Econometric Modelling

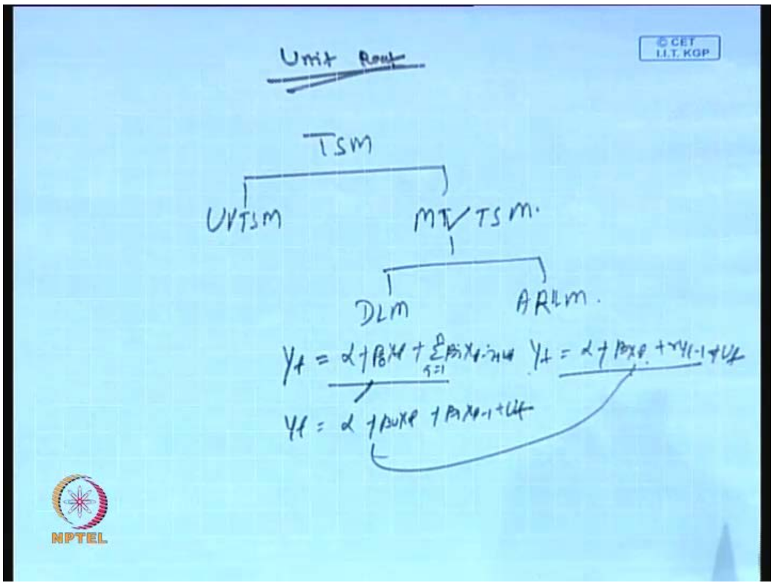
Prof. Rudra P. Pradhan
Department of Management
Indian Institute of Technology, Kharagpur

Lecture No. # 38
Unit Root

Good afternoon, this is doctor Pradhan here, welcome to NPTEL project on econometric modelling. So today we will continue the time series modelling. In the last couple of lectures, we have discussed the entire frame work of time series modelling means, we have discussed how it is different to cross sectional modelling and panel data modelling. In on the time series modelling, we have discussed various issue, various types of time series modeling in that too, we have discussed the volatility aspects of econometric modelling. Basically, time series modelling is divided into two parts - univariate time series modelling and multivariate time series modelling. And again under multivariate time series modelling, there are two different types of models we usually handle, one is called as distributive lag model, another is called as auto-regressive lag models.

So, there is also mechanism, how to transfer the distributive lag model through auto-regressive lag models. So, because most of the cases and most of the in means situation in the higher labels, we will handled directly with auto-regressive term models. The difference between these two is that, in the case of distributive lag models, it is the endogenous variable as a function of exogenous variables, and the error terms means exogenous variables it with respect its current time appears and its lag. Similarly in the case of auto-regressive lag models, endogenous variable as a function of exogenous variable and its lag, and endogenous lag and error terms, so like this.

(Refer Slide Time: 02:01)

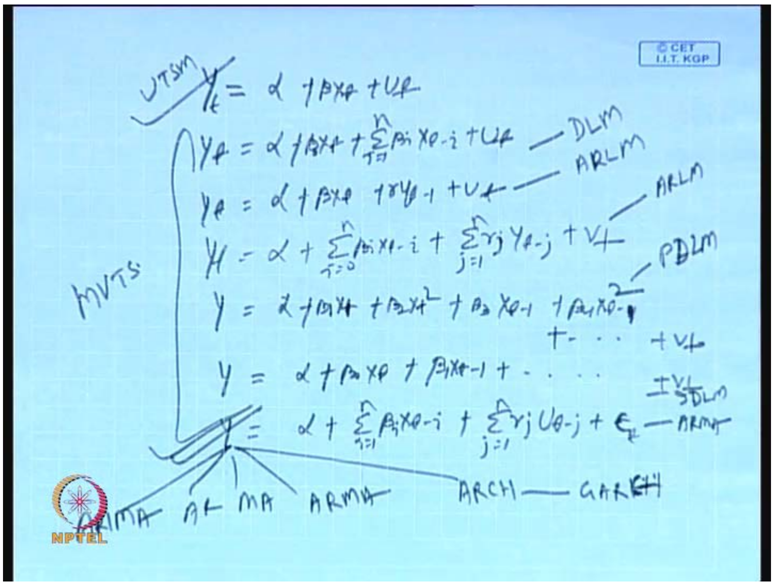


In the case of time series modelling, basically divided into two parts, univariate time series modelling, then multivariate time series modelling. In the case of multivariate time series modelling, we have discussed distributive lag models and auto-regressive lag models. So, here is the frame work is a like this, Y t equal to alpha plus beta x t plus summation beta i x t minus i i equal to 1 to n. So, this is better equality beta 0, and then this said Y t equal to alpha plus beta x t plus gamma y t minus 1. For simplicity, we are just putting simple models like this or this is obviously U t or if you like simples, then it is betters put Y t equal to alpha plus beta 0 x t plus beta 1 x t minus 1 plus U t, so this is U t minus 1, this is U t.

So, this moralism there is mechanism how you to transfer in this particular format. So that means, they this two are moralism's. So, this is how what we have already discussed in the last couple of lectures. The basic frame work is means; first I will once again highlight the various forms of time series modelling, then we will discuss various issues and problems related to time series modelling. And that two here, we have to discuss to aspects of time series modelling that two unit root and co-integrations. So, unit root is one of the typical problems we have to understand or you have to explores, in the case of time series modelling. And the other side's co-integration, it is a multivariate frame works, so that means for co-integration techniques, you must have at least two variables in the systems. While in the case of unit root, there is no such condition, so you can start with one variable at a time.

So means in the case of unit root, objective is to know the particular features of a particular variable. We will discuss details, when see will enters to this enter root concept. So first up all, what is the basic, what are the various types of modelling we have to usually handle? So, I will briefly highlight all this things and then will come down to unit root test.

(Refer Slide Time: 04:33)



So, as I have mention there is a there are two divisions of time series modelling, one is called as univariate time series modelling and another is called as multivariate time series modelling. In the case of univariate time series modelling, we will put alpha plus beta x t plus U t. So, in the case of, this is obviously U t, then U t Y t equal to alpha plus beta x t beta 0 x t plus summation beta i x t minus i i equal to 1 to n plus U t, this is another form of the models. So, then another form of the model is a alpha plus beta x t plus gamma y t minus 1 plus u t. Then similarly, y can write like this alpha plus summation beta i x t minus i i equal to 0 to n plus summation gamma i y t minus or gamma j y t minus j j equal to 1 to n plus b t, this is another form of the model. Then we can also write alpha plus beta 1 x t beta x t plus beta 2 x t squares plus beta 3 x t minus 1 plus beta for x t minus beta for x t minus 1 whole squares, it will continue plus v t, this is another form of the model. So, there is another form of models called as y t equal to alpha plus beta 0 x t plus beta x beta 1 x t minus once plus continue plus v t.

And another form of the model is alpha plus summation beta x t minus i beta i i equal to 1 to n plus summation gamma j U t minus j j equal to 1 to n plus epsilon t. So, these are the various forms of the time series modelling. So, what means we have to x plus in various aspects. In the last class, we have discussed this particular model, particular this type models. That to, you know we have discuss auto-regressive, moving average, ARMA auto-regressive moving average, then ARIMA auto-regressive integrated moving average, then we have discuss ARCH model and also we have discuss GARCH models. Auto auto-regressive condition data heteroscedasticity and auto-regressive generalize auto-regressive conditional heteroscedasticity.

So these are the components we have discussed in the case, in the last couple of lectures. So, this is univariate time series modelling and these are all called as multivariate time series modelling. That to this is purely distributive lag models, this is auto-regressive lag models, this is infect auto-regressive lag models, this is polynomial lag models, polynomial distributive lag models, then this is infinite a distributive lag models and this is ARMA models, so this is ARMA model. So, these are the various typical features of time series modelling. So that means time series as lots of issues and lots of concepts, so many concepts in front of view. So, we have to handle one particular problem. So, means at a particular point of time you may go through any particular models.

So, the as usual the basic from work of this particular modeling is that, so you have to fit a proper, you know proper functional form of the models and proper estimated models with respect to all this is specification means, all this test like you know specification test, goodness fit test and digit test. So, in the means, that means we have to every times we have to go to through the estimated parameters and the overall fitness of the models. That you know inverse statistics analysis of means a like you know r square adjusted r square, so that is mostly have analysis variance. So in the other sides, we may have diagnostic test like you know root means square error square root square errors, then you know mean epsilon deviations, mean epsilon percentage error. So, these are the thing we have to incorporate at a time in the case of time series modelling. So, these means, at a particular point of time we are very much concerned about the estimation of a particular models.

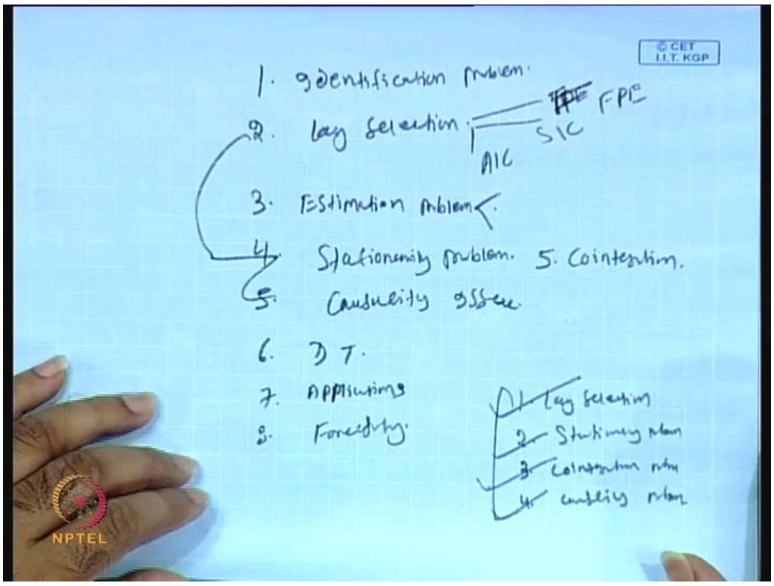
Before estimation of a particular model, we have to very careful about so many things. The wave when we are when we talk about the cross sectional modelling and panel data modelling. That two simultaneous or structural equation modeling, whatever may be the issues. So every times, which start with the application of O L S then ultimately O L S has a certain assumption and subsequently, once you have the estimated a estimated model. Then we have to compact to again assumptions and assumption has to be checked properly. If it is okay then that model can be consider as the best models and can be use for forecasting or policy use. Provided it has gone through all this specification test reliability test or something something. So that means, all together, we need to have a good models which can be used for forecasting and policy use.

So now as a result, we are going through various shapes on various structures. And one of the structures here is the time series structures, that to various forms of the models. In fact in the cross sectional modelling, panel data modelling, we have no search specialty. That is how, the time series is all about means, it has a lots of unit that is of, if there are various forms of the econometric modelling, we will be is generate or will create in comparison with cross sectional modeling and penal data modeling. Since, it is lag involvement, will create several forms of the model. And it is very intresting very you know more complex infect and also very justified so for as a forecasting and policy use is concerned. But you know, before you going to estimate all this models, any one of the models and for you know keeping in mind that you need estimated parameters and overall fitness of the models and all the this diagnostic element. So in every case, you must you must start with wireless techniques, but before that you have a works of standard assumptions. And let us assume that all this standard assumptions are also here, but here one of the more interesting points is that you know the stationerity issue.

So, the will come down to stationerity issue, this stationerity issue is model as you can say unit root problem. Before you go to particularly unit root problem, I typically highlight few; you know features of the time series modelling. That means we like to highlight, what is the problem aspects of time series modelling. Means in other words, we are very much concerned, what are the aspects, we have to no or we have to x plus in a better way are in broad way. So, that the time series specialty can be you recognize properly. In fact a it is somewhat different from the cross sectional modelling, the (( )) in the case of cross sectional modelling the step and structure is a model as very simples.

But in the case of time series modelling, the step and structure's are somewhat very complex. So, the various types of model you will give an indication. That there are the problems time series modelling is a complex problems and it has lots of additional features which are not there in the case of cross sectional modelings. We have to very serious, so that means, first of all what are the problem associated with this time series modelling. So, you at a time you can follow any particular models. Ultimately, you were men m in is it how to get the estimated parameters. And as a result, once means estimated models that are with respect to estimated parameters and other details statistics or that we will come to a position to check whether this model is more reliable, more accurate, and more appropriate, so that we can use for forecasting. But there are certain steps; we have to follow before you go to estimate estimating this means, model selection or you can say any times series modelling. So you see here is what are the problem basically will see?

(Refer Slide Time: 13:40)



As we have mentions previously, there is a separate lecture we have gone through that is called as identification problems. So here also same thing, there is an identification problems. So that means, the model may not be way perfectively the model may not be perfectly or sometimes, we may phase problems to handle or to detect whether it is distributive lag models or it is auto-regressive lag models or you can say, it may be ARMA models it may be you can say only auto-regressive models, so many ways you can find out.

It may be you can say, distributive lag model, polynomial distributive lag models or you can say infinite distributive lag models. So many ways is you have to find out, you can say or you can enter to any a new type particular problem, but the thing is that, so that particular models must be perfectly for you that is called as a mathematical perfection of the systems. If that is not the case, then obviously, it is question of imperfect condition of this particular model. So, that is going against the systems. As a result, you must be very particular about this a at a time series system. So in this particular setup, identification of problem must be very important, so you have to properly identify the particular step of the models. Second lags selection, there is a problem of lags selection, because as I mentioned, once you start with time series modelling, even univariate say or multivariate say. Where there are at least two variables in the systems and we have to start integrating with their lags.

So now, you know when you have one variable then you get hundred numbers of variables also, you can go for five numbers of variables. But the thing is that it depends upon two things, first thing is you must have an enough number of sample observations. And second thing you cannot choose artificial issue. So there is mechanism, how to choose the lag length; that means, optimum lag length as to be consider that is y this is very complex process. It is not like that you have to uses like cross sectional modelling you have to just fix the model. So, i equal to alpha plus summation beta x i that is all the problem is an altogether complete. And you have to just a get the estimated parameters and other feature other statistics then you have to go to predict test. But here itself, there is a additional problems that is you know choice of lag length means, once choice of lag length is fix then you have to get the estimated parameters or other statistics, then you have to go for its reliability checking that specification check or you can fitness of the models, etcetera, etcetera.

So, lags selection is the most important criteria, in the case of time series modelling, which we have discussed in the last couple of lectures. Lags selection basically, we use three statistics. You can say (( )) information criteria, squares information criteria and final prediction error final predictions error prediction errors. In fact we have final predictions error; in fact we have more number of statistics which confuse the optimum lag length.

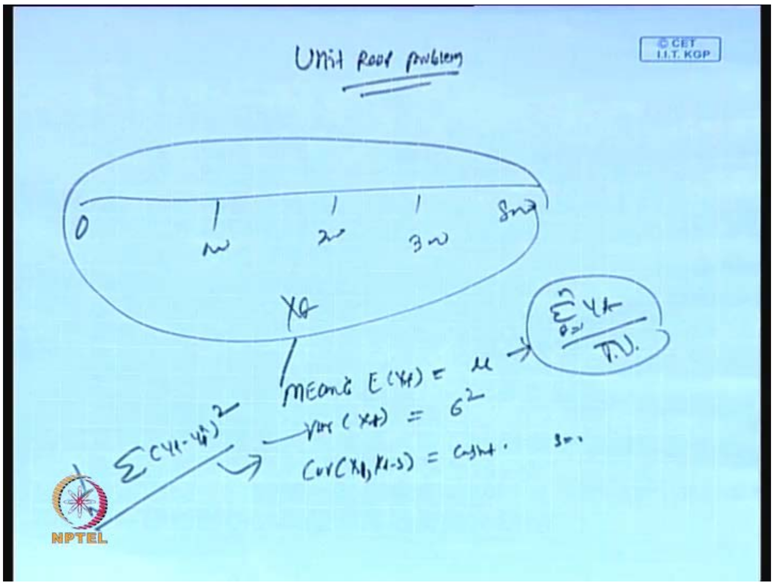
What this three statistics are very standard statistics and there frequently using the time series modelling. So, lags selection is very important, so we have to solve this lag solution with the help of the following statistics. Then third is estimation problem third is estimation problem estimation problem. Estimation problem means, you see here is we usually start with wireless technique. And if wireless techniques means, whatever estimated results you will have with wireless technique and that is to be gone through the you can say that is to be gone through you can say you can say that is to be gone through over fitness of the test etcetera. So, it is very easy to establish that whether this model is perfectly okay or not. just one minute.

In the model estimation, so estimation problem is very important issue here. So we must be very careful whether the model means, whether the technique is essential wireless technique or other techniques like realize technique or maximum likely hood estimator etcetera. So we must be very careful. There is as usual estimation problem and this particular problem is also there in the case of cross sectional modeling. So, estimation problem is there again in that time series modelling then most important thing is the stationerity problem. So, then must important thing is the stationerity problems. So now in the case of stationerity problems, that is over manger and today's discussions stationerity issue is that very simple statistics, we will come down again to that particular aspects. It is better I will first highlight then will come down to stationerity issue. Fifth, then that is the called as a causulity issue. Before that, there may be another trick called as cointegration. That means, this is purely multivariate frame work and then causulity is also multivariate frame work.

So, multivariate time saying with respect to one is to two; if it is one variable in the system and if then there are two variables in the system. One variable with its lag is not we are considering a multivariate. So, multivariate means two particular independent variables then we have to play the game with their lag involvement. Then causulity issue then finally, as of course, there is diagnostic test. Then you know applications and then finally, forecasting then finally, forecasting's. These are the things means as this is as usual standard process of any econometric modelling, but here means here in the time series modelling frame work. So, the major things are you know lags selection, stationerity problem, cointegration and causulity. So that means, we have the problem of lags selection, then second is the stationerity problem, then third is cointegration problem, then forth is causulity problem.

So now, in the next couple of lectures, we have to highlight only on this particular aspects. So lags selections infect we have already discussed. So our main things which are left are stationerity problem that is unit root concept, co-integration problem and causulity problem. We start with the first this stationerity issue. So first of all what is stationerity?

(Refer Slide Time: 21:18)



So, this stationerity otherwise called as, it is unit root problem, it is called as a unit root problem. So, first of all what is stationery? Stationery means you see in there are critical meaning and there is also statistical meaning. So for as a in this particular structure, in that infect this particular term is a very valued in very applicable, in the case of time series setting only. So, now statistical a stationerity means or unit root mean, first what is unit root? Unit root means, it gives in signal to stationerity issue. So now, what is means by stationerity? In a statistical frame work, stationerity means main variance and covariance in must be exactly equal to 0, constant mean we can say, constant mean, constant variance where instants we have a timeline like this way.

So, let us a 0 to 500, 0 to 100, 0 to 200, and 0 to 300 like this. Every time will check, because it is in the broad game actually. So, we are collecting few samples and testing all this things. And of course, the process of selection should be random in natures. So now, what is the agenda here? So, unit root as a three aspect, so that means, it is mean let us there is variable say x t. So, mean of x t, that is called as error of x t must be constant, let us say mean. So, then variance of x also constant, lets a sigma and covariance of x t, then x t minus s, let say it should be also f constant. So, provided here if we you know s equal to 0 then obviously, it will be come down to variance of a x; means what we use to do in the cross sectional setting, we put x i x j where i equal to j then it will becomes variance and i not equal to j it will covariance. So, similar here x t with x t minus, this is in not simply x it is obviously, all are x t minus x, so this should be constant.

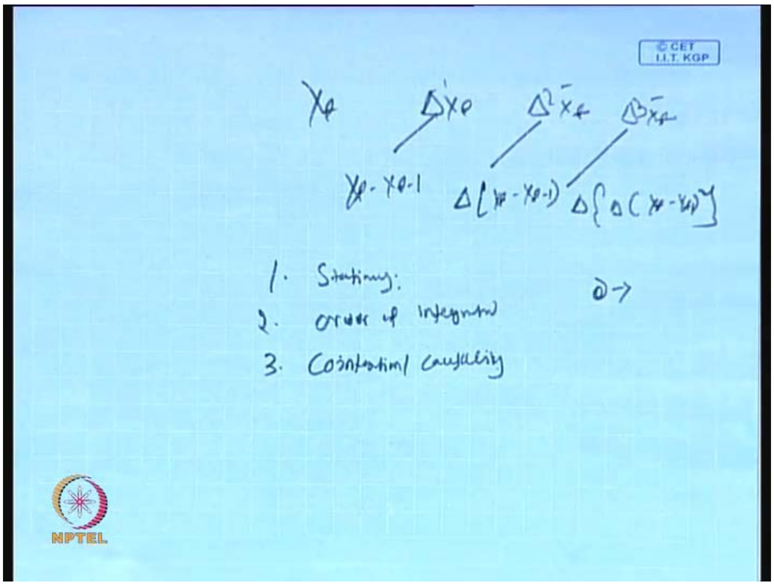
So that means, the time series modelling it should be schostatic process the choice is very much random in natures. So, random we will syllabus then thing you to find out the mean variance means, a very theoretically or you can say very (( )) how you to check the stationerity etcetera. So, then there is statistical procedures complicated procedures through which we can easily deterred the stationerity issue etcetera.

Now, what is mean i x? It is simply like this way summation y t y t equal to 1 to n divide y, you can say n number of total observation. This is how mean by of x t, we can derive. Similarly, variance of x t is nothing but y t minus y t y t bar whole square divide by 1 by n. So, this is variance is to be calculated. Similarly covariance, y t minus y t bars into x t minus y t minus 1 into y t minus bar obviously, it should be a constant. So, this is how we have to check the stationerity problem all together. So now, first of all what is the basic objective behind this stationerity? Means unit root.

Now the basic objective, there are two three objectives specifically for this unit root problem. First objective is to know the stationerity time series all time series variable in a particular system should be stationery. If it is not stationerity, generally particular not generally particularly financial time series variables they are stationery in natures. So that means, they have uniform unit root problems in the initial setup, but whether there is means you have variables then you have job is to check whether there is a stationerity or non-stationerity. But most of the cases, in the particularly financial time series variables you will find the variables at the original form is always unit root problems in non-stationerity.

So, then you have to continuously, you can say difference integrate till you get the variables stationerity; then finally, the variables which the difference variables should be huge in a final setting, so where they variables stationerity in nature. For instance, there is a variables x t, so for instance there is a variables say x t. So, I will call x t, I will call delta square x t I will call delta q x t.

(Refer Slide Time: 26:24)



So, this how I can proceed. So, this is called as a fast difference, this is called as a second difference, there is methods like differentiation, there is difference method. So, delta x t means, it is a nothing but x t minus 1, delta square x t minus x t means del upon again x t minus x t minus 1. Similarly, del three means you should del upons and del upons again x t minus x t minus 1. This is how we have to be means, we have to proceed furthers, till you get you know or stationerity. That means, a most of the financial time series the variables may be means variable must probably it is stationery unit root problem here, non-stationery. So, when we go for first difference then obviously, the series may be stationery. So once it is stationery then this variable particularly means the variable this is called as a transformation rule.

So, generally there are two wage, we have to use the data in your modelling frame work. So, either original variable or you can say a transferred variable. There are many wage you can transfer the variables and one of this is one of such important transformation rule particularly for the time series setting is the application of difference equation.

We are using difference equation for stationerity checking and also we have to find out the order of integration. Where the variable is stationerity and that order has to is use for you can say further estimation process. That is estimation is process is very complicated category in the case of time series setting. Until, unless you know the order of integration, then obviously, it is very difficult to fit a particular model, means particular causulity models.

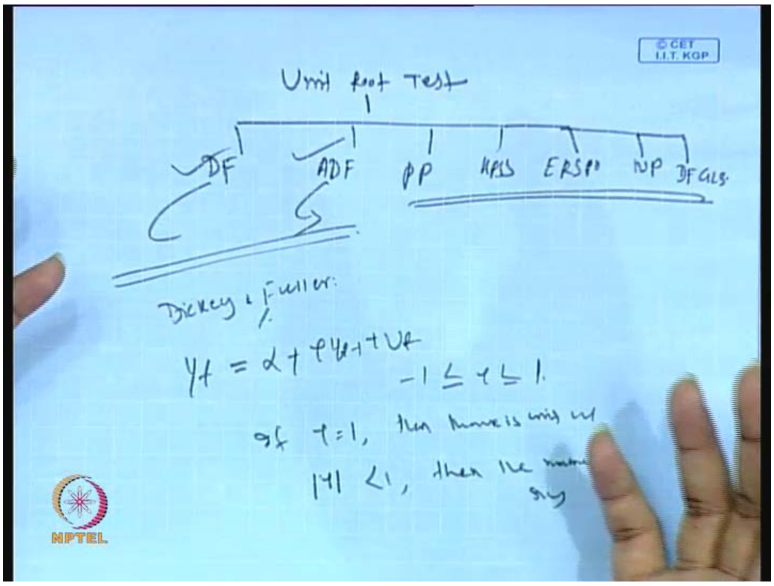
So, there are three problems. First is a no the stationerity, that is you can say stationery problems, so stationerity of the time series data. So this is the second problem is the order of integrations. Order of integrations means like this and this is order 1 this is order 2 this is order 3. That means, the variable the means there are various the means interpretation is like this. So, if the variable is stationery, then you can say that the variable has a no unit root problem and it is stationerity the label data, means in the first instance, you were getting the result that there is no unit root problem. So, if it is a non-stationerity then you have to go to the first difference. Then you check again whether it is stationery and non-stationery. If it is a stationerity, then obviously, you have to use that particular order for further estimation or further investigations. Or if it is again not stationery then you have not go for an another different difference. So, this is how particular term is called as a small d, d represents order of integrations.

Generally we mean most of the cases; you will find the variable is non-stationery at the label data. But when will go for fast difference, you will get stationerity; so most of the first difference label, so that variable is very much useful for the time series setting. This is how the structure and then third thing is, it will give you signal for cointegration and causulity, because ultimately in the time series setting. So, there are three altogether games. So, first is unit root setup, second is cointegration and third is causulity. So, unit root will give you the stationerity issue. Until unless you say the stationerity then the variable cannot be you cannot proceed furthers. If will proceed further without checking stationerity, that is the wrong way of entering to the time series econometric modelling. So, first entry label is check the stationerity, then you have entered to the second label. The second labels, here you have check the cointegration. That means, cointegration means they existence of long run equlibrium realationship, long run basically long run relationships.

So, we start with certain analysis, and then will go with long run analysis. Certain causulity, long run causulity, and then finally, we will end with the direction of causulity. Means here time series issues. So, there if there are two variables say then either x influence y or y influence x. So, this is how it is called as a there is a possibility of bidirectional causulity, but in the case of cross sectional settings, we usually go for one causulity, excepts simultaneous structurally equation modelling, simultaneous equation modelling. Other case, it is one causulity. That means, every times there are one dependent variables and other independent variables. And it is the impact through independence variable to dependent variables, but here the structure is there is, if there are two variables then there may be chance a x causes y and y causes x.

So, that is how. So, there are three different issues we will find. So, either they may not causes others, they may cause other at the one way, that means, that is one way causulity or it is called as unidirectional causulity. That means, if x causes y, then y not causes x, then similarly, y causes then x does not causes y, but then, if both will cause is other then called as bidirectional causulity. If one cause and another is does not exist and it is called as a unidirectional. If both will not cause is other, then there is question of no causulity. So, these are the complete game of the time series setting that to this over the enter setup here. So now, first up all how to check the stationerity? So, the main aim of is here two check the stationerity issue here is.

(Refer Slide Time: 32:30)



So now, unit root test, first we start with the checking the stationerity then will go co-integration, and then you will go for causulity. Unit root test has a several methods to check the stationerity. First is called as dickey fuller test, augmented dickey fuller test, they can then phillips perron test then called as KPSS test, then called as a ERSPO test, then it is called as NP test and GPM test and then the DFGLS. So that means, dickey fuller then I will squares techniques. So, there are various techniques infect there are lots of research going on this particular structures, but to unit root co-integration and causulity. So, our aim is here to check the stationerity of a particular time series where means, how to check the stationerity of a particular time series very. So, these are the methods, any methods we will apply you get the stationerity is problems. You have to detect the stationerity whether the variable is stationery or non-stationery. And means whether it has a unit root problem or it is not unit root problem.

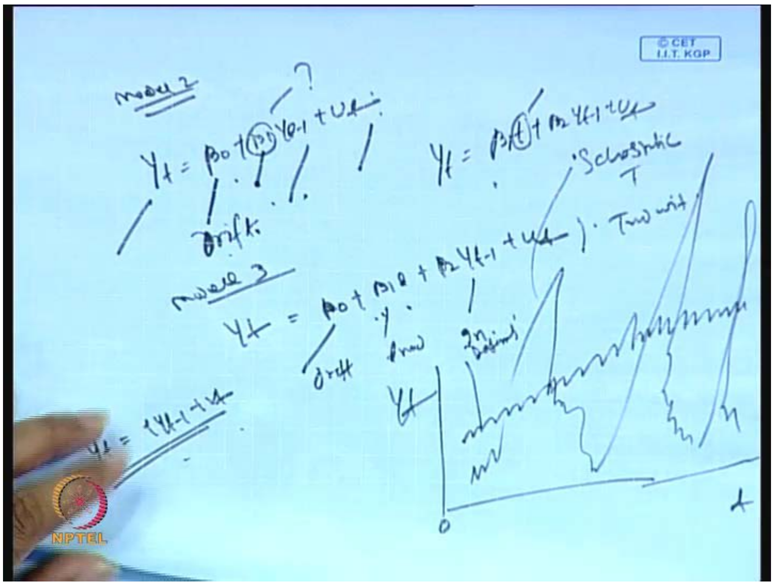
So, some techniques are very complex, some techniques are very simples. In a particular setup, if will if you get result in one technique then same results will get for from the other technical also. Provided, there may be plus minus is there means, something addition something subtraction not exactly, but you will get the themes done. So, the structure we start with is called as a dickey fuller test. So, what is dickey fuller test? Because basically, we will highlight these two test here, because this as very easy to apply and easy to understand and you know very quickly you can calculate the estimate estimated value. So, for as a class room problem is concerned, these two techniques are very useful, very handy. But in this technique you need to have the use of software, otherwise difficult to handle in the class room. So, let us a start with dickey fuller. So, what is a dickey fuller?

So, it is called as a dickey fuller test, dickey fuller and unit root test. So, what is the dickey fuller test, start with the you know regressive like this way y t equal to alpha plus rho y t minus 1 plus U t say minus 1 less than or less than and less than 1. If rho equal to 1 then there is a unit root problem then there is a unit root problems. So, if rho of mod of rho less than 1, then this variable is then the variable is stationery then the variable is a stationerity. So, this is how the structure is all together. So, there are infect there are many versions of the dickey fuller test. Then finally, there is augmented dickey fuller test. So that means, what you are saying.

So, in the very beginning of the time series setting, I clearly highlighted that, if we have a variable then you will created additional variables. Because in the time series settings one of the interesting features is that the current variables depends upon its first observations. So, as a result, there is another variable you have to create, y t minus 1, y t minus 2, y t minus 3 like this way, this is how you to proceeds; so that means, current variables will follow of with this fast values. So now, so, if that is the structure and that is structure creating, then obviously, two major problems you have to face. One is by default there will be multicolinearity problem and second there will be auto-correlation problem. And both are dangerous for the, you know so for as reliability test checking is concerned, overall fitness of the model is concerned. That means, if the problem if the estimated model has an auto-correlation problem or multicolinearity problem, then obviously, at the higher level, then obviously, that model cannot be use for forecasting in policy use.

So, that is why you must be very careful, how you to handle this situation. Obviously, one of the standard trick is that if will use the transfer variable, then obviously, most of the problems can be solves. It may not be there may be some mean of plus minus. But most of the problems, for instants if will apply first difference then auto-correlation problem may be solve and in the same times multicolinearity problem also. So, let me give you signals, because dickey fullers terms unit root has a different steps altogether to check the stationerity issue. Because, the time series variables has a different steps and different structures and with respect to particular setup; so, you have to use a particular form of the techniques, so that you can able to easily detect the unit root problems or stationerity issue.

(Refer Slide Time: 37:49)



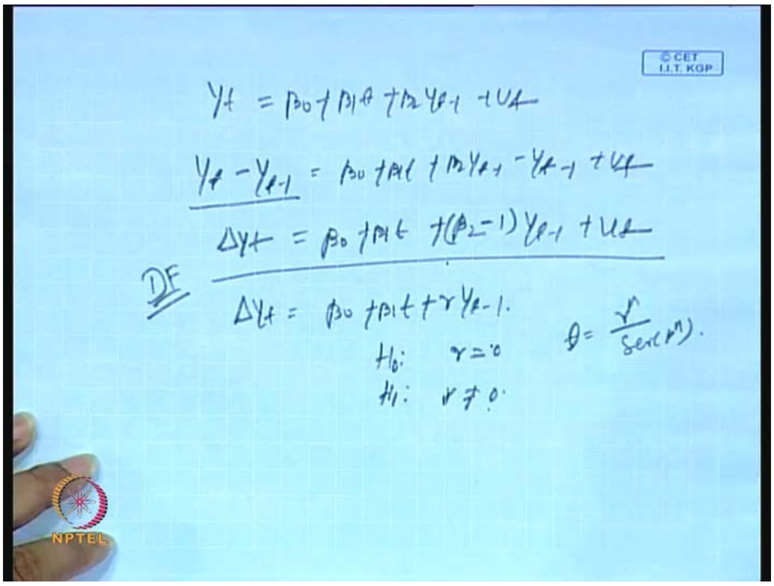
This is simple model once, in the model two, what will do? I will put like this way Y t equal to beta 0 plus beta 1 y t minus 1 plus U t. This is dependent variable, this is independent variable, this is error term, this is parameters which like to estimated and this is most important, because this significance of this will depends will it will be give you signal, whether there is unit root or not. And beta 0 is a constant is called as a drift, integer drift. Sometimes in the earlier case, we have not use any constant, now we are using the constant. And in the model three, I will write like this way y t equal to Y t equal to Y t equal to beta 0 plus beta 1 t plus beta 2 y t minus 1 plus U t. So, beta 0 is drift here, then this is trend, then this independent variables. Infect in between there will model, I can write a model like this way Y t equal to simply beta 1 plus beta 2 y t minus 1 plus U t. So that means, this a when I will write you know simple models like this y t equal to rho y t minus 1 plus v t. Then you know this particular model has a no drift and not trend this t transforms multi stands for trend here.

So that means, beta 1 t is, so that particular what is will give you the trend factors. The drift with the trend this is, without drift trend, this is drift without trend, this is trend without drift and this is trend drift trend with drift. So, this particular this called as a trend with drift. So that means, you may you must have here is initial setup may be very schostatic in natures, but you have to come down with the very deterministic trend like this. You see the structure will be like this way. So, all together like, this picture will find this particular step.

So, this particular structure is called as a schostatic trend. In between, I will give you a structure like this I will give you a structure like this way. This particular structure is called as deterministic trend. Of course, this is with respect to time and y t this is a respect to time and y t. So that means, you know your label, you know variables information in the original labels or that is called label data, then the shape of floating will like this way. So, it will be very much schostatic in natures, but when will go for transformation then obviously, it will be coming in a deterministic forms.

This is the forms you can find out. So, this is the process of integrate means this will be give you the processor of integrations or integrated process or you have to, if you like what is the order of integrations to get the deterministic trend deterministic trend deterministic trend.

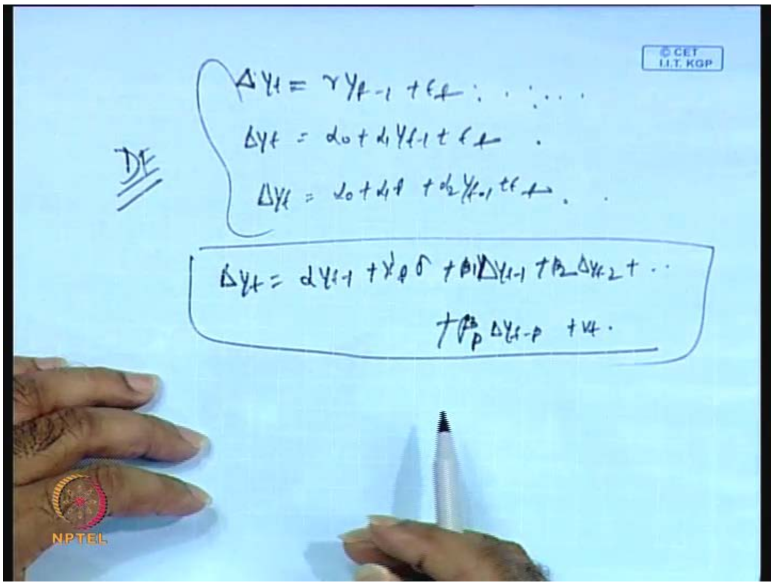
(Refer Slide Time: 41:11)



So now, we have the structures like this say Y t equal to beta 0 plus beta 1 t plus beta 2 y t minus one plus U t. So, this model what will do? So, I will subtract y t minus 1 both the sides. So, equal to beta 0 plus beta 1 t plus beta 2 y t minus 1 minus y t minus one plus u t. So, this is I will call it the delta y t, so this is delta y t; so, beta 0 plus beta 1 t plus beta 2 minus 1 into y t minus one plus U t. So, this particular structure is a dickey fuller models, it is called as a dickey fuller model.

So, now I can write delta y t equal to beta 0 plus beta 1 t plus gamma y t minus 1. So that means, here no life with see that gamma should equal to 0, against alternative hypothesis gamma, so not equal to 0. So that means, (( )) will less than to 0. Of course, here you to apply the t statistics to know the significance labels. That is nothingbut, gamma by gamma hat by standard error gamma hats. This is how you to calculate dickey fuller test statistics. So, dickey fuller test statistic has a several versions. So, I will give you means, if I will summarize then there are specifically three different steps.

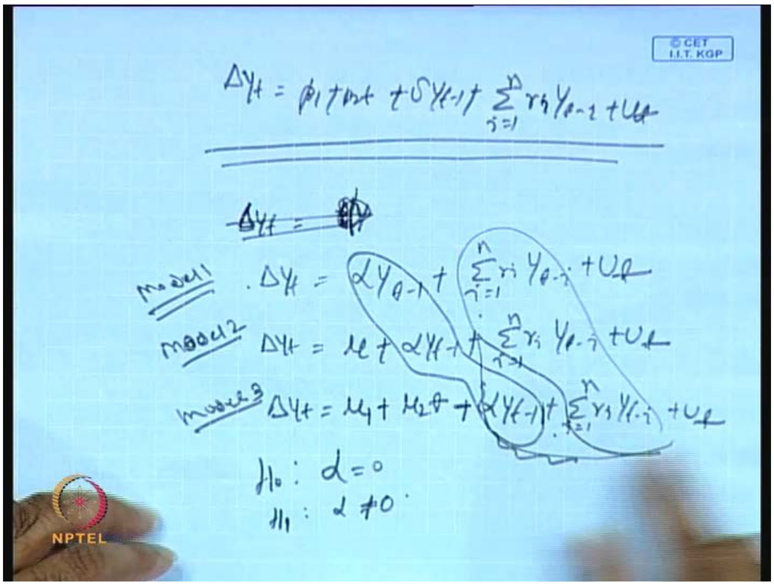
(Refer Slide Time: 42:53)



So, first step is like this. It is delta y t is equal to gamma y t minus one plus epsilon t, this is single one forms. Then another is a delta y t equal to alpha 0 plus alpha 1 y t minus one plus epsilon t. then delta y t can be alpha 0 plus alpha 1 t plus alpha 2 y t minus 1 plus epsilon t. So, this is you know without drift and trend, this is with drift, and this is with drift and trend. So, these are the things of you can say, it is called as a dickey fuller test statistics. So, dickey fuller test is a generally use to test the stationerity problems. So to check whether the variable is stationerity in nature on not. So now, in addition to dickey fuller test, there is there means there is advance person. It is actually in the name of two professors' dickey and fullers and dickey fullers. So, it is with respect to the in response to their names, so the statistics is called as a DF statistics. So, they have a given a modify version of statistics, it is otherwise called as a diffuse augmented dickey fuller test.

What is the augmented dickey fuller test? So, the test will be like this. It is nothing but delta y t, so delta y t is equal to alpha y t minus one plus x has t delta plus beta 1 delta y t minus 1 plus beta 2 delta y t minus 2 plus continue, you know delta this is beta actually. Then beta p delta y t minus p plus v t. We start with this particular issue, what ultimately I will better I will come down to the accurate form of problems, because, we have not time to come down to the original format.

(Refer Slide Time: 45:14)



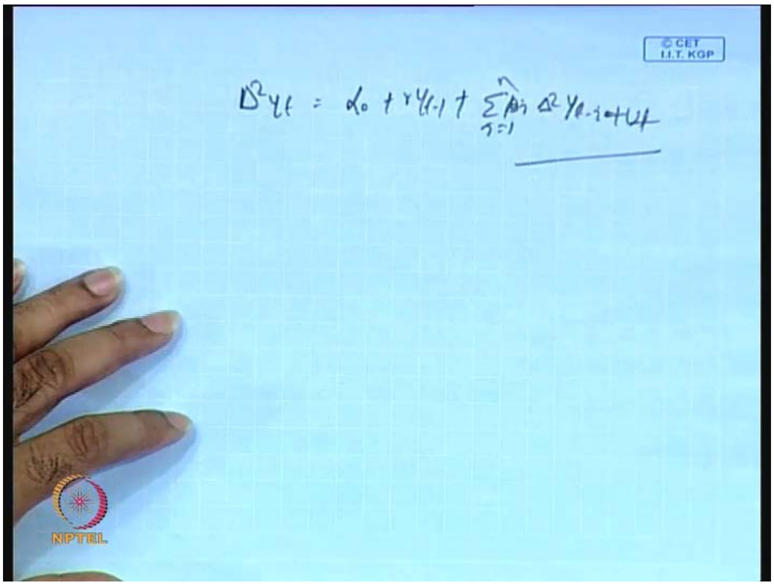
So, here this specific form of the dickey fuller statistics is write this delta y t equal to beta one plus beta 2 t plus delta y t minus one plus summation gamma i y t minus i, i equal to 1 to n plus U t. So, this is the typical frame work of, you can say augmented dickey fuller test. This is typically the former (( )) augmented dickey fuller test. It like dickey fuller test, it has three different versions. So, I will let me highlight three different versions here. So, delta y t equal to delta is, let say alpha, once again I will write it, delta y t equal to alpha y t minus one plus summation gamma i y t minus i i equal to 1 to n plus U t. So, this is you know model one, this is in the question of model one. Then I will a write delta y t equal to, lets mu plus alpha y t minus one plus summation gamma i y t minus i i equal to 1 to n plus U t. So, this is another problem a form is called as a model two. Then I will write like this way delta y t is equal to mu plus mu 1 plus mu 2 t, so then plus then plus alpha y t minus one plus summation gamma i y t minus i i equal to 1 to n plus U t.

So, this is model three. So that means, like dickey fuller test. We have three difference sets of models here, in the case of augmented dickey fuller test. But only photon thing we have added as this particular person, so this is the additional net addition to the dickey fuller test. So now, because it will give you optimal frame work of checking the unit root problems. In the first case, in the first models, it is the model with the no trend and no drift, this is with drift no trend and this is with drift and trend.

So now in every case, our standard objective is our, not like that way. So, this is the standard this is not the boundary. So now, in our objective is to handle this particular frame work, so this particular. That means, alpha no hypothesis alpha such that alpha equal to 0 alpha 1, such that alpha 1 alternative hypothesis that alpha not equal to 0. So that means, in this particular frame work your alpha statistics should be statistically significant. If alpha statistic is statistical significant, then will say that it is stationery in natures. If alpha statistics is not significant then obviously, it is called as non-stationery problems.

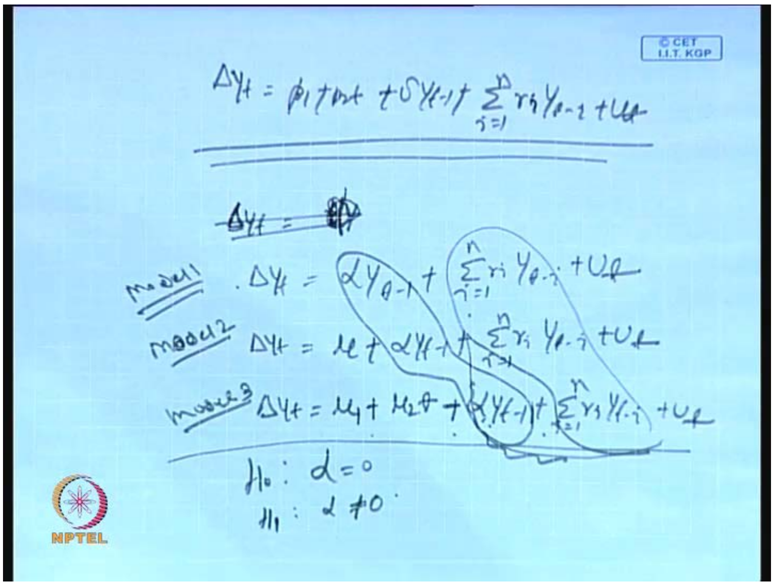
So that means, if will you know further suppose you are not getting, you know a stationerity label or order of integration at a particular label, in this particular label you are not getting a stationerity issue. Then you will go for second difference. So, then you will go for third difference. So like second difference, in the case of second difference delta square you y t will be summation like this way, it will come in the case of second difference.

(Refer Slide Time: 49:38)



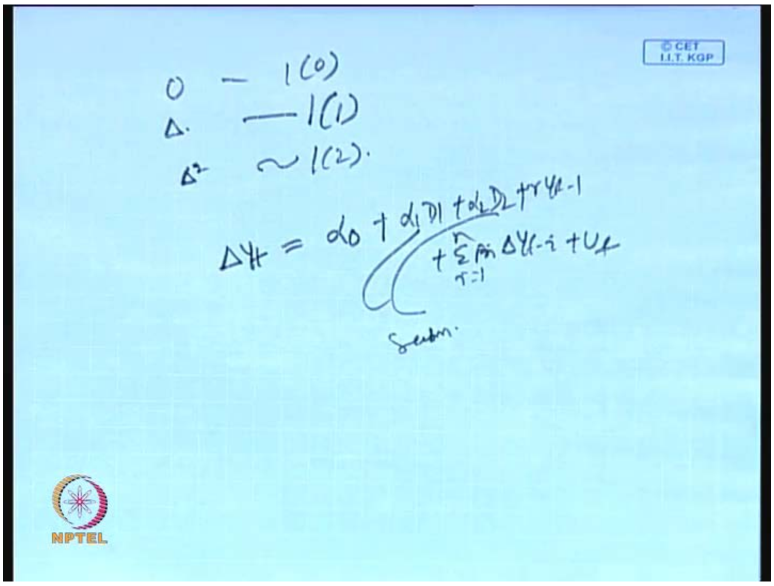
So, it will come like this way, delta square y t is equal to alpha 0 plus gamma y t minus once plus summation beta i, then delta squares y t minus i t minus i i equal to 1 to n plus U t. Generally, this is different issue high versions, but mostly these are the three versions we may use, but this is the standard tricks here.

(Refer Slide Time: 50:03)



Suppose at this particular labels, you were not find this alpha hat is not significant and again you have to go for first difference, second difference, third difference, etcetera etcetera. So, the moment it will a say suppose, it is stationerity at the label data then you can say that the variable indication will be like these way.

(Refer Slide Time: 50:34)



So, its indication will be say that if it is integrated then you know say i 1. So, if it is integrated at the first difference label. If it is the original label then it will integrated of 0. So i integrated of order one means you are getting stationerity at the first difference label. So similarly, suppose at the second difference labels, it will be integrated of order two like this way. So, if D is the order of integration then obviously, variable will be stationery at the i upon D. That is how the order of integration can be detected. Similarly, you have to apply in different aspects to check the stationerity issue. So, means like you know, in the case of K P S S, then phillips perron test, then you know NG test, etcetera and N G P R test. Because of lack of time, it is not possible to go through each and every technique to check the stationerity issue. But, most of the generalize and standardize a particular variable is the augmented dickey fuller test.

So, infect its more advance, sometimes you can check the structural deck also in this with the help of this augmented dickey fuller test. So like test, in that case, you can write like this way alpha 0 plus alpha 1 D 1 plus alpha 2 D 2 plus gamma y t minus 1 plus summation beta i a delta y t minus i i equal to 1 to n plus you can say U t. So, U t 1 D 2 is this is a null components it will give you the breaks there. Sometimes you know the issue is y the variable is not stationery. So, there may be some structural break is there. If will detect there structural break, then obviously, you can get to know the complete picture stationerity. Otherwise, it is difficult to find out the stationerity issue. Anyway whatever may be the situations, one of the standard problems in your time series modelling is unit root test. So, that is to check the stationerity issue and that is very use full for co-integration and causulity test.

So, before you going for co-integration and causalities, these are the main objectives of a particular time series modelling. You must know the stationerity labels means, order of integration where the variable will be stationery. There are various techniques available to check the stationerity issue that means, unit root problems. So, we start with the dickey fuller test, then augmented dickey fuller test, you know then phillips perron test and g test etcetera. So many tests, what we already highlighted. What basically, we have briefly discuss the details about the dickey fuller test and augmented dickey fuller test. Dickey fuller test is the easiest methods, very simple to understand, very simple to calculate and its modified version is called as augmented dickey fuller test. So, that is what you know, just you know giving the optimum lag length structures and degrees of freedom adjustment. So, means that is a how augmented dickey fuller test is most advances and you know more interesting, more reliable then the dickey fuller test. Most of the problems, you can use a augmented dickey fuller test to check the stationerity issue of a particular time series variables.

So now, similarly other techniques with you know, so many you constants or you know conditions you can apply. Sometimes, you know more like you know, N G P test can be applicable in a more advance way. Sometimes phillips perron test can be applicable in various ways. So, we are not concerned about these things, but ultimately our men agenda is to check the stationerity issue. Whatever techniques you were apply, so ultimately and result are you to know, whether the variables are stationery in natures or not means or means a heaving unit root problem, so not unit root problem. If it is unit root problem then that what labels or active what order of integrations you will get the stationerity. And that order will be use further for co-integration and causulity. So, will discuss detail about this co-integration causulity in the next class. For this in time being, we can close this class. Thank you very much, have a nice day.