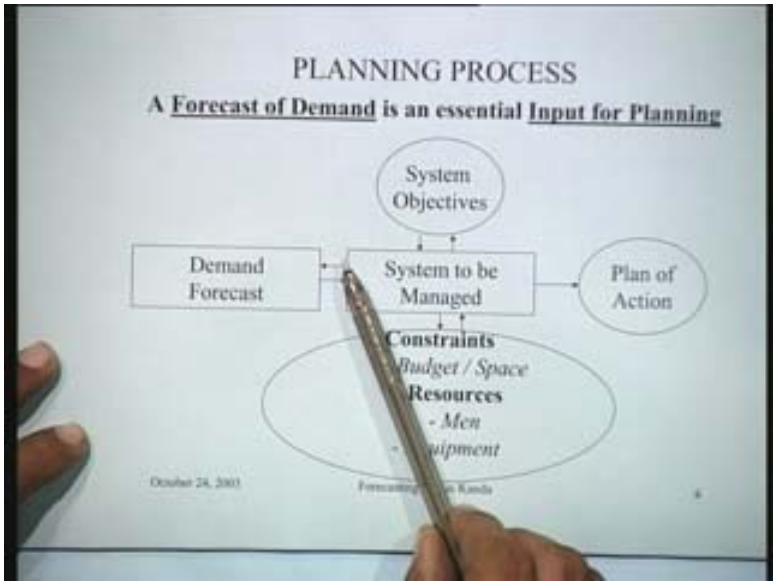

Let us quickly look at the planning process in general. You will notice that the forecast of demand is an essential input for planning for instance, what is that you want, suppose you are the manager in charge for a certain system, some system to be managed. This system has some objectives, so you know that the system objectives will guide your decisions and then of course you operate under a set of constraints. The constraints could be the space available with you. Then you also operate with certain level of resources which could be the men and equipment that you have at your disposes. The constraint and resources have to be kept in mind. The system objectives have to be kept in mind and of course the demand forecast is a very important input which will tell you the level of operation that you should actually indulge in different periods. So keeping these three major inputs in mind you come to a plan of action and the point therefore is that the demand forecast is one of the very essential inputs for planning. That is why demand forecasting is so important for business. Let us try to look at some of the methods of forecasting. We can club these methods into 5 different groups. The first group is the class of methods which we can call subjective or intuitive methods.

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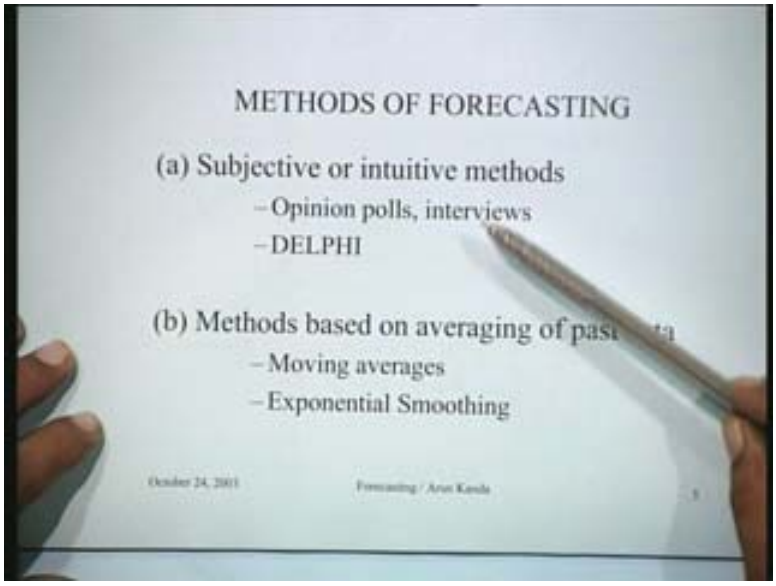

The categories of these methods are opinion polls interviews and DELPHI. The basic idea is that information is gathered from a set of people/ a set of experts on what the demand forecast is likely to be and this could be done through either opinion poll or a personal interview or DELPHI procedure. We will talk about these little later in some detail. But what is the basic advantage of these methods? The basic advantage of subjective or intuitive methods is that that you are relying upon the vast knowledge base and experience of individuals. A person who is knowledgeable can tell you what is likely to happen as for as the demand is concerned and so on. For instance if you are interested in share price fluctuations, if you probably talk to an influential or a person who is inexpert in the area, he would tell you that certain stocks are likely to pickup, certain other stocks are not likely to pickup and he would have his own reasons for doing this. Basically that is the major advantage of subjective or intuitive methods. You are banking upon the huge knowledge base of the individual. Of course there is a disadvantage too and the disadvantage is the subjective bias which comes in if you relies upon this particular forecasts. Then we talk about methods based on averaging of past data.

If you have data available on demand for the past few years, you can use these methods then the 2 most commonly used methods in this category are moving averages and exponential smoothing. They are both weighted averaging methods and we can use this method to determine what is going to happen to the demand if the previous history is, what it is. The third category of models that we have for forecasting are basically regression models on historical data. If you have access to information of demand for the last 5 years plotted as a graph, then you can do some trend extrapolation and based on this trend extrapolation you can project what is going to be the forecast for the next year or the year after that based on the trend that exist in the historical data. This is a very common method of forecasting and it is useful because you are using regression to estimate the function which would represent the historical data and of course it has limitations. The major limitations of these methods trend extrapolation methods is that

they essentially assume that whatever was happening in the past will continue to happen in the future as well. This means that the trend that was continuing in the past will continue to happen in the future. If that assumption is true these are good models. If this assumption is false these need not be good models. The alternative in that case is casual or econometric models. Casual or econometric models are also regression models but the basic advantage of this models is that you can answer what if questions. What would happen to the demand if the variable such and such drops by so and so? What if the government policy changes to such and such thing? So the regression models will not be able to answer these trend extrapolation model will not be able to answer those questions.

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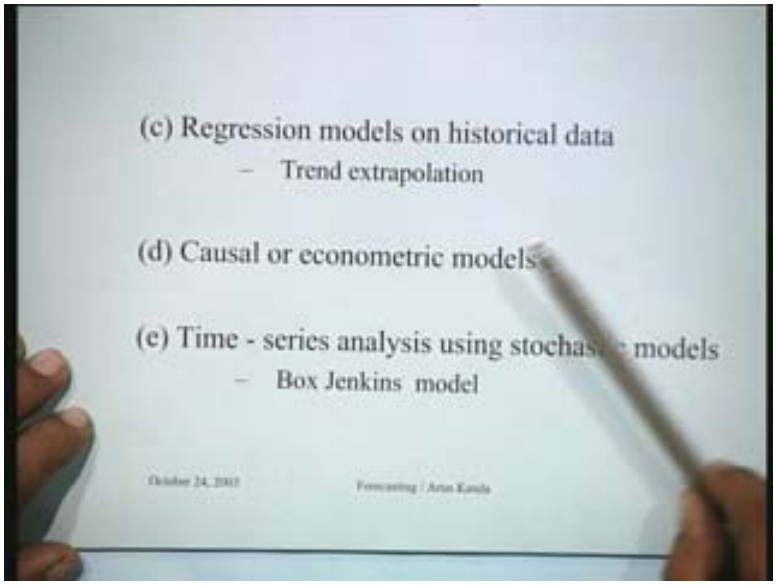

We will examine some of the features through an example subsequently and then of course we have time series analysis we could talk about either time series analysis using decomposition, which is a very commonly used method of forecasting or we could talk about time series analysis using stochastic models. In that category we have the set of box Jenkins models which is essentially stochastic model for generating the demand has it goes on. So you are generating the demand distribution as such and using that for purposes of forecasting. The major advantage of this model is that they are pretty accurate for short term forecasts, but the kind of effort involved in modeling is considerable. Really speaking they are not very popularly used in fact you will surprise to know that in a survey carried out on the methods of forecasting used by various industries. The most popular method of forecasting was subjective and intuitive method of forecasting and not the other methods. It would be interesting to find out the difference between what we call forecasting and prediction. In schools of management and in IIt is and other engineering colleges, they teach you forecasting, they not teach you prediction. Maybe in some schools of histology they would be teaching you methods of prediction as well that is the different thing. But the difference is I think forecasting is essentially objective whereas prediction is a subjective kind of a thing.

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Forecasting is the scientific discipline whereas prediction is an intuitive discipline. Forecasting is generally free from bias, whereas in prediction the individual bias would come into play. Forecast generally is reproducible but predictions are generally non reproducible. What do you mean by this? What you mean by the reproducibility of a forecast what we mean as for instance that prediction is something that probably a soothsayer would give a person. So the forecast is not reproducible however if you are using a mathematical model for forecasting, if I run the model on the computer in the morning and if I run it again in the evening, I will get the same result that is what we mean by reproducibility. Error analysis is also possible here that means you can find out what is the extent of error that a particular method is producing whereas here error analysis is generally limited in that sense. But in our lives we rely both on forecasting and prediction and remember that forecasting is the scientific discipline and that is why it is taught in business schools and in engineering colleges whereas prediction is something which is intuitive and therefore taught. Here we have some commonly observed normal demand patterns focus is on the word normal. What we mean by normal demand patterns is that normally what would happen is that the demand verses time would exhibit some kind of random fluctuations. But by and large you find that the demand is constant. So this is a typical example of how a constant demand would present itself in real life.

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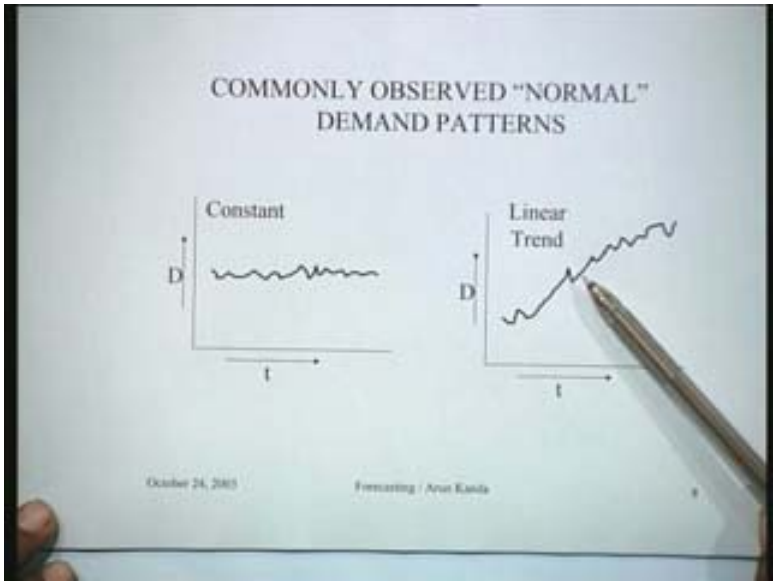

On the other hand if you talk about IT store which is gradually increasing its sales over the years, then a linear trend would show that apart from the random fluctuations the demand would generally turn to rise in this particular fashion and this could be best model as a linear trend. On the other hand the demand may be cyclic that means the demand for a product exhibits a peak and then comes down and there is a valley here and then it again exhibits a peak and so on. This is typically true for instance a woolen garments, for there is a peak during months of let us say December or November, December, January may be and then there is a dip during the months of may June when you do not require, so only the honeymooners going for sale would go to knot place and tend to buy a woolen coat during this period that is why this is a zero here. There would be some bias for woolen garments even during this particular period but essentially the demand is cyclic.

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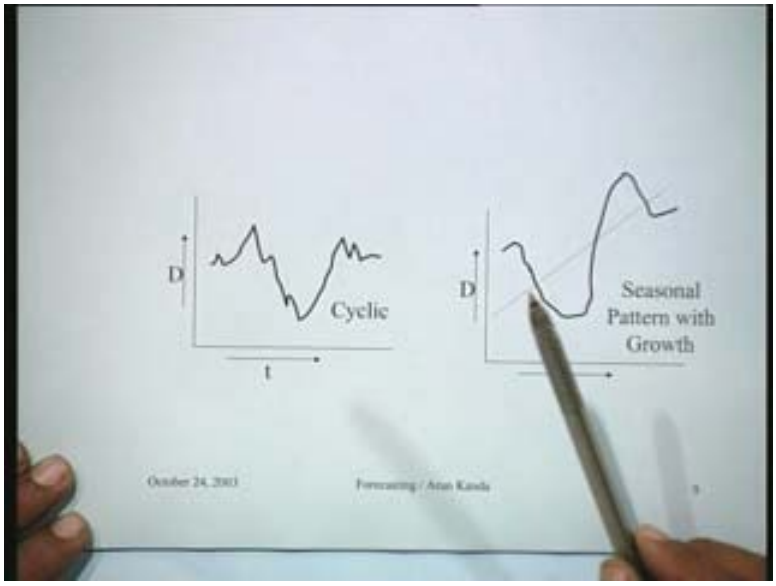

Can you give me some examples of other product which would exhibit a cyclic demand. Air conditioners would be one typical example which could again show a peak in summer and something like this in winter. So now apart from this cyclic demand what may also happen in practice is that there could be a seasonal pattern with the growth, for instance if we look at any particular big store that is say you look at Shoppers stop, you talk about the number of woolen garments which they stock or something like that. You find that in the first year the stock was something like this in the next year, they stock increases. This is because of the general pattern of growth so although they have a seasonable demand for the product, by and large it is underlined by a pattern of linear growth. Seasonal pattern with growth, these are some of the normal patterns of demand which will normally be observed for various types of products. Let us now try to look at some abnormal demand patterns. What do you mean by abnormal demand patterns? What happens is that suppose the demand is constant up to certain level here and then All of a sudden there is a rise in demand and the demand remains constant for some time and then again falls down and you again remain constant up to certain level.

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This is what we call as transient impulse and this is something abnormal. What we mean by calling it abnormal is, what do you think this could be caused by, what could be the reason for a sudden rise in demand for this company, which is operating at this level? All of a sudden the demand rises and then it falls off. It could be because of an epidemic. There is sudden demand for a certain type of drug you have something like this or it could be because of other reason. It could be because in competitors factory there is a strike, if there is a strike in the competitor's factory, then he is supplying the entire demand on both the people for that particular period and there is something. The point that is to be noted here is why do we call it at normal? This would be something that is triggered by external causes and would therefore not be modeled in normal process of modeling forecasting demand models.

Similarly there could be a sudden rise like this, why we think there could be a sudden rise? All of a sudden you are selling so much and then all of a sudden you find that there is a rise in the demand. It could be because of the liquidation of your customer, which could be one reason. Therefore your demand rises and so you are doing well and you are happy about it, where it could work. There would be a sudden fall in your demand and this sudden fall in the demand could be the appearance of a competitor who is much more efficient and much better in terms of price and quality than you are. So your demand all of a sudden would fall in this stage because of the introduction of the new competitor on the scene. All these factors are actually factors which are something in normal in that sense that means something has happened which is not normally happening and as a consequence you exhibit these abnormal demand patterns. Why it is necessary to know about this normal and abnormal demand patterns is that normally we are doing the modeling for demand. You are modeling demand only for normal demand patterns and not for an abnormal demand pattern. These are super imposed on the normal demand patterns if you want to actually determine. So you have talked about the common types of

demand patterns. Let us go to the various methods of forecasting. As I indicated, the simplest method of forecasting is taking an opinion poll.

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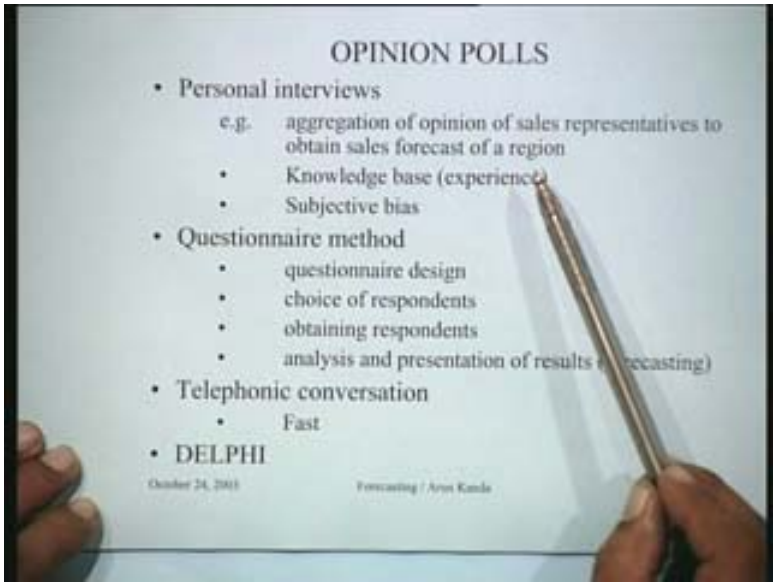

It can be very easy for instance you can take personal interviews and for instance what happens is that if there is a manager and he is interested in the sales for the entire region. How do we make the forecast? If the general manger wants a forecast for the whole region, the simplest thing that is done is to aggregate the opinion of sales representative to obtain sales forecast for a region. So he could say that he will call the first salesman who is responsible for the first region and ask him how much you sold this year. He will probably say 80,000 units. He probably might give him a bit of his mind. Why you so less? How much do you sell in the next year? He probably says 100 units. He gets an idea that the 100,000 unit is likely to be the likely sales for that particular year for that particular unit. Something similar could be done for each of the regions and then ultimately he would by compiling this information know the demand for the entire region. This is how he can obtain the forecast.

The basic advantage is that he is utilize the knowledge base and the experience of the individual salesman who are very knowledgeable people because they know their customers and therefore they know how much they can sell. The major advantage is the subjective bias because one particular individual might be very anxious or very keen to satisfy or impress his boss so he might say I will sell 200 and at the end of it he might be able to sell only 100 units. The individual bias can always impair the accuracy of the forecast of this nature. Other methods for taking opinion polls in the questionnaire method the most important thing is the questionnaire design, which should capture the information that you want to actually obtain. Then there is a choice of respondents which is equally important because you must talk to the people who have the information that you seek. Obtaining these respondents and getting the information from them and having obtained them is to do an analysis and presentation of results and ultimately obtain a

forecast. This is how the questionnaire method would operate. Normally the questionnaire method is very slow because the process of designing a question at takes long time. Then obtaining responses from respondents is also quite slow and many people may not give the responses. You might send out something like 100 questioners and you find ultimately that only 10 to 15 respondents. Normally this is the kind of response that you have in using the questionnaire. This limitation to some extent can be taken care of in opinion polls done through telephonic conversation. The major advantage of the telephonic conversation is that it is very fast and you get an opinion poll almost immediately. For instance if you have watched the news on BBC or CNN or NDTV any of these, what do they do? If there is a major accident, somewhere then they immediately talk to the important people near by the side or those who are responsible and you immediately get instantaneous feed back through this kind of an opinion poll on the accident from different people. That is the major advantage of telephonic conversation. The telephonic conversation is good in the sense that it does not take too much time from the respondent; either it does not prepare a report. You can talk to him for 2 minutes; he does not mind talking for 2 minutes. You can get the information very fast and it is a method where you can disturb the person anywhere. I mean especially with cell phone you can catch him anywhere, even in the toilet. You have therefore this advantage of telephonic conversation. However what is the major defect of all this opinion polls?

The major defect of all these opinion polls is the subjective bias which comes into this place. DELPHI is the method which has been devised to get rid of the subjective bias but at the same time to try to get most of the advantages of these methods which is actually accessing the knowledge base or the experience of these people. How does a DELPHI operate?

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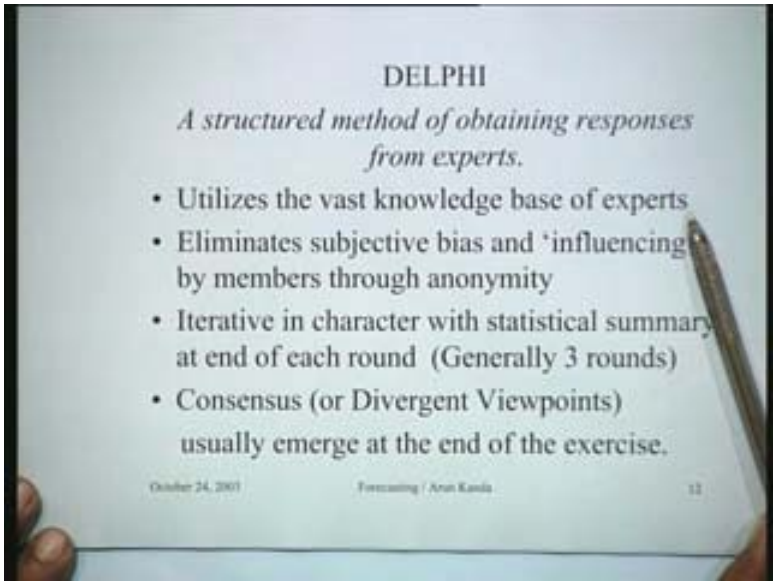

A DELPHI is the structured method for obtaining responses from experts. It utilizes the vast knowledge base of experts. It eliminates subjective bias and influencing by members

through anonymity that means a people on a DELPHI panel do not know the others in the panel. For instance if I am asked to give my opinion and I know that the person next to me is a noble laureate, in his presence I probably not be able to speak up my mind and give my frank opinion on what is happening. They keep anonymity so that every person gives us on his opinion. It is iterative in character with statistical summary at the end of each round, generally three rounds are there and consensus or divergent view points usually emerge at the end of the exercise that is the purpose. It is like a committee. The only thing is the committee members do not know the other members in the committee. When the advantage is that for instance interested in finding out I mean how the questions are there with the committee you trend to pickup those people who are most knowledgeable about that particular aspect and it could be done from anywhere. The nature of the operation is something like this, you have the coordinator for the DELPHI panel and depending upon the problem which is interested in seeking an answer to he picks up experts. Let us take an example, suppose for instance, a question is that I want to forecast. When will the petroleum reserves of the world come to an end? Now for answering this question, who do you think of the relevant people? Maybe from India you must say the petroleum secretary will be one person who knows enough about this. Somebody from major royal company said may be somebody from Indian oil their director and so on he could be there reach to people.

You probably like to have somebody from the opaque countries or oil based countries who are supplying most of the oil. Then USA is the major player in all political decisions so we would like to have maybe somebody from the United States who is interested, who is responsible for petroleum. So we have a panel of the 5 people. It becomes a DELPHI panel so you would write to them or you can contact them, request them to be panel if they agree you are the panel and then you ask them the question and then what happens really is we have 5 people. We ask them when the petroleum reserve in the world comes to an end. At the end of the whole exercise what will happen is somebody might say they will come to an end here. 5 people will respond differently to this question.

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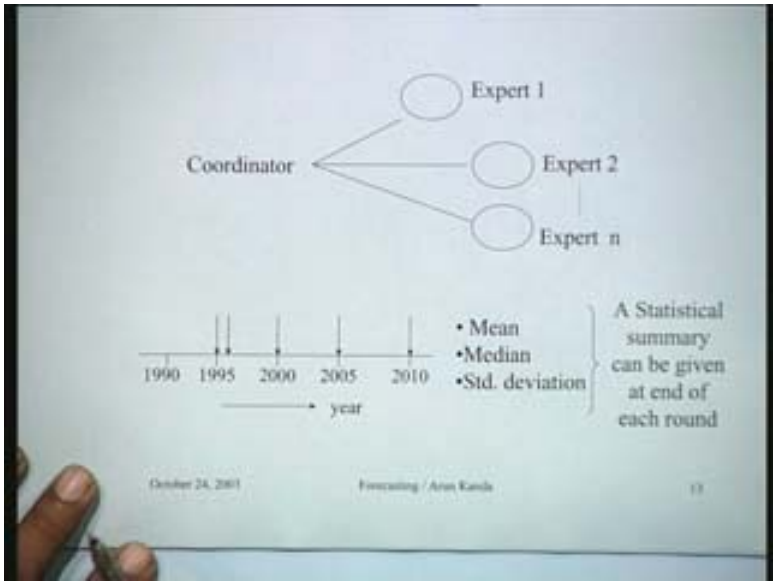

Some say the petroleum reserves in the world will come to end by 2010, some say 2005, somebody say much earlier. They optimize and specify whatever it is. This kind of information is then mailed to all the participants without telling them who said this and who said that. So they know that this is the range. Find the mean median and the standard deviation of the responses and on the basis of this information, the experts can revise their opinions, this is how it operates. At the end it might be something like this initially this might be the response and when the round 2 comes, these people feel here we are probably too much on the left side. They might want to join them. This fellow might feel that I am too much on the hand side and he might want to join them. In the round three they might come and so you have a more or fewer consensuses and this would say that this is the approximate date at which the petroleum reserves of the world will come to an end. Alternatively in the DELPHI panel what may happen is you have this response to begin with this person. The round 2 checks his calculation. He is no perfect. In fact I should be here, so he comes here and he comes here.

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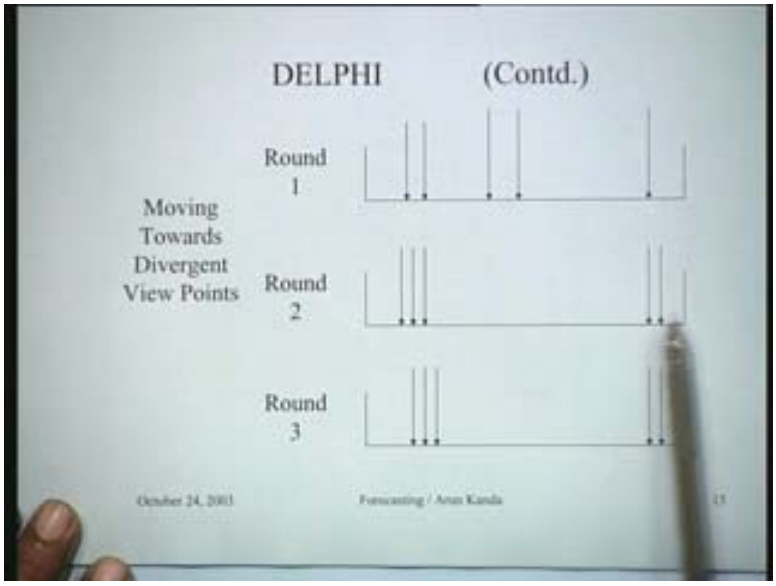

Both these blocks take solid stands, so this could be like the soviet stand in the beginning in the Russian American stand. They are very stiff in their stand. This is what it remains. This is like moving towards divergent view points. This is also a universal or a useful forecast. Why, because you can say that there are 2 grades of people in the world. Some people think that petroleum reserve will go on till 2020. Other people think they will be ending by the year 2005 and that is it. That again is the forecast. I like to tell you the significance of the term DELPHI. The word DELPHI was actually a oracle in grease who used to stay on mountain climbers and use to make predictions and all his prediction used to come out true. That is why great kings and princess used to line up and wait for an appointment with him to get to find out their future. Is it the time to go to war or should I marry this girl or whatever it is.

His modus operandi was that whatever problem the king posed to him, he would keep it to himself and then he had a set of disciples he would go and tell the 5 disciples, I posed this problem and tell me what should be the answer and they would think about it and come up with an answer. At end variably that would be the answer he would communicate to the king. Essentially these are the disciples who are basically answering our questions in DELPHI and they are the methodologies. Thus the genesis of the methodology of DELPHI says the regular method in finding out exactly what should be done. Let us now talk about the category of methods, moving averages and exponential smoothing. What happens is suppose this is the demand history for the one year that we have with us, what will happen is that you can calculate a three period moving average, a three period moving average is something like the demand for January, the demand for February, the demand for march end it up, divided by 3 will give you the three period moving average which is computed at the end of march. This will be a forecast for next period. It is a short term forecasting exercise and when the actual demand comes out, it is probably 208, so there is an error here of 8, whatever it is. You take the new moving average so now the 3 values are this, this and this. You take the average 203 which is

now the moving average for next period and so on. So the moving average will become a forecast for the next period based upon the demand averages for the current three periods.

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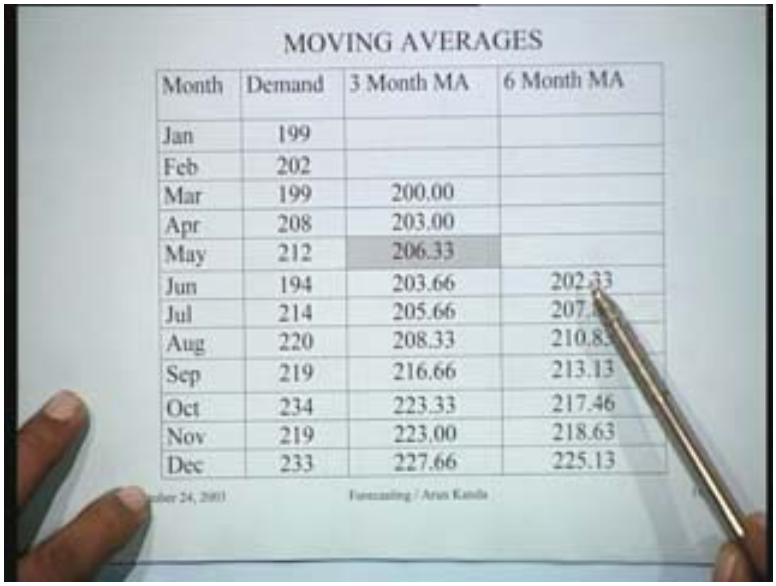

You would for instance also take a six month moving average which would available after six months. So you have data for the first six months, you take the average you get this value and this becomes an average for the next period and so on. So it is a very simple method of obtaining a forecast for various periods and the method of calculation is a k period moving averages, the average of the k most recent observations.

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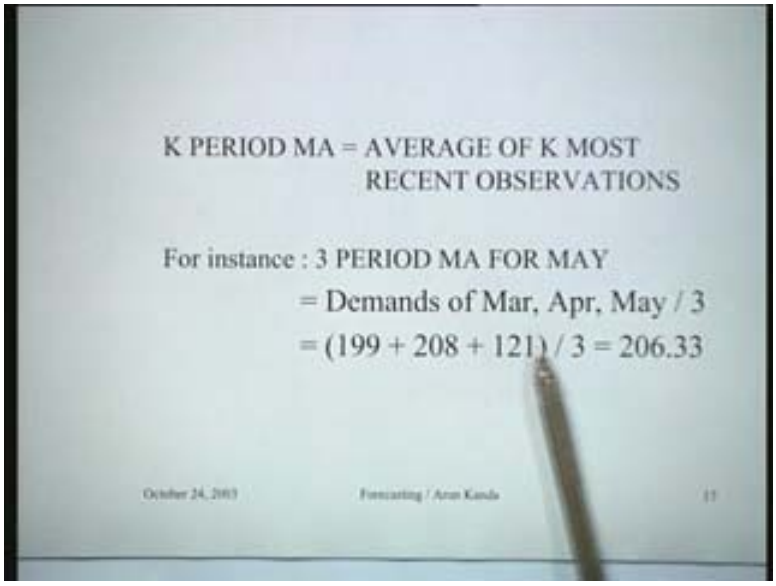

In the example that we had done just now the moving average for May is the demands for March, April and May divided by three which were these values and so you had 206.33. So this was 206.33. So calculations are very simple but it is a very simple method of obtaining a forecast. However the moving average has certain characteristics.

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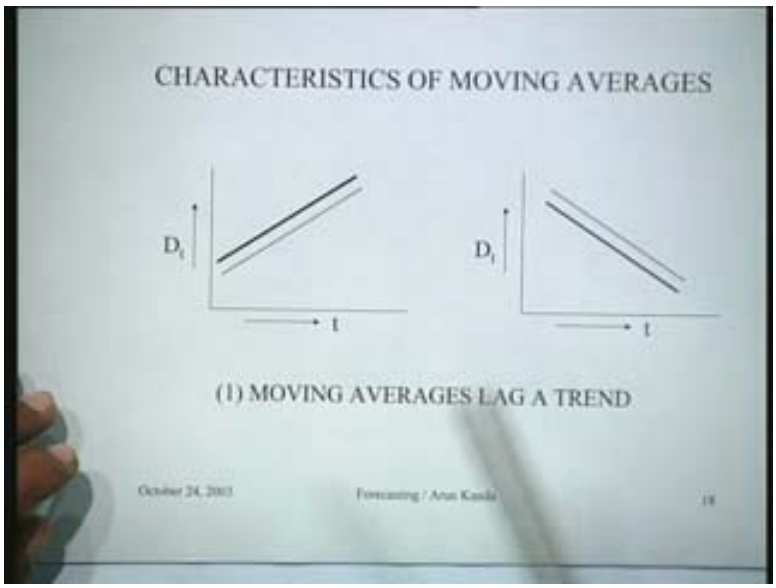

It is important to know those characteristics for instance if the actual demand is rising, as shown by the solid line, the moving averages will always be lower that means it will produce a forecast which is lower. Similarly if the demand is falling the moving average will always be higher and it will give you a higher value of the demand. What is that

actually? This can be said by saying that moving average lag a trend. If there is a trend in the demand, if it is rising we are below if it is falling we are above. So it is always behind, it is like a lagging boy who does not keep paste with a classmen. There could be some correction which could be given for this purpose. If you having a cyclic demand the moving averages are out of phase for cyclic demand. What it means is, suppose this is the actual demand, if you calculate the moving average, the moving average will be little later like this. So what does it show? It is out of phase, so this shows a peak for instance, in January, this will show a peak in March. If it is a three period moving average it will show the basic feature that you get for this particular aspect of demand. On the other hand if this is your demand, the moving average is something like this because, this was showing a peak of so much but this will actually flatten the peak because of the average. If somebody hammered the peak and they will lower the peak here and lower the peak here as compared to what is this is, these are some of the errors which will come about if you are using a moving average. The other averaging method very popularly used is exponential smoothing. Exponential smoothing is we have Ft is the one period ahead, forecast made at time period t and Dt is the actual demand for period t so this is a forecast and this is the demand. Let us define alpha is smoothing constant which lies between 0 and 1 but generally chosen values lie between .01 and 0.3. Experimentation as shown the alpha should be between .01 and 0.3 and we use an equation like this which says Ft = Ft – 1+ alpha into Dt – Ft – 1.

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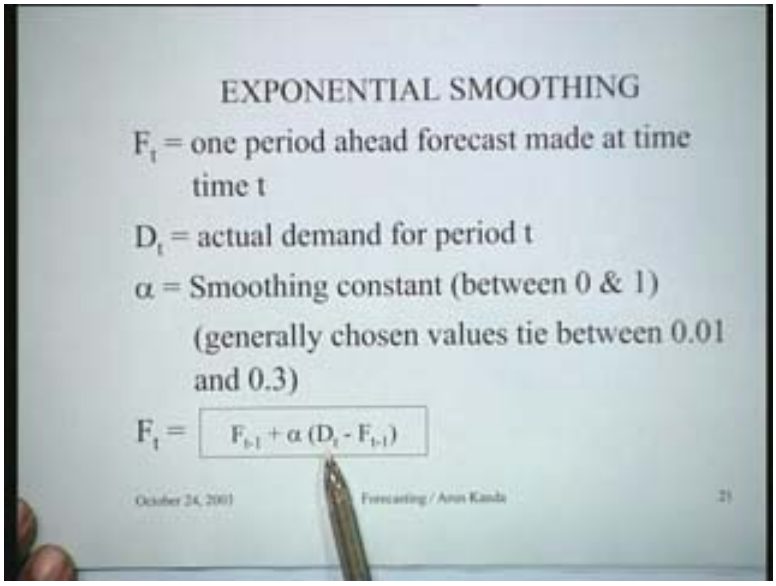

This is the demand and this is the forecast of demand that made a period before so this difference is nothing but the error, so forecast made a period before + alpha times error becomes the new forecast that is the formulae which would use for computation. You can rearrange that equation and write it as Ft + l = alpha D_t + 1 – alpha into ft – 1. You can always rearrange the equation like this and then for Ft – 1, you can again regressively substitute this value Ft that is alpha D_t + 1 – alpha into Ft – 1is alpha $D_{t-1}$by using the same equation + 1 – alpha whole square into Ft – 2 and so on.

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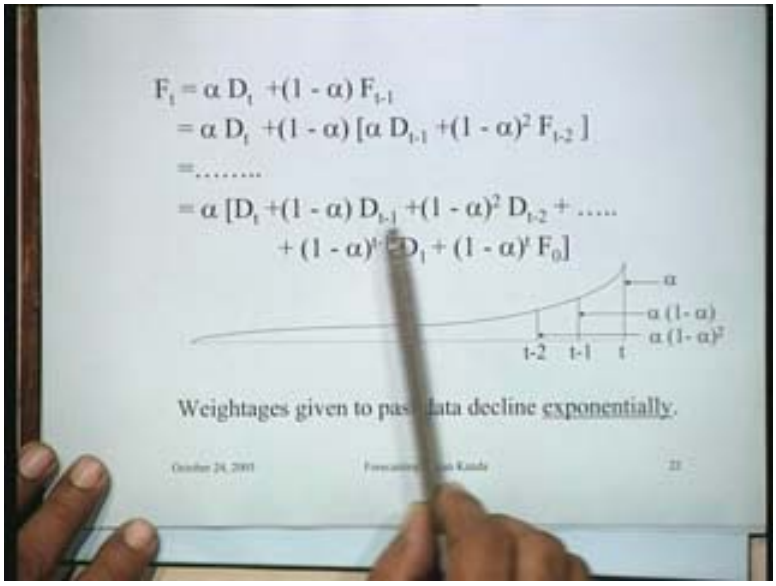

If you continue like this you find that the whole thing is a series which says alpha multiply by D_t alpha into 1 – alpha multiplied with D_{t-1} alpha into 1 – alpha whole square multiply by D_t – 2 and so on. Now this gives us an interesting result for instance if we take the demand data point, this the most current point at time t, this is a point at time t – 1this is a time at t – 2 and so on. What do you find that the current demand D_t gets a value weightage of alpha so this the alpha. The next demand D_{t-1}gets a weightage of alpha into 1 – alpha, the next demand gets a weightage of alpha into 1 – alpha whole square and because alpha lies between 0 and1. You find that the weightages given to the demand points keep on declining exponentially. This is the reason why it is called exponential smoothing which means that this is the procedure for making a forecast and this point that is taken as the weightage average of all the points in the past by giving more weightage here less weightage here and so on.

It is like saying that you are in a joint family and the person who is the youngest person who earns the livelihood for the family, he is given the greatest weightage and then the next one who earns less gets less weightage and so on. Maybe at this point of time the old people like the mother and father who are probably lying on the cot and unattended most of the times, are also in but very little weightage is being given to them. That is the kind of thing that you have whereas in a moving average what happens is you can sit at only the most three most reason points. So it is like an American nuclear family, the husband and wife and the child. You give weightages only to that and once the point becomes old, the child becomes capable of warning, he is thrown out and you have the next point which comes in and you are not giving any weightages there. So the distinction therefore is in exponential smoothing. You are taking into considering all the data points and the forecast is a weighted average of all those points, whereas in the moving average you are considering only the 3 or 4 or 6 most reason points and you are not considering other points. In fact it can be shown that moving average and exponential smoothing are equivalent. Equivalent in the sense that there is a relationship between alpha and n and

that relationship between alpha and n is simply alpha = 2 divided by n + 1. That means if the number of periods in the moving average is large it is equivalent to a smaller value of alpha that is the significance of this term. Let us for instance take the demand history for a product that we were just considering and let us say that this solid line shows the actual demand which shows over the year what is the demand in January, February, March, April, May and so on up to December.

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This is what we have. If you calculate a three month moving average what you find is this average which is available at this point is shown by this dotted line. This is the three month moving average. If you compare this with the six month moving average, you find that the moving average six month moving average is like this. The difference is that the three month moving average is much more responsive to the actual demand for instance there is a peak here. This also shows a peak and then it comes down because this is the depression here. It comes down and then goes and then there is a peak shows the peak and then gradually comes down, whereas the six month moving average just comes down and then gradually keeps going.

So it is more like a big elephant which takes a lot of time to get up and the three month moving average is like a deer which responds with agility to the forecast. If you have a smaller number of periods in the moving average obviously it would respond faster to the demand. But you can have this one as the smallest number of period. But the danger is that it is not a one period moving average; while it could give you false alarms. It could give you false alarms when nothing has happened and average is the situation where a number of demand points are collectively giving you this answer. You should judiciously choose between this and the same kind of effect will be true between different values of alpha, for instance if we take alpha is equal to let us say 0.1 and alpha is = 0.3, you would very much see the behavior to be very much like for instance this particular value here corresponding to alpha is equal to, if you have the smaller value of alpha,

smaller value of alpha is equivalent to, as I said it is equivalent to larger value of end. So it would be a very sluggish kind of response which you would have and vice versa. These are some features of methods based upon averaging of past data. Let us now come to the category of methods called common regression functions. If we have demand points we can fit any straight line, the most common straight line is the linear relationship.

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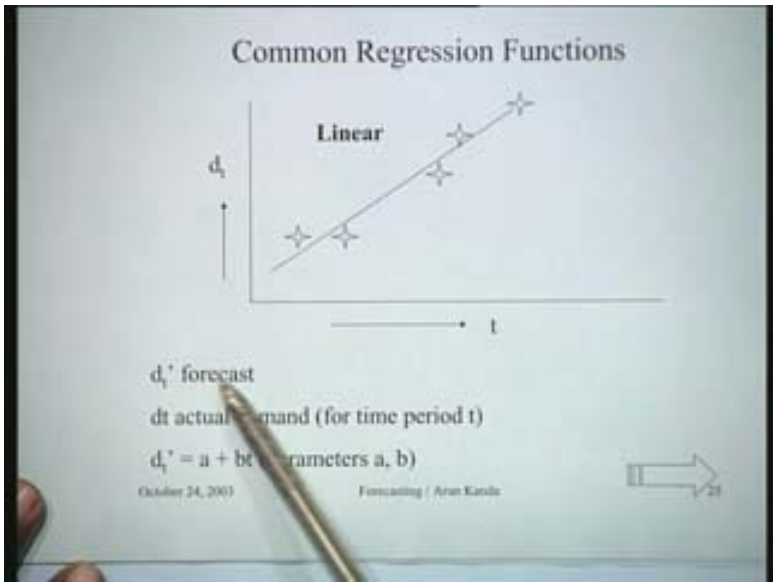

So d dash t is the forecast and D_t is the actual demand. We can fit a straight line d dash t = a + bt and what we are actually expected to do is to calculate values of abl a and b and this can be done by the method of least squares. We shall go to the detail of estimating these parameters in the next lecture. Similarly a common demand variant is a cyclic demand. In the cyclic demand what do we have? We have d dash t which is the forecast would be =a + u Cos 2 pie /n into t + v Sin 2 pie /n into t and this becomes the forecasting model.

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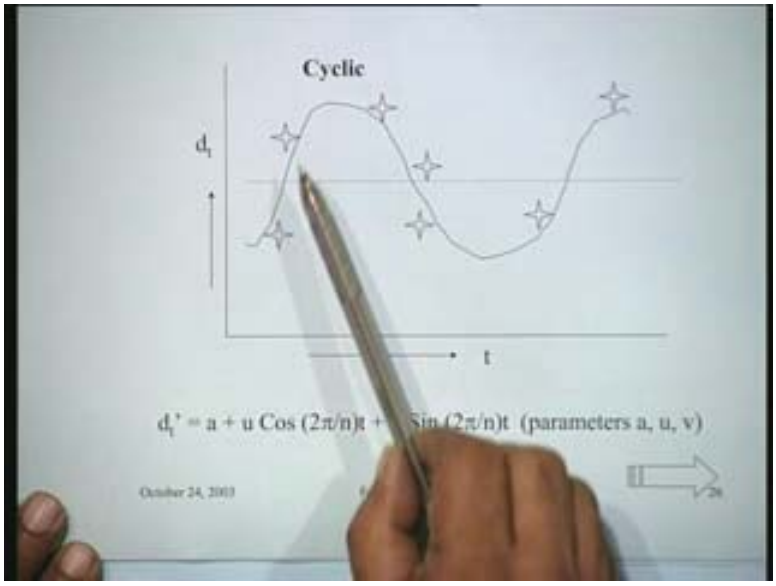

n is the number of periods, number of periodicity of data. If this whole cycle repeats after 12 months then periodicity is end 12. So this was the given data. You fit this function and here you have to estimate the three parameters a, u and v these are the three parameters. So once you estimate these parameters you know the function completely and you can use it for forecasting the demand. Similarly you might have a function with growth cyclic function with growth. So the equation for this line could be d dash t is = a + bt + u Cos 2 pie /n into t + v Sin 2 pie /n into t. The parameters now are 4 a, b, u, v and these have to be estimated. They can be different mathematical functions. You have to identify the appropriate equation and then use the data to estimate those parameters or you might have a quadratic function which means which goes like this or like this.

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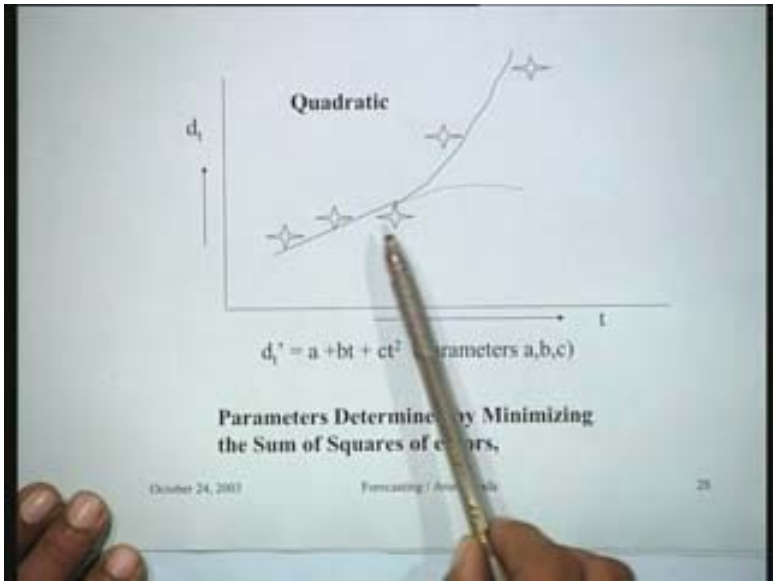

The equation is d dash t is = a + bt + ct square and you have to estimate a b and c. Obviously if c is positive you go this way, if c is negative you go this way. Again the parameters have to be estimated by determining the sum of squares of the errors, for instance if we take the demand example that we were considering all along, we had this pattern of the actual demand.

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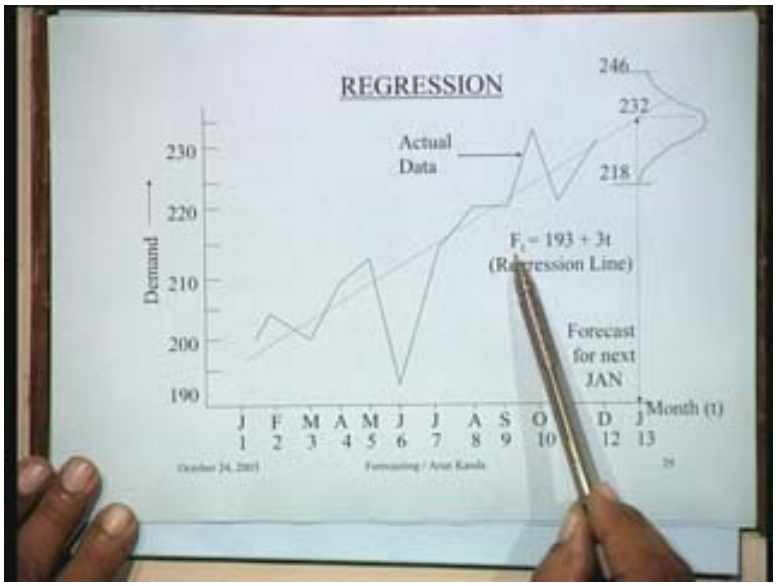

The straight line that is fit is Ft is =193 + 3t and this equation, when plotted is shown here. Now if I want to make a forecast for next January, suppose I have this entire year from January to December and I want to make a forecast for the thirteenth period, i.e., the

January, what happens is I can utilize the notion of the standard error of estimate to get intervals in which the demand may lie. How will I do that because if I put for instance in this t is =13, t is = 13, I have 193 + 3 into 13 which is 39 and the value is 232. So the expected demand for the next January is 232 but what I can do is I can find out the standard error of estimate which is nothing but the summation from 1 to n of D_t – Ft. This is the error so some of those squares of the errors divided by n – f, where n is the number of data points that you have and f is the number of degrees of freedom lost. The number of degrees of freedom lost in this case is = 2 because you have estimated only 2 parameters. This is straight line equation a + bt. You have estimated a and b so the number of degrees of freedom lost is 2. As a consequence the standard error of estimate works up to 7.32 or approximately 7. What you can do is if you want the 95 percent confidence limits for forecast for next January, 232 was the value that was obtained + / – 2 sigma for 95 percent confidence.

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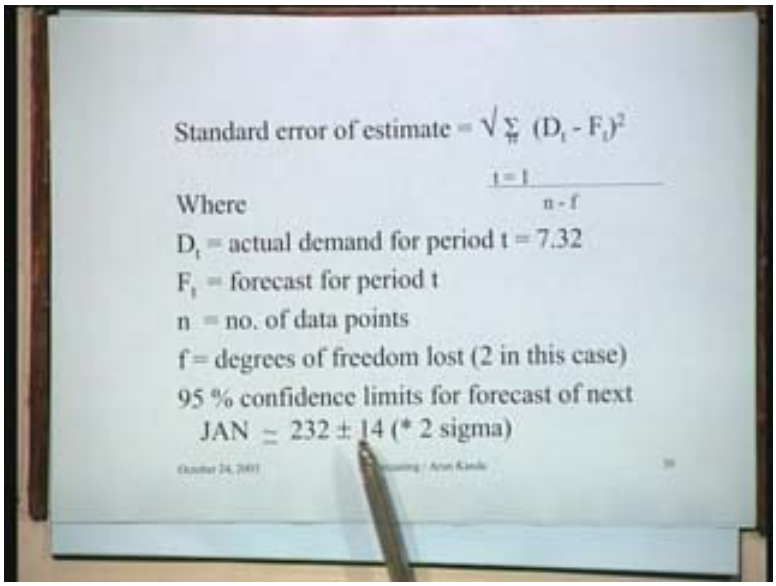

You would get 232 +/ – 14. This gives us some very useful information. For instance this shows that the demand for next January may lies 218 to 246, with 95 percent confidence. We can make probability statements like this and make more exact forecast by using the concept of the standard error of estimate. Then we can talk about trend extrapolation model, we talk about casual models.

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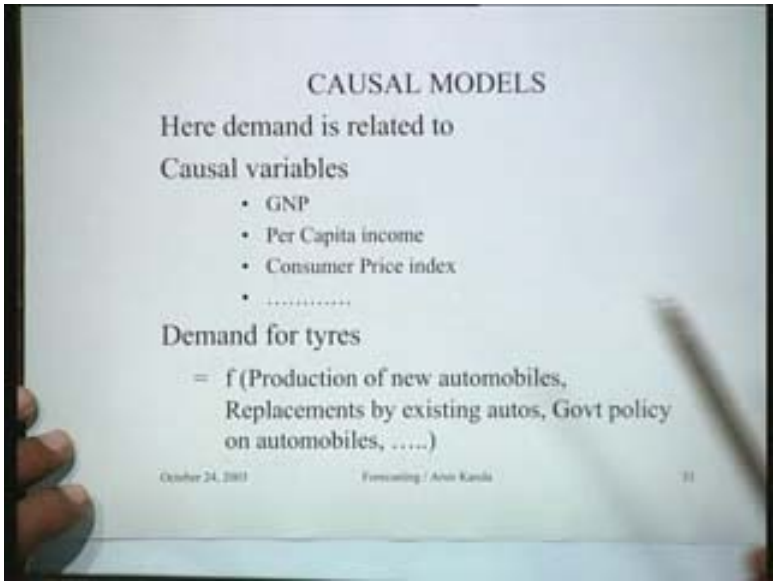

Here demand is related to causal models. What are causal variables? They are like the gross national product, per capita income, the consumer price index these are actually published figures which would be available to you before. So these are generally taken as causal variables. Let us see for instance how we make a causal model for the demand for tyres, you see what we will do is if we were interested in the demand for tyres, we could just plot historically and do a regression analysis of the kind that we just indicate for that does not tell us what would happen to the demand for tyres if there was certain changes in the government policy. We say that the demand for tyres is a function of primarily the production of new vehicles and the replacement of existing autos and the government policy on automobiles etc. Each new automobile produce requires 5 tyres each and then most of the tyres are the replacement of existing autos so it goes in that and then of course the government policy on automobiles. So we make a model saying like this that the demand for car tyres is a function of alpha times pt. pt is the production of cars and time period t. What is the government capacity for car production and let us say beta pt – is this is the production of car 5 years ago. You can say roughly that cars which are produced 5 years ago would come for replacements. Of course cars which would be produced 1 year, 2 year, 3 year they would all come for replacement. You can include that in the model but it would make it a very complicated model.

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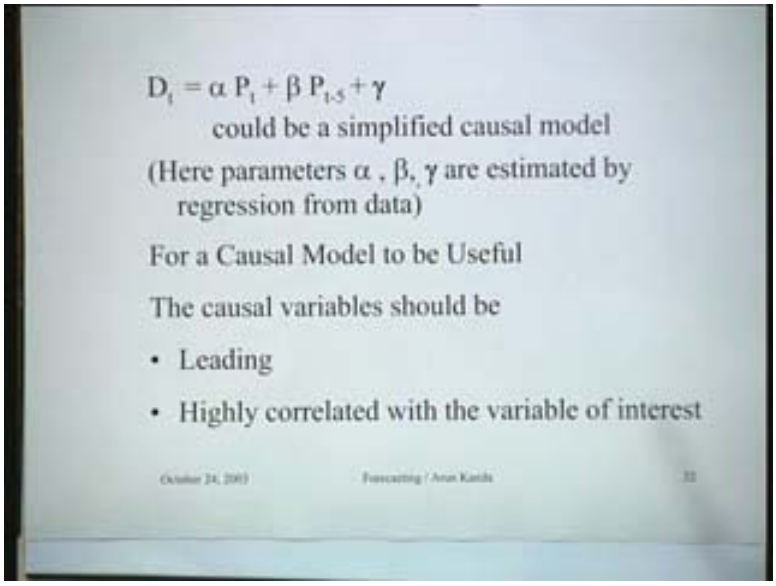

Just as a simplification to illustrate the notion we can say that the demand for car tyre is alpha pt + beta pt – 5 + gamma. This could be a simplified casual model. These are the parameters which are to be estimated by the regression from the data and ultimately what is going to happen is this is useful because if the government decides to cut the production of automobiles for reasons of pollution or other thing you know pt for that particular year, you can then directly find out the demand for car tyres. These are the kinds of "what if" questions that can be answered by casual model of course for a casual model to be useful, the causal variables should be leading. Leading means that there values that should be obtained before the time that it occurs otherwise they would not be available and they should be highly correlated with the variable of interest. So the correlation between D_t and pt and the correlation between the D_t and pt – 5 should be fairly high. That is essentially the notion of causal models.

Finally we come to the discussion of time series analysis. Time series can be decomposed into trend seasonality cycle and randomness. Once we isolate this components in time series analysis what is done is that the forecast is generated from these components. You find out the various components of the time series and put them together and find out what these components are at the new period of time and get the new forecast so that is the essential philosophy.

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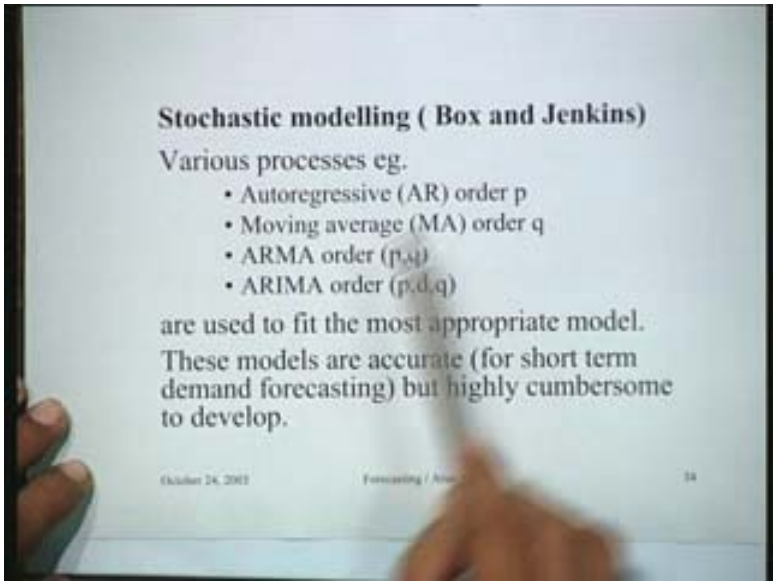

There are various processes such as auto regressive process of order p moving average, process of order q and combining these we get auto regressive moving average. So it is ARMA process of order p and q. It could be integrated auto regressive integrated moving average order of p, d and q. These are the most commonly used processes which are used for constructing models of the box and Jenkins variety. The basic idea is that these are stochastic processes in themselves and the model generated is like a stochastic model and these models are accurate for short term forecasting but highly cumbersome to develop. I think this gives you some idea of the various classes of models that we have. Finally the more important thing for any forecasting system is whether it would opinion polls or forecasting or regression or time series analysis or anything is that the forecasting system has to be validated. How is it validated? You have past data; you are using this for forecast generation. So you are getting a forecast which you sent here and then actual data on the new forecast becomes available.

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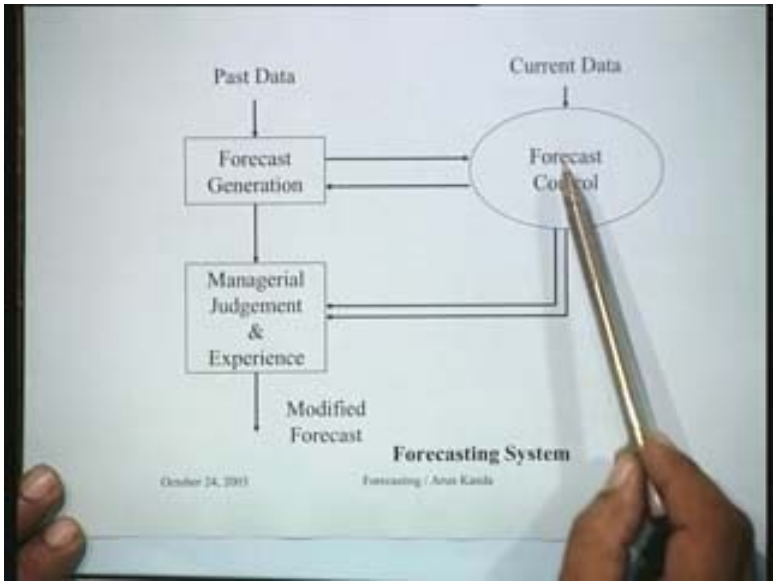

You have forecast control here which compares the errors and these errors are then subjected to managerial judgment and experience which tell you whether the forecasting model that you are using is fine and then you can use a modified forecast. So this is to be a continuous forecast control system which tells you exactly and it is basically on monitoring of the errors, if the errors are becoming very large in monitoring it shows that there is something wrong with your forecasting system. In order to keep track of this, a control chart is used; it is generally called a moving range chart to control forecasts. What happens here is the moving range is defined as forecast – demand so this is the error in time period t. This is the error in time period t – 1so error in time period t – error in time period t – 1and the mode of that is what we take is called the moving range.

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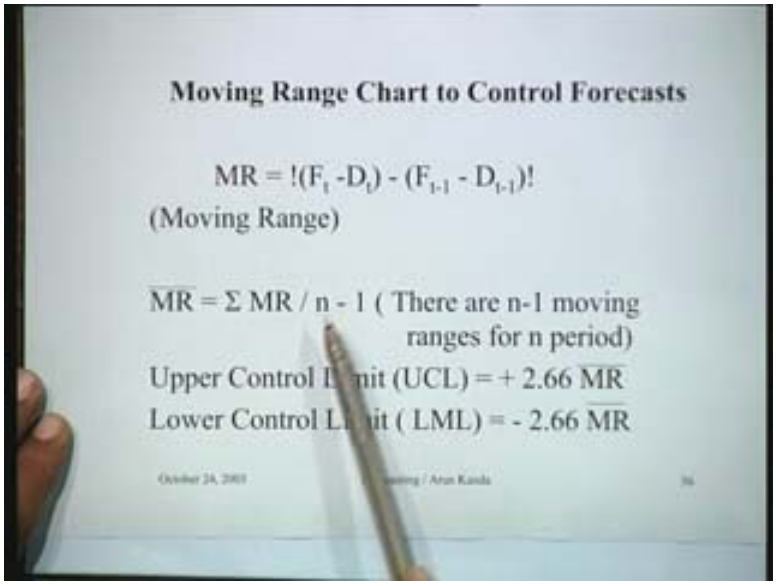

If you have n data points the moving range the average moving range will be summation of MR divided by n – 1. Why n – 1because for n points there will be only points only n – 1moving ranges. So you can calculate upper control limit which is + 2.66 MR bars. This is valid for any forecasting system and you have a lower control limit which is – 2.66 MR bar. Having computed this limit it becomes very easy to plot a control chart. So what we do is we have the upper control limit and the lower control limit which is plotted +/ – 2.66 MR bar and the variable to be plotted is the error.

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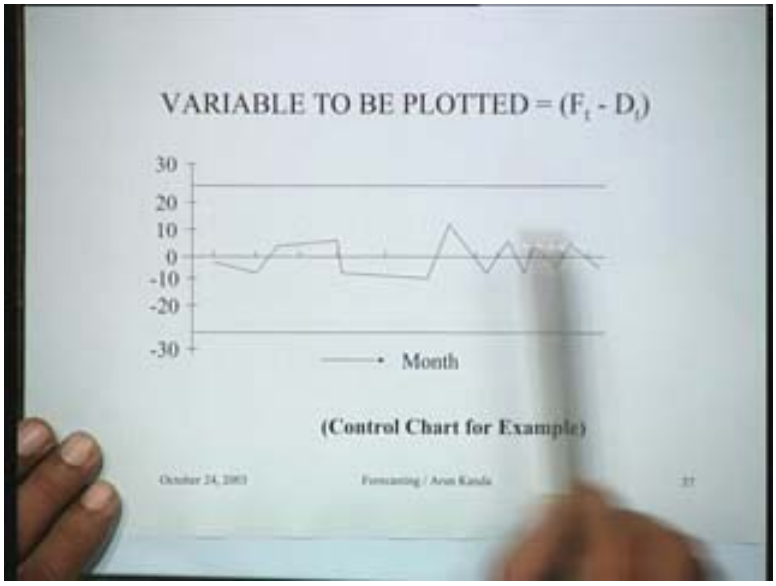

Ft – D_t, so error at this point is so much. Next time if the error means within this control limit, it shows that the forecasting method that you are using is consistent and it is if the error goes outside, it is a point out of control then you have reason to suspect that there is either in a sign able because your model has actually gone Orin. Let us summarize what we are trying to do in this particular lecture. We have looked at the forecasting problem in totality.

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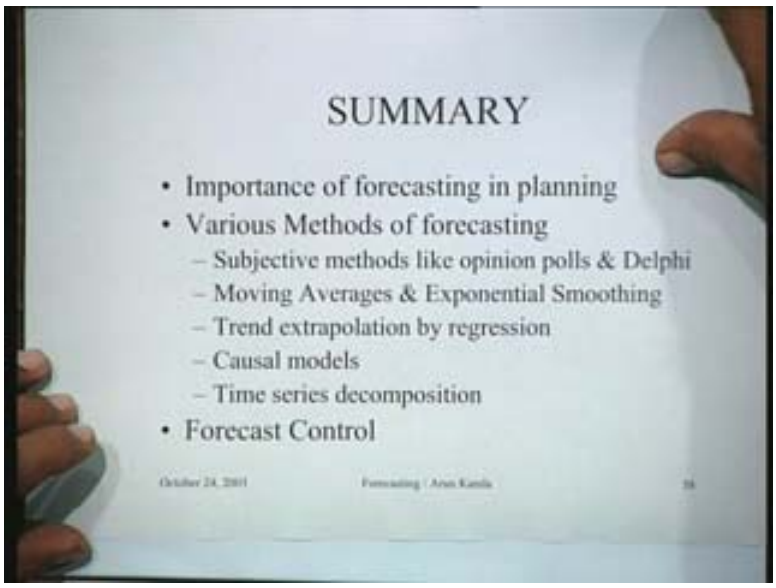

We have looked at the importance of forecasting in planning decisions. For all kinds of decisions, long term median term and short term we have forecasting which is an

essential input. Then we looked at the various methods of forecasting. The subjective methods like opinion polls and DELPHI, the moving averages and exponential smoothing procedures which are based on averaging of past data trend extrapolation by regression causal models and the time series decomposition. Finally we looked at this process of forecast control which was essential to tell us whether the forecasting system that we were adopting is appropriate or not. We shall actually look up or dual on the details of many of these methods in our next lecture.

Thank you!