Business Analytics for Management Decision
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Lecture – 35
Predictive Analytics: Time Series Forecasting

Hello everybody, this is Rudra Pradhan here. Welcome to BMD lecture series. Today, we will continue with predictive analytics and that too the topic of discussion is on time series forecasting.

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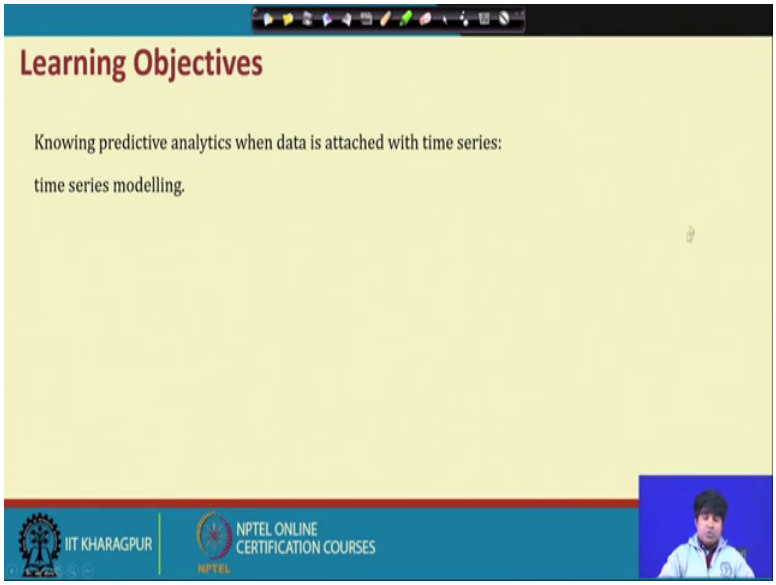

So, what we like to actually highlight in this particular case is like this we like to know the predictive analytic structure, where the data is with respect to time so that means you know in a real life scenario we have lots of you know variables information's which can be available with respect to time. And that too it may be with respect to you know annual observations, it may be with respect to weekly observation, it may be with respect to monthly observations or day wise observations something like that.

So, when we have actually set of you know in information with respect to time, then the predictive structure can have actually more you know means can be you know having different kind of you know look. And we can explore something more about to the kind of you know the as per the kind of you know business requirement.

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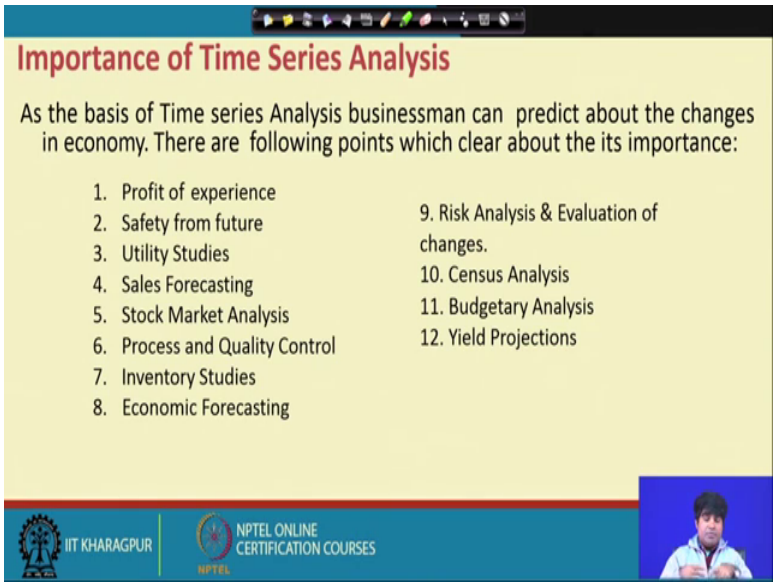

So, what are the things we are supposed to have in the kind of you know time series forecasting. So, let us you know start with that. And in fact, you know it is very important in the day today business environment like you know the profit forecasting, safety future forecasting, utility studies, sales forecasting, stock market forecasting's, inventory studies, economic forecasting, budgetary analysis, risk analysis.

So, you know whenever there is a kind of you know problem and the problem can be addressed with a with you know set of variables; and the variables information's are available in a kind of you know time series format, then obviously a one the standard structure which we can actually investigate the problem. And then go for the predict you know predictions or something a you know like forecasting. And that too with a help of you know time series techniques.

So, there are so many time series techniques are there. And the requirement of this technique you know is that you know data must be available with respect to a particular time. It may be annually; it may be monthly; it may be quarterly; it may be weekly; it may be day wise; it may be minute wise. So, there is no such you know you know kind of you know typical structure, but data most the; you know recorded over the kind of you know arrange with respect to a particular you know time structure. So, then the meaning of you know time series forecasting or time series analysis will be very active.

Otherwise we may use time series data, but the kind of you know modelling for the predictive kind of you know environment where you will lose the kind of you know importance when there is any kind of you know gap or some kind of you know inconsistency happens in the in the process of you know data gathering.

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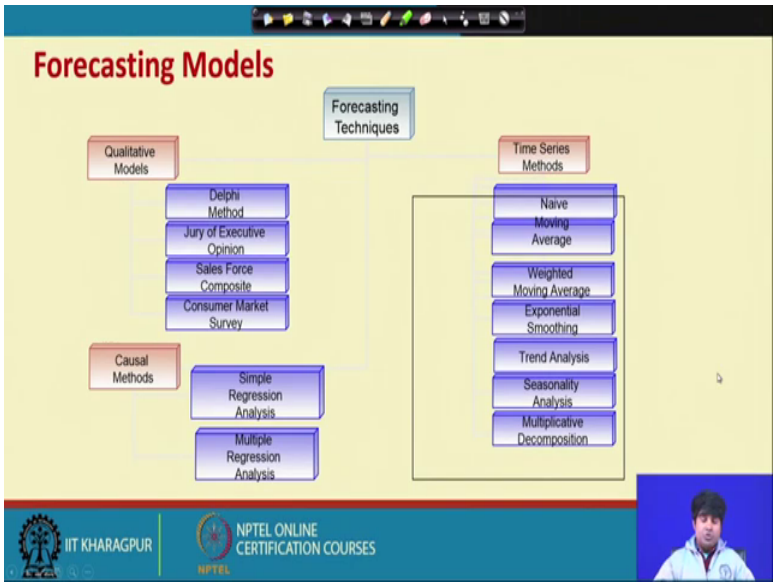

So, this is a you know kind of you know interesting structure through which you can actually go for the predictive kind of you know environment. So, now, you know the typical discussion is on you know various forecasting models and you know so far as a forecasting models are concerned, so it can be divided into two parts.

One part is called as you know qualitative models, and then you know casual models, and then finally, the time series you know models. So, some of the qualitative forecasting tools like you know Delphi technique, then the kind of you know grounded theory, sales for compositions, consumer market survey. So, these are you know various qualitative you know techniques are there through experts opinion or something kind of you know you know experience people's opinions we can actually you know forecast something else as per the business requirement.

Then we have already discussed so many casual you know techniques like simple regression analysis, multiple regression analysis. However the time series modelling is not slightly you know you know different from these grows, but it has a some of you know typical features through you can actually discuss this particular you know analysis.

In the time series you know forecasting's, so we have a kind of you know simple structure and so many complex structure through which you can do the forecasting as per the business requirement.

So, some of the standard you know methods are Naive technique, moving average, weighted moving average, exponential smoothening techniques, trend analysis, seasonality analysis, multiplicative decomposition analysis, so many you know you know techniques are there in the kind of you know time series umbrella. And depending upon the particular you know problem and the kind of you know particular technique, we can go for the kind of you know predictions and the kind of you know forecasting's.

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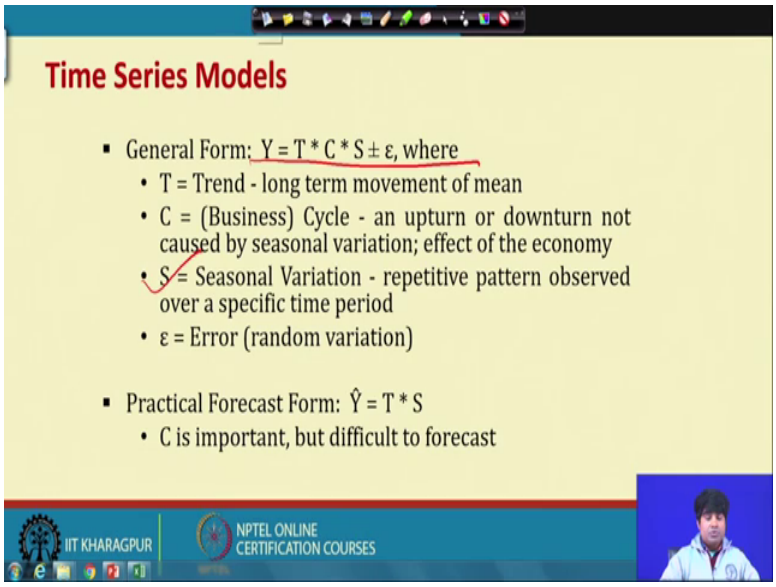

So, in the first hand understanding so far as time series model is you know like this. So, here we have actually the kind of you know compositions Y a equal to T cross C cross S with a error term, where T is represented as a trend and that is actually represented as a long term kind of you know impact. And C represents the business cycle operations; and it mostly affected by upstream, downstream and not typically affected by a seasonal kind of you know structure. Then S is the seasonal variations and then this is actually seasonal variation; it may be due to you know seasonal effect and then finally, the error terms.

In the practical you know so far as a real life scenario is concern we try to actually you know explore trend you know trend forecasting and seasonality forecasting, because you

know the kind of you know business cycle impact is very difficult to integrate in the process of you know forecasting's.

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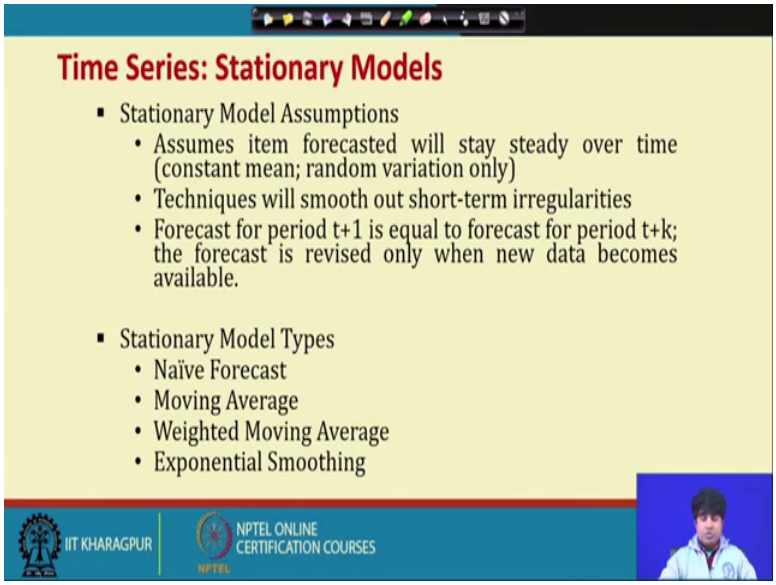

So, what we will do here, so let us see how is the particular you know structure. In the time series kind of you know a models, so some of the assumptions are there and different models are there through which you can do the kind of you know prediction. So, one of the structure is called as you know stationary issue you know; that means, actually so there should not be highly kind of you know volatile while you know studying the kind of you know prediction so that means, like you know heterogeneity issues.

So, the a stationarities which you know the mean variance of a particular series should not be actually deviate over the time. If it is actually deviate over the time then this may affect the kind of you know predictions.

Then so some of the actually you know stationary process you know we have a different models like you know Naive forecasting, moving average, weighted average and exponential smoothing. So, in the today's lecture we specifically highlight some of these techniques through which you will do the forecasting's and like to check what is the kind of you know prediction structures as per the you know business requirement.

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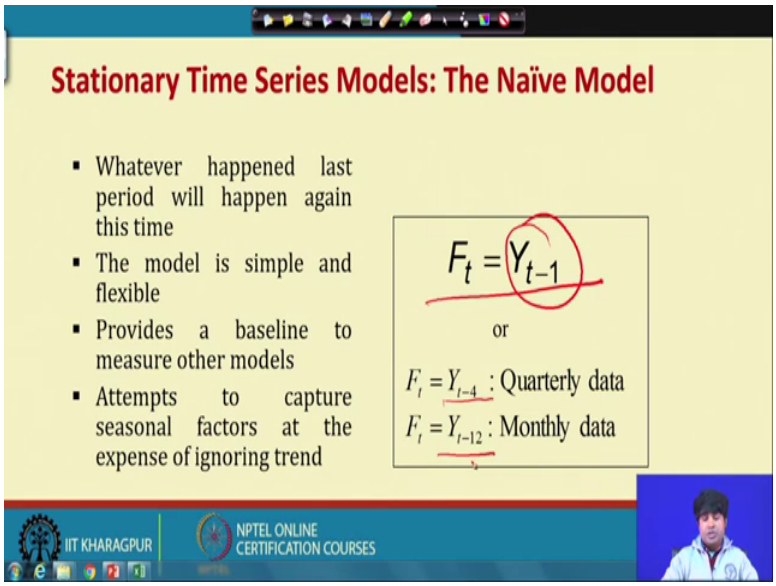

So, now you know the typical you know in time series structure, so we like to actually connect with the all historical data and because it is a available with respect to time usually called as you know historical data. So, the usual procedure of you know forecasting here the starters of a particular variable that is represented as a you know current framework and that will be predicted through you know its past you know structures like this particular you know examples here.

So, F t equal to you know function of Y t minus 1 so that means, so you know the forecasted figure of a particular you know variable with respect to t depends upon the lag of the previous year's. So, it is actually here represented you know quarterly data means t minus 4, then monthly data t minus 12. So, there are various ways actually you can you know do the kind of you know forecasting as per the business requirement.

So, we have actually you know lots of you know flexibility to address this problem like you know dummy modelling or (Refer Time: 09:27) data modelling, we have a lots of you know different models through which you can you know predict the kind of you know business environment.

So, in the time series, we have actually extensive kind of you know structure through which we can do the same similar kind of you know predictions and the kind of you know forecasting's. So, we will go one by one and highlight what are the a typical issues through which you can actually check some of the problems right.

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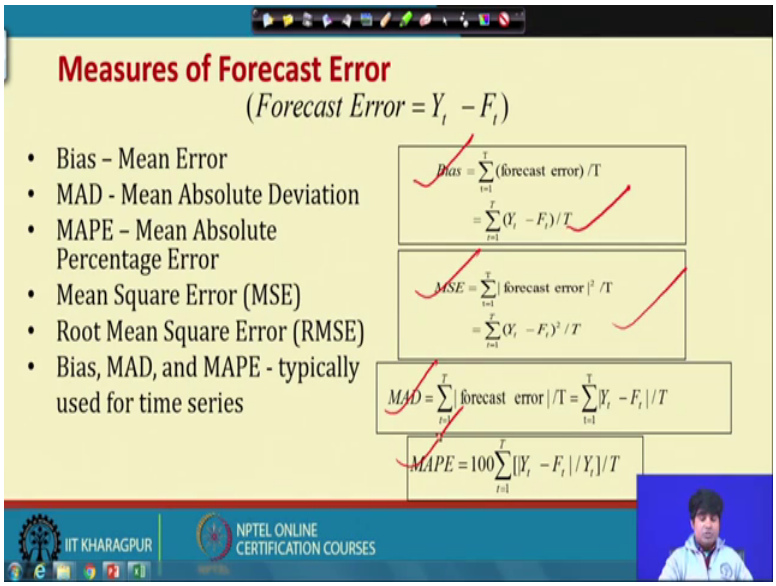

So, in the in the process of this particular you know discussion, so what will you do first you know every times we may use different models you know for the prediction and forecasting's. But so far as validation concern under the judgement means we like to check which one is the best you know for this you know particular prediction. So, we have a some of the you know typical statically indicator or predictive indicators through which you can declare that you know this model will be good for the forecasting.

So, some of the indicators are represented here. So, first indicator is bias that is mean error; and it is a difference between the actual value minus true value. And then mean absolute deviations; it is actually you know same, but we like you know find out the kind of you know mean difference from actual and you know predicted with you know removing this sign of particular you know structure. Then mean absolute percentage errors, so mean square error, root mean square errors, so there are so many you know standard tools are there which can you know help you to pick up a particular model for the forecasting and whether to for a particular you know business requirement.

So, these are all various you know you know you know statistical formula through which you can actually operate and then we will finally, so that means, first you know prepare a forecasted models then the actual information and the forecasted information's, you will find the error term. And after getting the error terms, so these are the indicators can be obtained finally, and to check or to judge which one is the best model to go for you know

final forecasting or the final predictions. So, what are the ways we can do. So, we can discuss you know one by one.

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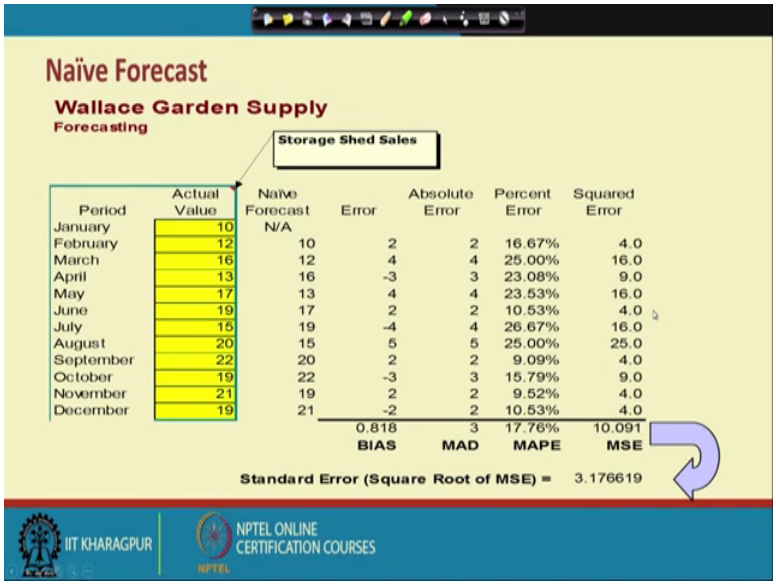

And let us see here ok. So, this is what actually the kind of you know structure. So, what will you do. So, first you know there are couple of methods which we have already highlighted here.

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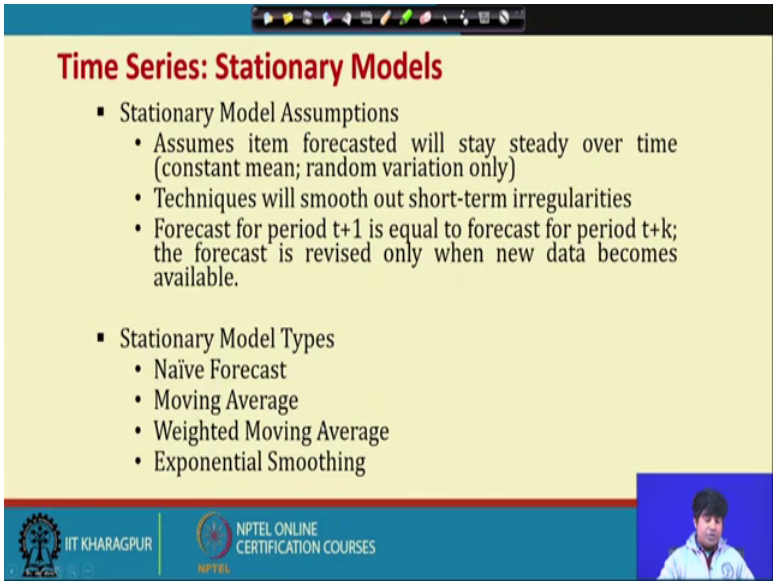

So, these are all various methods through which we can get the forecasted a kind of you know model.

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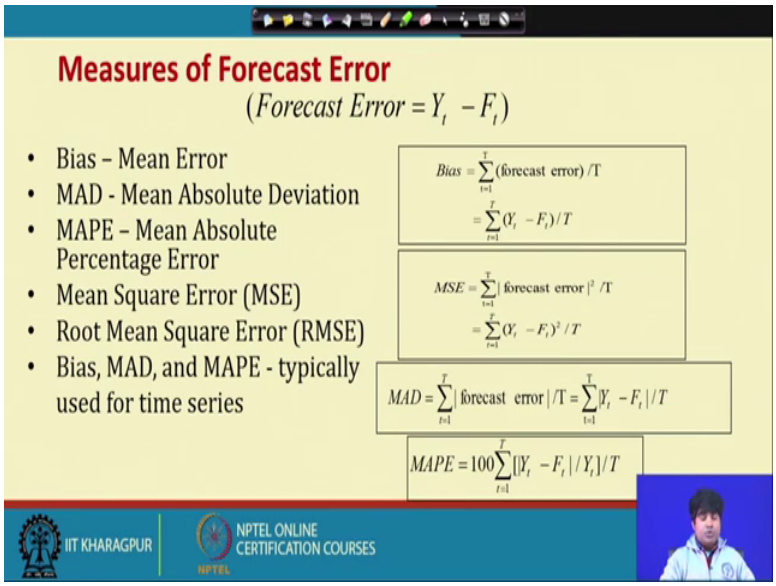

And then the difference we have to find out with the actual information and then finally, check which one is the best model as per the particular you know business requirement. That means so these models these models can be used for forecasting then these indicators are used for fixing or you know checking the best model you know as per the particular you know business requirement.

So, now we will go one by one. So, the first structure is called as you know Naive forecasting. So, here we are going to going for you know sales forecasting's. And for that you know we have a monthly observations from first month to last month January to December. And these are all you know actual sales. And then we will we will do the predictions through actually the kind of you know Naive forecasting.

And the structure of Naive forecasting is nothing but a actual value which is the forecasted value will be depends upon the previous value so that means, actually we start with 10, 12, 16 then in the Naive forecasting's, so the current item 12 depends upon the previous item 10. Similarly, 16 you know items depends upon 12 like this, so that means, one one point behind. So, it is like you know Y t and Y t minus 1.

Then here the actual and then the kind of you know predicted structure. And the difference between actual and predicted will give you the error component. And finally, once you get the error component, and then as per the previous discussion in lots of you know predictive you know analytic structure, so first check is the check you know

whether error sum is coming you know close to 0 or not. So, now, this is actually we are checking the kind of you know error, and then we are finding out the mean sum error that is here we represented as a bias.

And then absolute mean error. So, we just remove this sign and then find out the sum and divide by number of observation, this will give you the kind of you know structure called as a mean absolute deviation. And then finally, mean percentage error. So, the absolute error divided by actual value, and then we find out the you know mean error. And this called as a mean absolute percentage error.

Then finally, we have a error here. And we can go for you know errors error squares. And then finally, a sum of the error sums squares we can you know and divided by the sample observation will have a mean sum square. And square root of all these you know mean sum square is nothing but called as a root mean square error.

So; that means, so these are the following indicators through which we can check that you know whether the particular you know forecasting say this is actually the forecasting forecasted value and that too for you know you know Naive forecasting. And then finally, we are checking the checking the validity through these you know indicators right.

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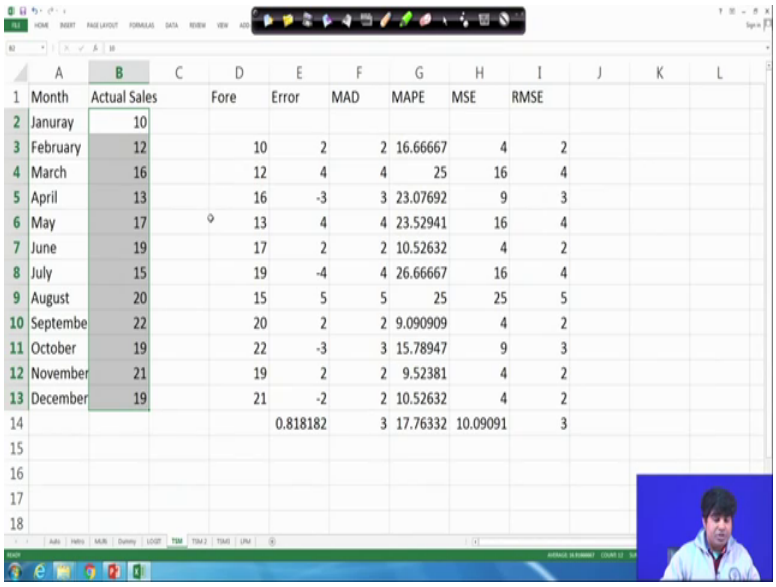

	A	B	C	D	E	F	G	H	I	J	K	L
1	Month	Actual Sales		Fore	Error	MAD	MAPE	MSE	RMSE			
2	Januray	10										
3	February	12		10	2	2	16.66667	4	2			
4	March	16		12	4	4	25	16	4			
5	April	13		16	-3	3	23.07692	9	3			
6	May	17		13	4	4	23.52941	16	4			
7	June	19		17	2	2	10.52632	4	2			
8	July	15		19	-4	4	26.66667	16	4			
9	August	20		15	5	5	25	25	5			
10	Septembe	22		20	2	2	9.090909	4	2			
11	October	19		22	-3	3	15.78947	9	3			
12	November	21		19	2	2	9.52381	4	2			
13	December	19		21	-2	2	10.52632	4	2			
14					0.818182	3	17.76332	10.09091	3			
15												
16												
17												
18												

For instance, if you go to the let us take you know examples. You go to the excel sheet. And then in the excel sheet, so these are you know variables same variables which we have actually plotted here. And we have actually series of data here and what we done here is so this is monthly observations. And then this these are actual sales. And the forecasted sales as per this net you know forecasting so just what we will have actually you know this is actually the actual values.

So, what will you do. So, you can put one point behind and then and then paste it. So, you will get the particular issues. So, by default this sample will be removed. And then we will find out the kind of you know errors, error this is now that means, technically Y t has a function of Y t minus 1. So, as a result this will be by default the forecasted figure. And then the error will be the difference between the actual value minus the forecasted value. And then we will we will get the error component.

Again if you if you extend, then you will get the particular you know difference, these are all called as you know different error difference at different point of times between actual sale and predicted sale. And then finally, we will look for the some of the error terms so that means, technically so this is actually mean error by default you know we can go for the average.

So, either you can calculate the total and divided by total observations or else you can directly calculate the average. And this will be coming actually mean error. And then in the case of you know mean absolute deviations, so these are all error. So, what will you do, so we will we will calculate the mean absolute error. So, what will you do, you just put equal to then you ask for the absolute value, and absolute value of this series. So, you can indicate this ones. And then you can actually scroll down. And then you will you will find the particular the entire items will be transferred into positive sides.

And against will find out the you know what I called as you know mean that is called as you know again you look for the average and this will give you mean absolute you know deviations. Similarly, in the case of mean absolute percentage error, so what will you do. So, it is actually the kind of you know difference between the mean absolute deviations and divide by the actual sales so that means, technically so this can be equal to mean absolute deviation divided by actual sales right.

So, then you will get this particular series. And then finally, you can extend this one and finally, you can calculate at the kind of you know structures and you know the kind of you know average right, this can be calculated. And again since mean absolute percentage, so you can multiply with hundreds. So, this will give you the kind of you know the impact and then mean sum I mean sum error.

So, this is actually you know what will you do you have a error here and then you can actually square all these errors. Then finally, you can after you know finishing all the you know columns then finally, you can look for the average. So, this will give you mean error mean sum you know square error and then it is called as you know root mean square error.

So; that means, if you squaring all these things then finally, if you take square root then this will give you root mean square error. So, that means, technically so these are the kind of you know you know statistical indicators through which we can just the fitness of the particular you know model. So, means technically so the Naive forecasting is actually one-way to go for the forecasting when you are you know variables are you know variables information's are available in a kind of you know time series format.

So, that means, this is a this is a very sophisticated technique actually, because every time forecasted figure you know Y t depends upon you know previous year Y t minus 1. So, as a result, so while you know having the kind of you know forecasting, so your data should having a kind of you know consistency. So, if any gap in between then this forecasting may be getting affected drastically.

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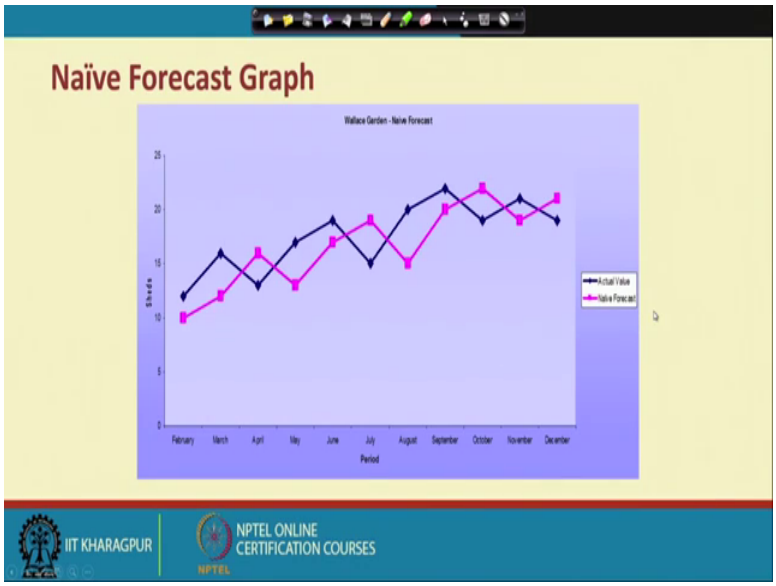

So, then against moving forwards, so now this is the difference between the actual sales and the kind of you know Naive forecasting. Then you will find there is a drastic difference. And the difference also we have actually plotted here, and we can find out and then we can plot it. So, this is the kind of you know red one is the forecasted you know line and then the actual line.

So, you will find there is a difference. Some cases error is positive some cases error is negative which is actually as per the particular you know requirement and that is rule of the forecasting. So, so that you know total error, so error sum should be equal to 0; the if that is the case then the first hand choice is that you know we are we are in a right track for this kind of you know forecasting.

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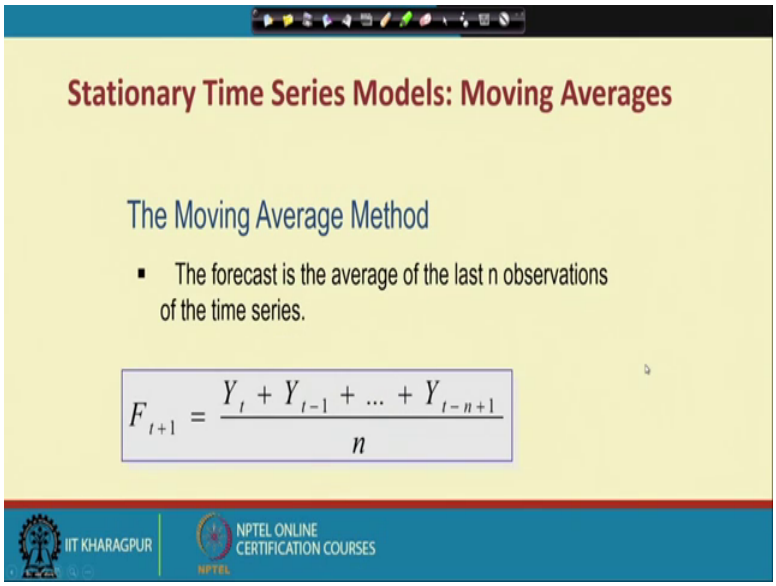

And then in the stationary kind of you know process we have actually moving average technique through which again we can do the forecasting, we can go for three-year moving average, we can go for five year moving average, we can go for seven year moving average and then we can do the forecasting.

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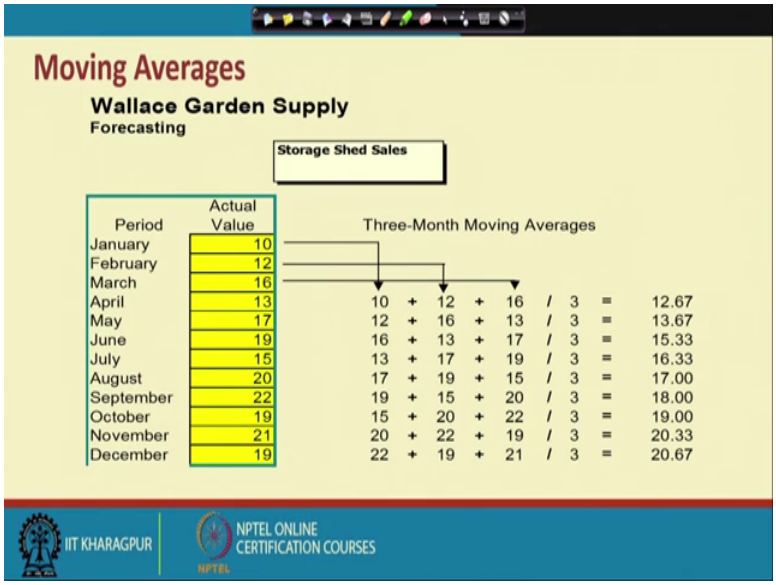

And we start with actually three-year moving average. So, now the same data, so this is the monthly data of you know sales from January to December. So, now, in the case of you know three-year moving average, so first three point you know can be clubbed and

take the average. So, similarly then again 10, 12, 16, so it will give you a particular figure; then again it will start with a 12, 16, 13 then it will give you another figure. So, likewise so your forecasted figure will be so the you know three-year data points three-months data points and then we find out the average.

So, likewise we have the series here and against so this will be the forecasted figure, and then we will find the difference and the difference will give you the kind of you know error component so that means, for every you know in this kind of you know three-year moving average. So, first two data points will not be there because we need three data points to get average. So, as a result it will start with you know 16 and then it will continue up to last data points so, as a result.

So, these are the kind of you know forecasted figure. So, 10 12 16, so this will give you the first figure; and 12, 16, 13 so this will give you the second figure. And then 16 13 17, so this will give you third figure and so on.

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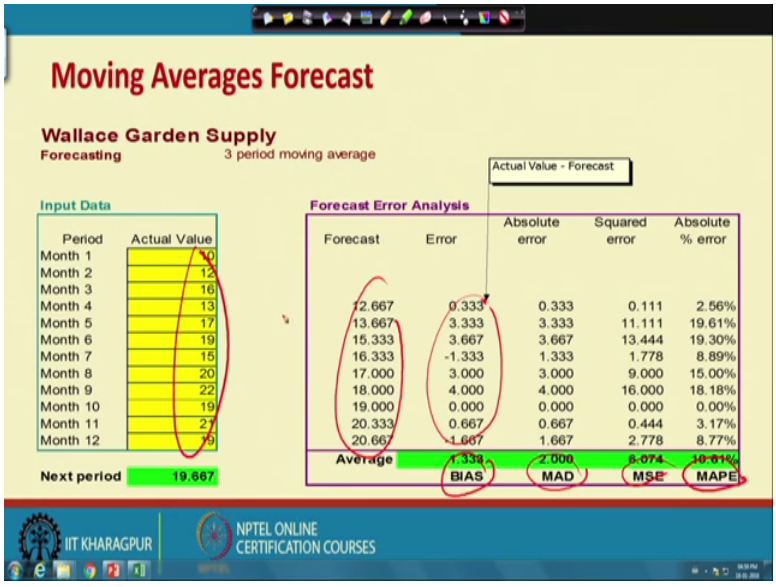

So, in the next slide, so we have actually actual values and then the forecasted value which we have here in the right side. So, then that will be taken into consideration here. Now, the actual value minus forecasted value, it will give you the error component. And now again so you will check the particular you know structure here so that means. So, this is the actual structure and then this is the forecasted structure and the difference will give you the error structure. And this is the sum of the error terms that is actually mean

error and then mean absolute deviation then it is actually mean square error then mean absolute percentage error.

So, we have completed earlier. So, it is just sum a we can actually calculate here. And then check whether actually you know this particular forecasted you know structure is rightly to go for the prediction or not. So, likewise we have actually lots of you know similar kind of you know techniques through which we can you know go for the predictions.

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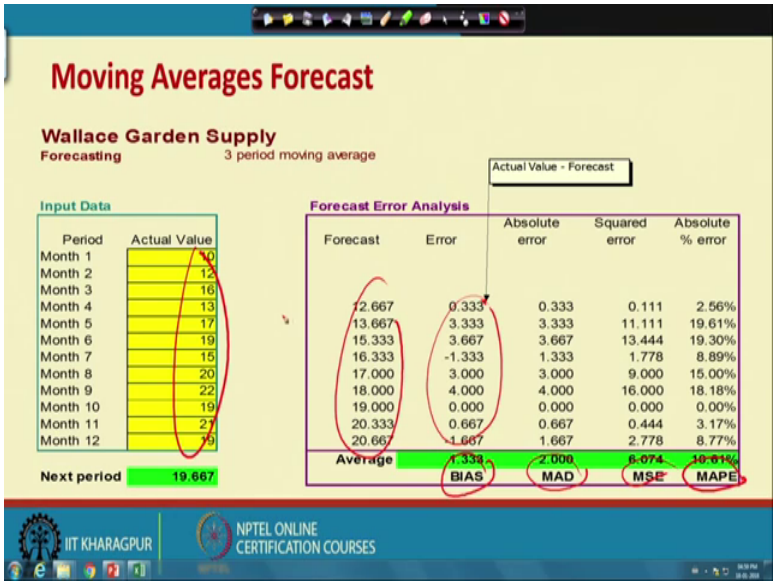

And again if you compare actually this is the actual scenario that is the you know blue one. And then the yellow one is the forecasted figure which starts with you know at the third point because it is the kind of you know three-year moving you know three-year moving average forecasted structure.

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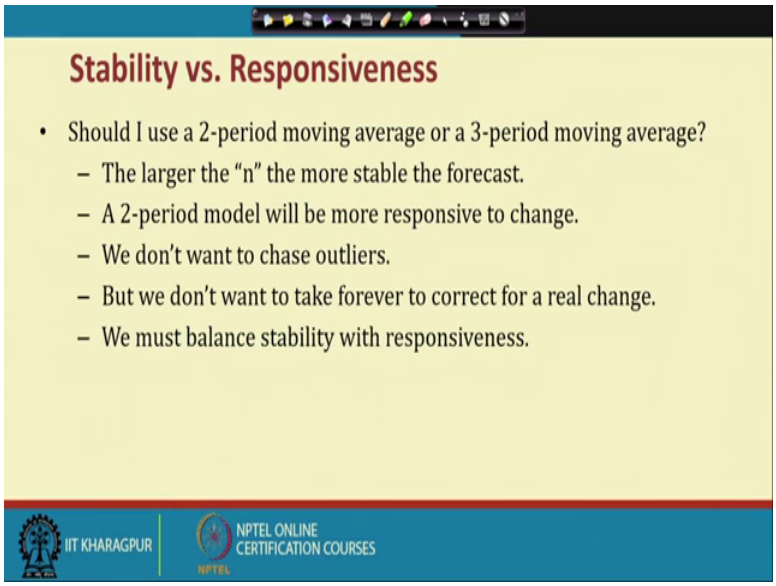

Again so far as a stability point of view, you know we like to check you know whether you know the three-year structure or five year structure or seven year structure is more effective. So, when only add you know you know 3 to 5, 5 to 7 then you know the idea is that you know this tablet will be more accurate because you know every time you are normalising with you know bigger spool of the data.

And obviously, the forecasting will be strengthens as per the particular requirement. And by the way every times through these you know indicators you can check the fitness of the models and then finally that will be useful for the kind of you know prediction and the forecasting's.

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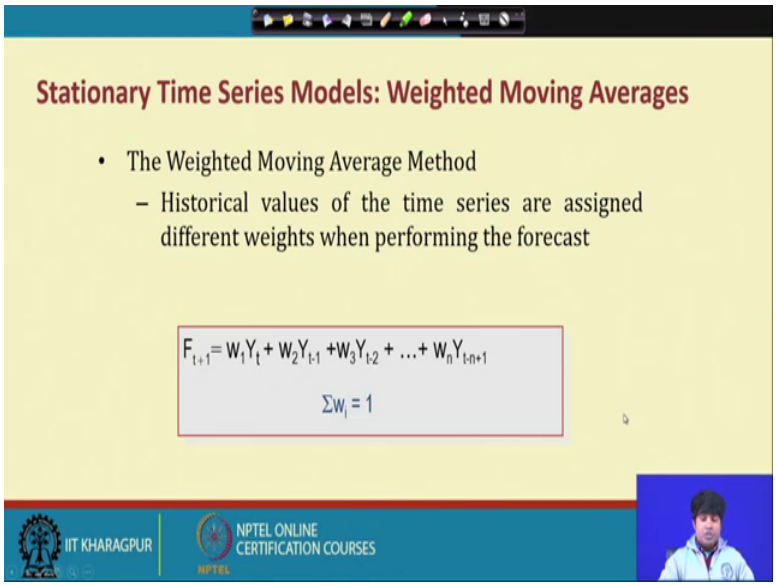

So, now against there is another model called as you know weighted moving average. So, in that case, same way we are going for actually you know three-year moving average or seven year moving average, but every time now it is now a simple kind of you know addition and the kind of you know mean calculations. Here we like to allow weight and then we can calculate the average. So, some of the weight should be equal to 1.

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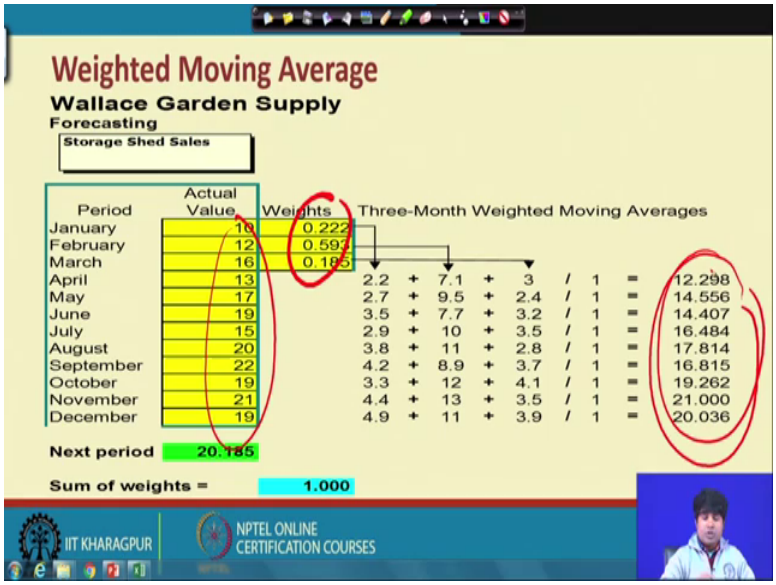

But weight will it you know you can go for you know you know equal weightage or unequal weightage, but equal weightage there will be you know you know 0.2 go for

these weightage, so obviously weight should be unequal. But how you have to assign weight for 2 d in the three different structure so that is actually a question mark. Sometimes you know we use principle component analysis to derive the weight use a kind of you know structure through which you can actually go by in weighted moving average.

So, now in this case we use actually let us say first one is 0.22, 0.593 so that means, actually we assume that you know this is a kind of you know weight structure through which we can actually we can we can actually go for the kind of you know prediction. And now the same structure earlier we are you know adding 10, 12, 16 and taking the average now 10 into W 1, 12 into W 2, 16 into W 3, where W 1 is equal to 0.222, and 0.593, and 0.185. So, as a result this will give you the forecasted figure. So, now this is the actual figure and this is the forecasted figure.

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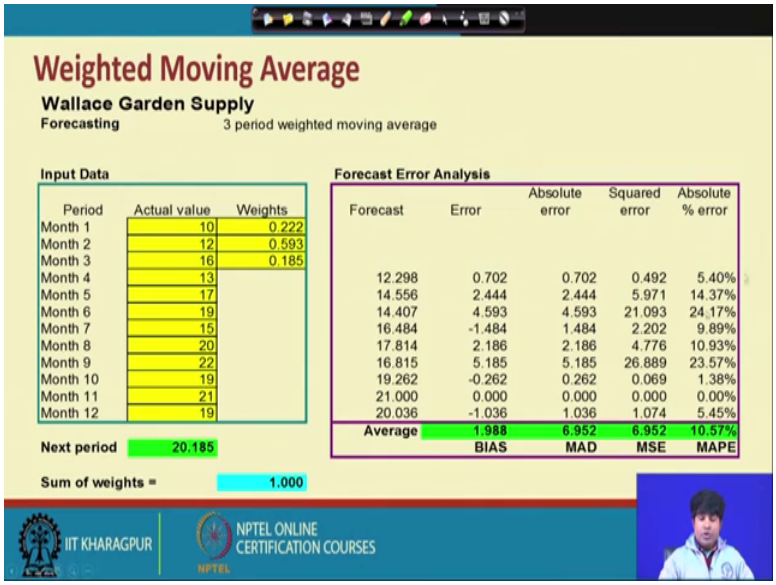

So, what will you do again, so we will go the same kind of you know structure and then we will check the kind of you know error then first check is the find out the error terms and you check the mean error. And then mean absolute error, then mean square error, then mean absolute percentage error and similarly root mean square error. So, this actually standard structure; only the structure is actually what is the particular mechanism which we apply to get the forecasted value. So, the actual value will be there. So, we need to have a forecasted value.

But here the beauty is that you know the forecasted figures are well connected with the actual structure and that is how the time series prediction is slightly different than the cross sectional predictions. So, the typical structure is actually you know called as you know weighted moving average. And that too we have already discussed the Naive forecasting simple average and weighted average moving average forecasting structure.

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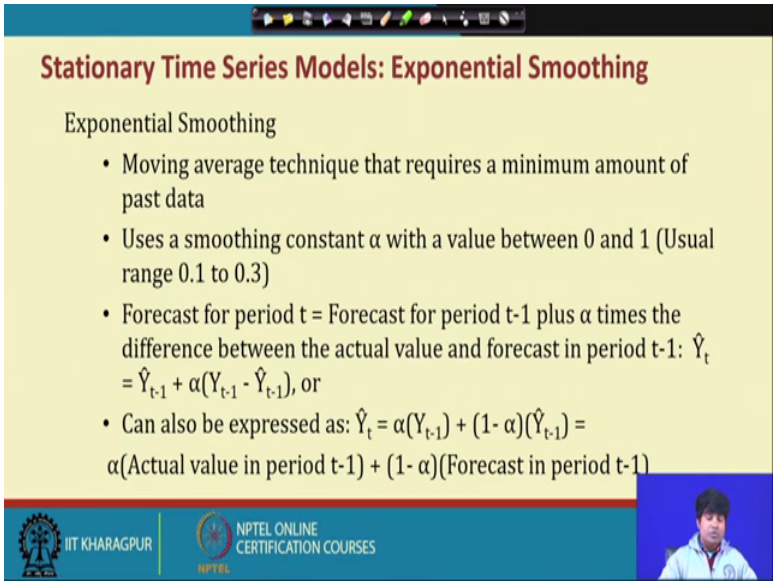

Again, whereas, you know similar kind of you know models are there exponential smoothing you know structure through which you can do the predictions. So, now, in this case, your forecasted figure will depends upon you know the structure of you know you know previous years you know data, and the kind of you know the difference between the two different time periods and the kind of you know forecasted figures. So, this can be another way to do forecasting's.

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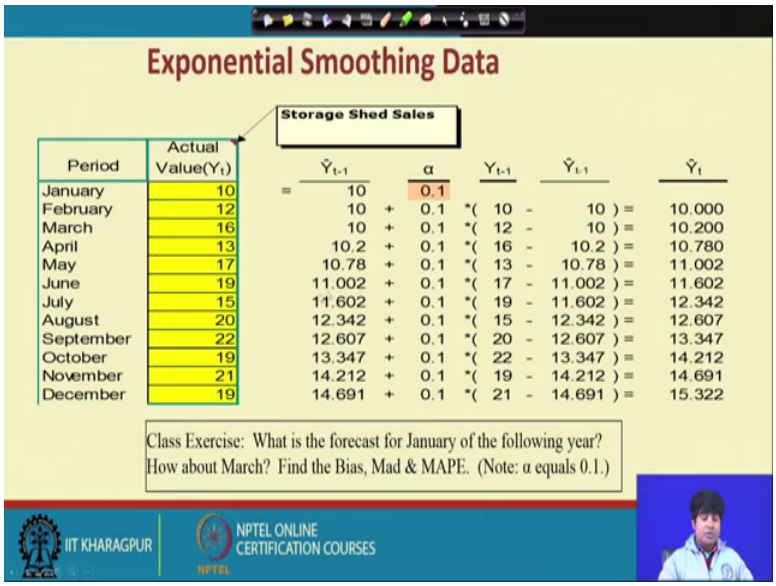

So, now, in order to understand the data structures so let us actual values actual value can be represented as Y t. And then we calculated actually Y t bar that is or Y t head that is called as you know estimated structure and the lag of the estimated structures. So, now, the error the this is how the modelling structure through which means as per the particular you know formula here. So, we have to just connect here. So, this is what the kind of you know exponential smoothing structure through which actually you have to find out the predicted kind of you know environment ok.

So, once you get this particular you know predicted structure then again you will go for the you know comparison. So, this is actual. And by default this will be finally, the predicted component. Then again similar way we have actual value and then the forecasted value, and the difference will give you the error component. Again you find out the mean error, mean absolute error, mean square error, mean absolute percentage error and then finally, root mean square error.

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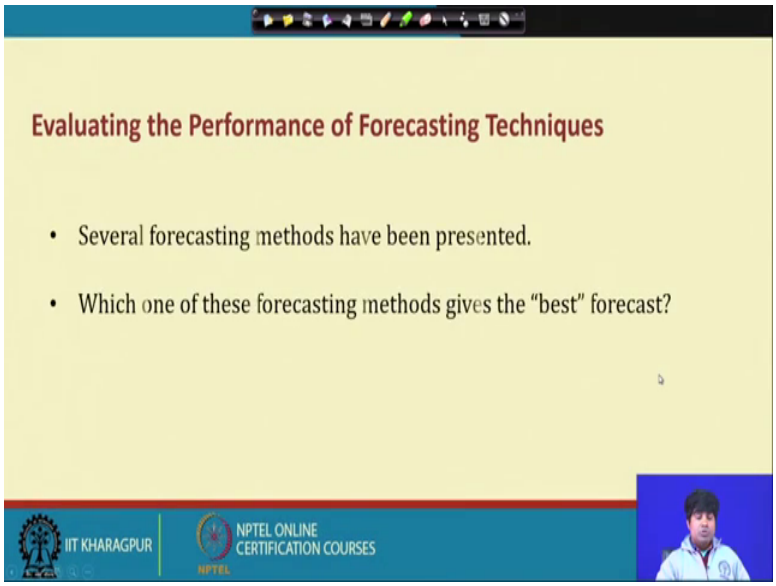

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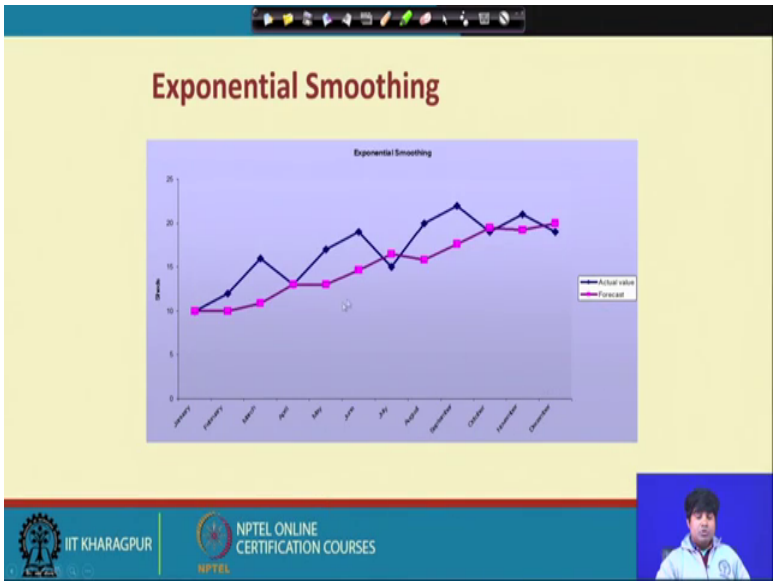

So, likewise actually you will find here so many this is comparison between the actual plotting and the forecasted plotting through exponential smoothing. And the every times you will find there is difference and some error are positive, some errors are negative which we which is as usual and that is good for the kind of you know prediction structure. And that too when the data is in a kind of you know time series framework.

So, now, again question is the what is the proper evaluation technique through which you can say that you know which model is actually best fit for the particular you know

prediction and the particular you know business requirement so far as you know perfect management decision is actually you know is the kind of you know requirement. So, in that case what will you do, so we have a different kind of you know models. We have a discussed Naive techniques, moving average, three-year moving average, five-year moving average, then weighted average then smoothing techniques. So, that means, you know same problems and you use different kind of you know prediction structures or forecasting structure.

Then what we like to you know do that you every times you know by using a particular technique forecasted technique, you find out the error terms. And then find out the error indicators that is the mean error, mean absolute percentage error, mean absolute deviations, root mean square error, then you do the comparative analysis. So, technique one, technique two, technique three, then you report all these indicators. And usually a particular you know structure will be declared as you know very effective for the prediction and forecasting, if the particular error indicators behaviour is very less. So, that means, the error mean square error, mean absolute percentage this should be actually in a kind of you know declining structure.

So, when the kind of you know when there is a kind of comparative analysis between two models, in one particular model the mean error mean error or mean square or root mean square error are comparatively low compared to the first one then by default the second model will be derived choice for the prediction and forecasting. So, the so the idea is here when we when our judgment is which one is the good forecasting technique so far as the particular business requirement is concerned or particular management decision is concerned, so we have to create some forecasted models.

Because same problems can have a different forecasting structure like what we have already highlighted here for five techniques. And then finally, we have to declare that you know which particular technique is more effective more efficient so far as a the particular problem is concerned. And that is typically based on this you know the so the kind of you know validation will be through these indicators only. A particular model will be declared as you know efficient when the these error are having actually low level compared to the compared to you know previous models or you know forecasting with you know previous techniques.

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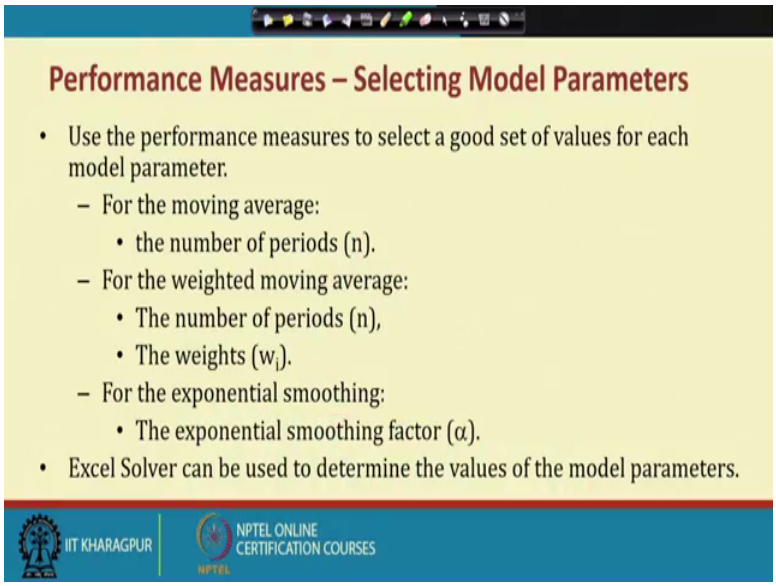

So, there are you know many, many ways we can actually check the performance you know structure through which you can declare the model is best fit for the prediction and the kind of you know forecasting's right.

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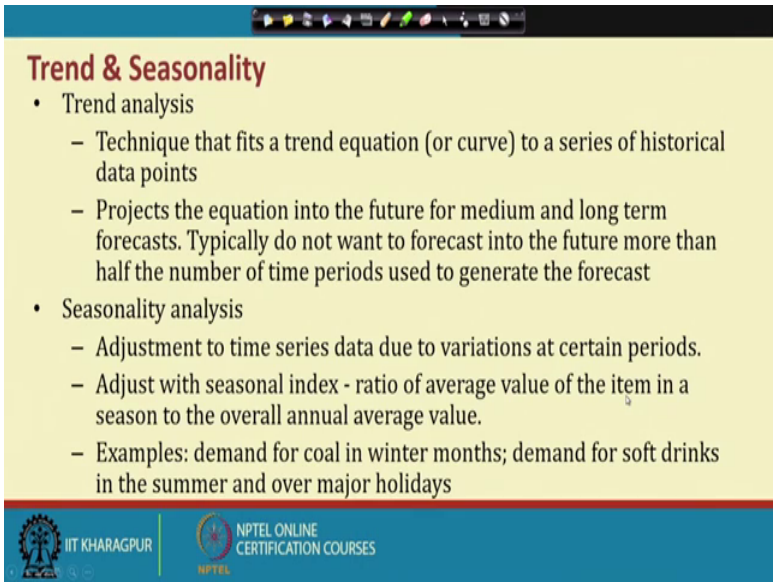

So, there are some other issue like you know trend analysis and the seasonality, all these things will be you know there in the particular you know process. And in fact, in this particular you know time series framework, we can also use dummy technique to find out you know the kind of you know seasonality effect and the kind of you know

quarterly effect, monthly effect, and but for that you know you may you must have actually big data set. And then these are things we can you can also target, and we can also explores or you know there are other things like you know structural way also can be checked when you have the data with respect to time for a particular you know variables.

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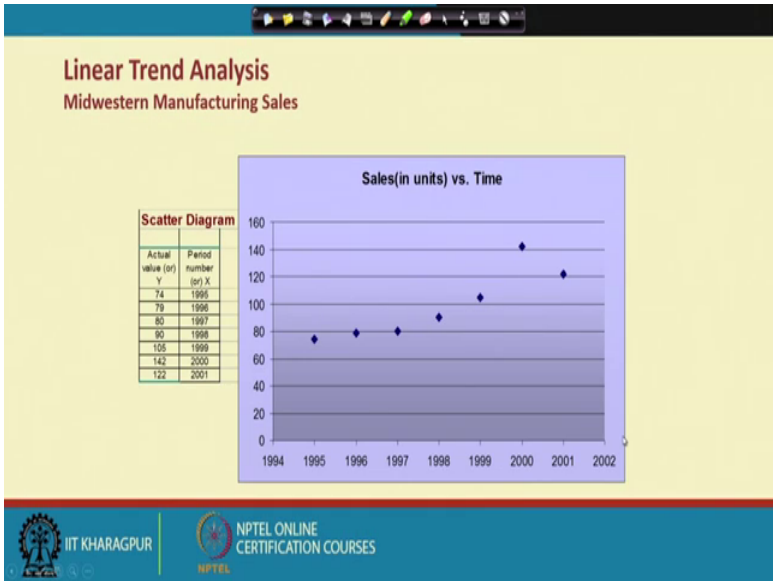

So, likewise you know there are many things which we can actually explore and means the idea is that here. So, in the time series structure, we have actually n number of techniques through which we can prepare a forecasting models or you know predicted model through which you will do the forecasting's and do the you know predictions as per the business requirement.

So, we have actually some of the discussion we have already discussed so many techniques. And a likewise there are couple of other techniques are there which can also you know means very useful for the kind of you know prediction and forecasting. And that too in the context of a even in the context of you know time series modelling. So, we will continue this particular you know discussion in the next lecture; and we will stop here and.

Thank you very much, have a nice time.