Engineering Econometrics
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Lecture - 47
Time Series Modelling- Volatility Modelling

Hello everybody this is Rudra Pradhan here. Welcome to Engineering Econometrics, today we will continue with the Time Series Modelling in that to the structure of volatility modelling. In the last lecture we have discussed this concept technically, time series models in one way we can classify into two different parts, the linear structure and the non-linear structure.

We have discussed couple of problems under the linear structure starting with you now autoregressive scheme moving average schemes ARMA schemes ARDL schemes which we have discussed slightly in the last lecture and a some of the previous lectures. And again in the last lecture we have also covered the non-linear structure. And that to we have highlighted couple of models just you know taking the clue or extension from the linearity structure that to the structure of autoregressive scheme, moving average scheme ARMA schemes.

In specific way in specific we have discussed 3 aspects of you know non-linear modelling that to non-linear time series modelling. The 1st one is the ARCH clusters the 2nd one is the GARCH cluster and the 3rd one is the artificial neural network. However, we will give you know more stress on ARCH cluster and GARCH cluster because these techniques are too important so, far as volatility modelling is concerned.

Though artificial neural network is a kind of you know you know linear clusters, but basically it is a classification technique and we have lots of you know limitations compared to ARCH and GARCH modelling. That means, technically artificial neural network is not a solid technique to represent the volatility concept which is very essential or very important in some of the engineering and you know management problems.

So, that is why the plan of the lecture is just to you know start with the artificial neural network concept. And then move into ARCH modelling and GARCH modelling before that I like to give you little bit stress on non-linear structure. Of course, we have

discussed lots of in an non-linear modelling not specifically in the context of time series modelling.

We have discussed you know simple model with you know non-linear functional form and we have also discussed some of the qualitative response regression modelling that too dummy modelling. Where we have also discuss various types of you know non-linear models that to non-linear regression models specifically logit model and probit model. Which is very useful very essential for most of the engineering problems where dependent variable is the kind of you know qualitative in nature and then we use both probability density functions that brings the logit model and then normal density functions that brings the probit model.

And in that contest we have not used specifically the time series structure. That model may be used in the time series data, but more accurate more appropriate in the case of you know cross sectional data or cross sectional setup. And what we like to discuss here today is the non-linear types of you know econometrics model where we like to use two things or we like to connect two things that is very important here. The 1st one is the time series data and the 2nd one is the involvement of lag variables.

Which is actually feasible when there is a time series data so, as a result we maybe in a position to address the volatility aspect and that to the ARCH modelling GARCH modelling and the kind of you know ANN Artificial Neural Network. Of course, artificial neural network can be used in the cross sectional setup, but it is it can be also equally useful in the time series data, but artificial neural network is not such a you know big tool to highlight the volatility aspects.

So, in any way we like to touch up on three things the ANN artificial neural network modelling. The ARCH modelling that is autoregressive conditional heteroskedasticity and the GARCH modelling that is generalized autoregressive conditional heteroskedasticity modelling. But, we will give more emphasize on ARCH modelling and GARCH modelling compared to artificial neural network. We just give little bit you know touch up on the ANN then we will move to artificial ARCH modelling and the GARCH modelling.

Let us start with what is exactly the you know non-linear concept and then we will come into the kind of you know ARCH modelling GARCH modelling and you know neural

network modelling. Of course, in the ARCH modelling and GARCH modelling one common is that we will we need to have a error component and then error component can be used as an instrument to highlight the or to address the ARCH modelling and the GARCH modelling. Which is not exactly in the case of you know neural network that is the difference big difference between the ARCH and GARCH cluster and then the artificial neural network cluster.

So, let us start with simple you know understanding about the nonlinearity and then we will move into these three models and we address volatility aspects that too solve some of the engineering problems. Where, we need actually predictions and that too with the help of you know volatility structure. Volatility literally means variations when the variation is very unveil nature that is what the term volatility literally means and it affects drastically or it affects lot in the prediction process and forecasting process that is how we like to know how we can deal. So, that we know we can minimize such you know forecasting error or prediction error and then we can do the better in the you know decision making process and that to some of the engineering problems.

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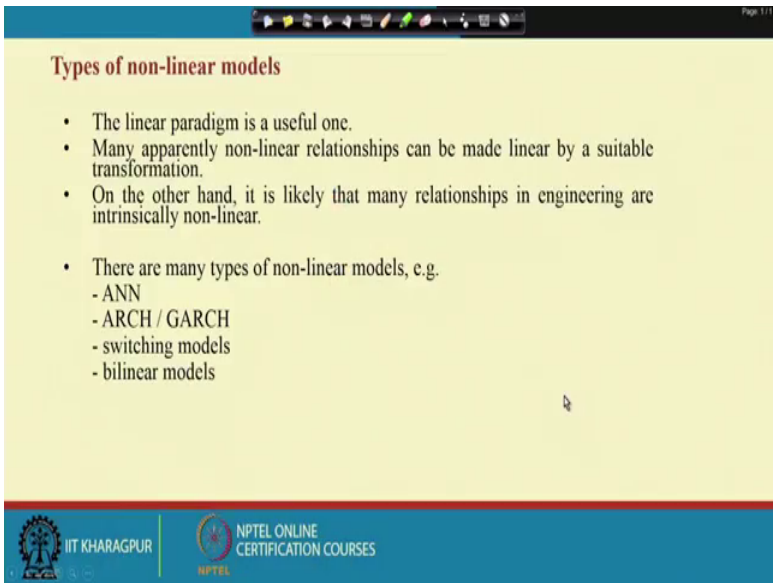

So, let us see here how is this particular you know structure. That is what we have already discussed the there are many types of you know non-linear models of course, we have discussed. And in this case typically we are touch up on ANN ARCH and GARCH cluster. And besides ANN and ARCH GARCH clusters we have switching models a

bilinear models, we have plenty of models, but you know with time constants we like to just touch upon you know artificial neural network and then we will cover ARCH and GARCH cluster, but you know beside this cluster there are various other models like you know switching models and bilinear models which is actually somehow connected with the this ARCH cluster and GARCH cluster.

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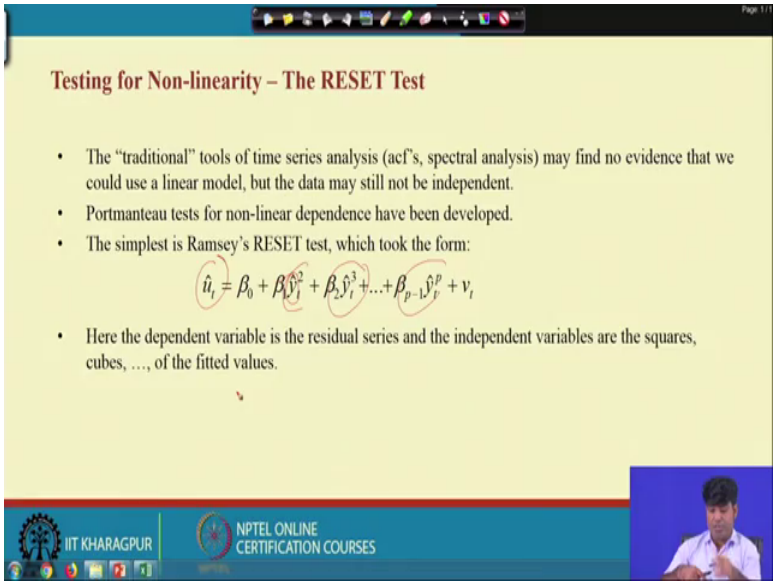

So, let us start with some kind of you know nonlinearity. And a here the nonlinearity starts with actually the kind of you know variables not exactly the functional form. And a earlier we have used a concept called as you know Ramsey's reset test that is called as a regression specific reset transfer regression specification test. So, the process of this test is that you know even a particular model is you know is pass through specification test g f t goodness of heat teat and that too diagnostic test still that models cannot be completely declared as the reliable model for the prediction and you know forecasting.

So, as per the you know Ramsey's structure so, the end part of this you know reliability maybe you know using the reset test. The test basically deals with you know error component and then we will we means this first step of this process to estimate the model and have the error term and then go through all the specification tests GFT test and diagnostic test and after that again rerun the model by applying reset test where error component as a function of the estimated variables that is the predicted variable which

we generally recognize as y cap. And that too with a lots of you know in non-linear you know setup.

For instance, here we have u t and then we connect with you know this y cap is the estimated y. And we connect with the y hat squares then the y hat to the power cube and so, on that too you know y hat to the power p. So, degree of you know linearity will starts here. So, that means, the same estimated variables use as the independent variables to predict the error terms and then check the you know reliability of the model. So, that means, somehow this kind of you know nonlinearity we have already discussed, here the dependent variable is the residual series and the independent variable are the squares cubes of the fitted values.

And then you know test the model whether it is reliable or not. Same we have just you know estimate the model and have the r square and that r square need to be tested whether it is actually reliable or not that is what the basic structure of you know Ramsey's test. So that means, technically we have already used this concept of nonlinearity.

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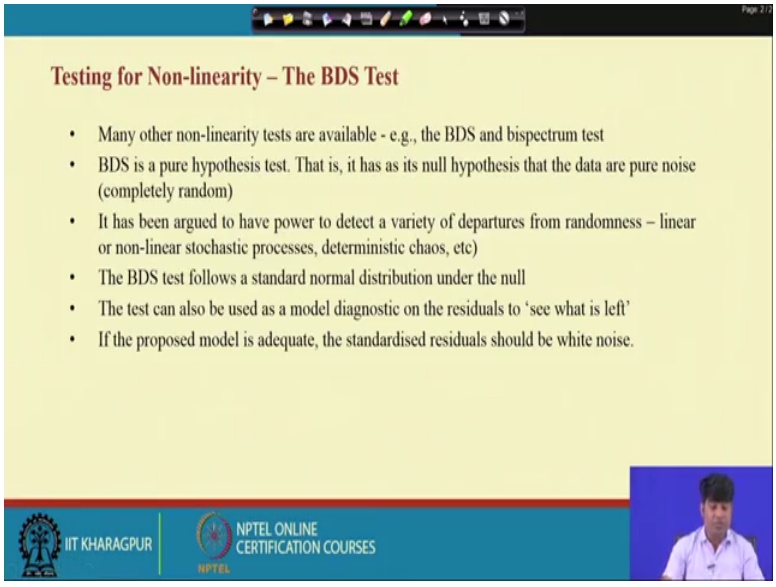

Besides that means, besides Ramsey's reset test we have couple of you know non-linear tests like you know BDS tests and the bispectrum test. Starting with BDS it is a pure hypothesis test that is it has it is null hypothesis that the data are pure noise that means, completely random. It has been argued that to have power to detect the variety of the

departures from the randomness the linear or non-linear stochastic process deterministic chaos etcetera.

In fact, the BDS test follows a standard normal distribution that too under the null hypothesis. This tests specifically that is the BDS can be used as model diagnostics on the residuals to see what else left. If the proposed model is adequate then the standardised residuals should be white noise that is what the reliability and that is what the you know structure of the requirement. Now, come you know just you know I am touching upon you know couple of you know non-linearity structure and that too in a time series setup.

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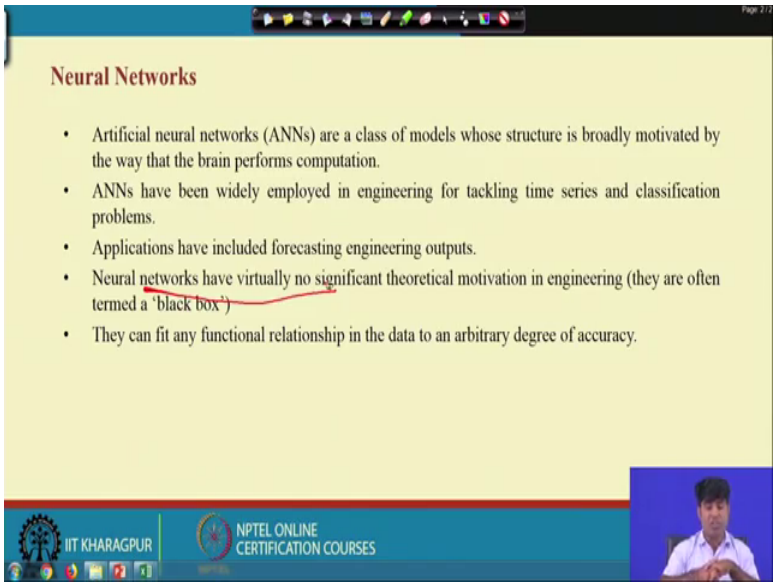

So, starting with reset a BDS bispectrum test and then touch upon the slightly you know neural networks then we will move to the ARCH cluster and GARCH clusters which is actually the you know true story of this you know volatility modelling. In brief artificial neural network are a class of models. Whose structure is broadly motivated by the way that the brain performs you know some kind of you know computations.

Neural networks have been widely used in engineering and management for tackling time series and classification problems. Of course, it is a more excellent technique in classification compared to time series, but sometimes we use in time series data and time series modelling to check the forecasting accuracy compared to other non-linear models as well as the linear models. That means, technically the particular engineering problem

maybe common, but we can estimate, we can analyze, we can use the model for decision making process in the form of linearity structure and nonlinearity structure.

When we are comparing the particular you know problems and that to two different aspects linear verses non-linear and by default neural network can be used as a tool more specifically that too. So, far as a applications are concerned we use an to forecast some of the engineering outputs or managerial outputs. More specifically neural networks have you know neural networks have virtually no significant theoretical motivation that too in engineering. If the you know general perception is that it is a kind of you know black box how it happens it is nobody knows.

However, theoretically it gives some kind of you know clue how it predicts and you know do the kind of you know forecasting. It has you know some kind of you know mathematical you know understanding mathematical logic and mathematical structure to predict the kind of you know requirement. Even though the inside box is not clear which is called as you know black box till that technique is not.

So, relevant it has lots of utility and really importance to predict certain things and compare the results in a non-linear angles compare to linear angles even non-linear angle with different models. They can fit any functional relationship in the data to any arbitrary degree of you know accuracy. So, that is what the basic structure of neural network.

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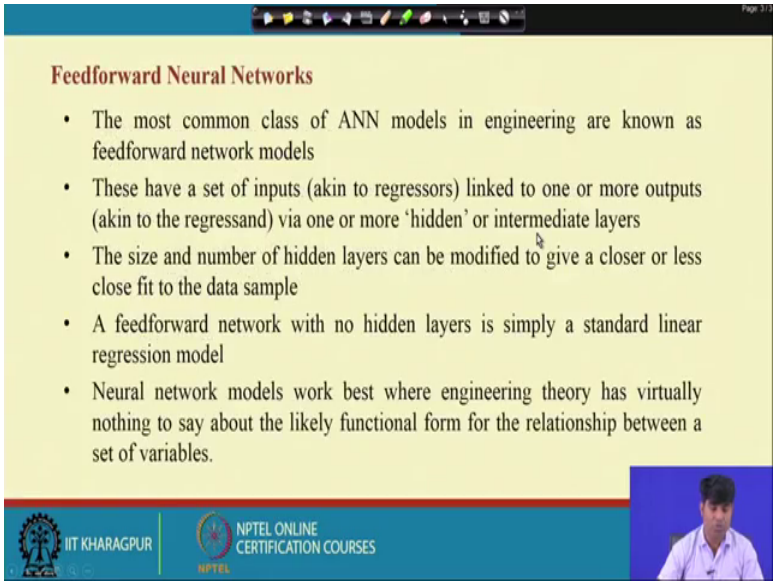

And the some of the other features are you know it has actually couple of you know moralities and most of the occasions we use feed forward network models. These have a set of inputs linked to one more outputs through some hidden or you know intermediate layers. So, that means, actually it is the classic example of you know interdependence some independent variables may not affect the dependent variable directly. It can be passed through some you know other variable that is what called as you know indirect relationship or intermediate or which we represent here in the neural network is called as you know hidden layer.

The technique is such you know big or some kind of you know very important in the sense even if you do not know the you know indirect relationship the kind of you know interdependency that you know hidden layers will explore and you know find out some way. Even though theoretically there is no clue, but still you know this model can bring some kind of you know reality to predict such you know dependent variables. Of course, the size and the number of hidden layers can be modified to give a closer or less close fit to the data samples.

At feed forward network with no hidden layers is simply a standard linear regression model. So, that means, technically it has a close connection with you know linear models. So, if you remove that you know hidden layers which actually brings the non-linearity structure to predict the dependent variable. So, since there is some communality so, simple regression results can be compared with you know artificial neural networks results and then check the validity and the requirement as per the particular engineering requirement and the decision making process.

Neural network model specifically this work where you know engineering theory has virtually nothing to say about the likely functional form between the relationship among the variables so that means, we may not have actually solid theory how is the basic functional form. So, neural network can bring some kind of you know clustering. That is what the beauty of this particular technique to address some of the engineering problems. Of course, we will not go in details, but this is a some kind of you know structured a technique through which you can actually predict certain you know engineering problems.

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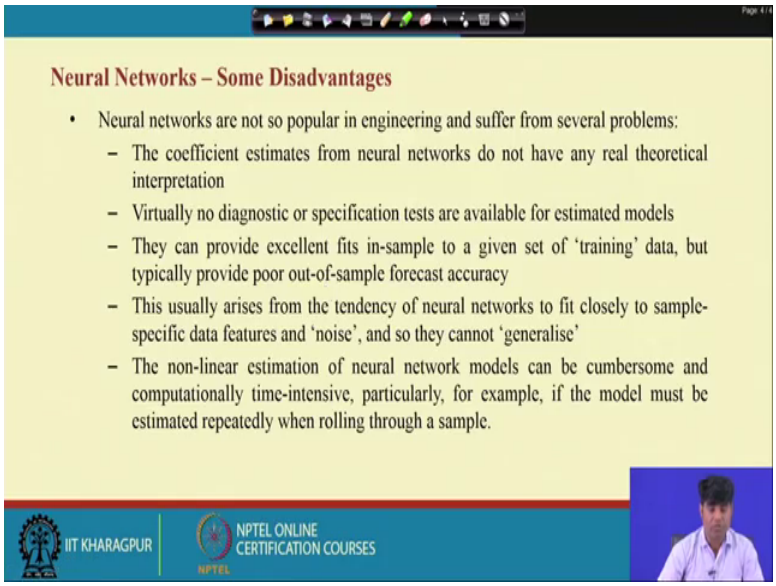

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Neural network has some advantages and some disadvantages. We have highlighted the particular you know plus sides where you know we do not know or if you have no idea theoretically how to bring a functional form then blindly we can use neural network as it is actually kind of you know black box mechanisms which helps or to predict the environment.

However, neural networks are not so, popular in engineering hence you know have a lots of you know limitations. The coefficient estimates from neural network do not have any real theoretical interpretation that is the big disadvantage compare to linear structure and the type of model like you know ARCH modelling and GARCH modelling.

Virtually, no diagnostic or specification test are available for estimated models. Simply neural networks can provide excellent fits in sample to a given set of training data and then give excellent out of sample prediction accuracy that is the beauty of this particular you know technique.

This usually brings from the tendency of neural networks to fit closely to a sample specific data features and the noise and so, they cannot generalise that is the big deal. Moreover, non-linear estimation of neural network models is computationally very time

intensive particularly, for instance if the model must be estimated repeatedly rolling through a sample that is the again big disadvantage.

In anyway neural network has some kind of you know merits and some kind of you know demerits. Of course, all models has some kind of you know demerits, but still this model can be used as a tool for you know any kind of you know prediction and forecastings.

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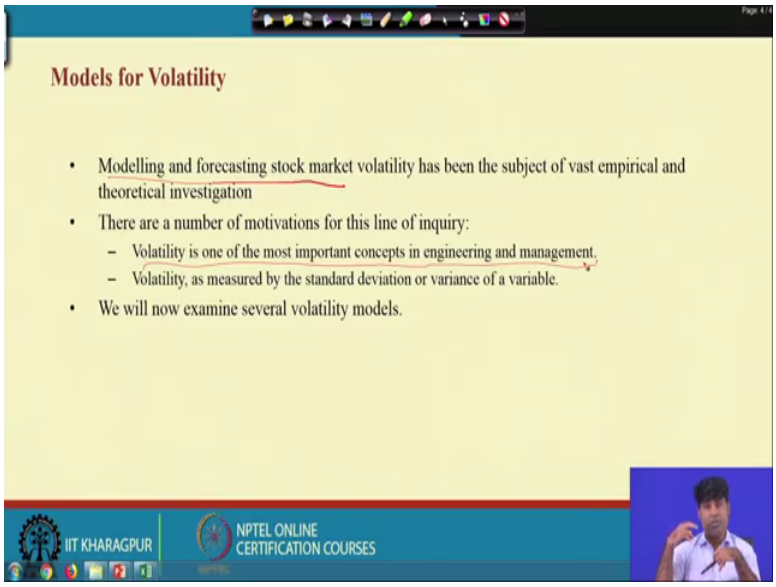

However, we are not going in details because this type of models are very frequently used in data analytics and machine learnings. So, that is why we are not so interested to discuss in details about this technique which is having actually you know less impact in the kind of you know the item which will address the volatility concept.

So, compared to neural network the ARCH modelling and GARCH modelling will be more appropriate and more you know accurate to do the predictions and do the forecasting as per the particular requirement. So, models for volatility means you know we are specifically highlighting modelling and forecasting like you know stock market, stock market volatility or you know some kind of you know engineering volatility and that to subject to empirical you know theoretical investigations

There are number of motivations for this line of you know investigations because, what I have mentioned you know volatility is the key in specifically time series data, which may

specifically dilute or you know drastically affect the prediction and you know forecasting. Because, you have no guarantee and you know some kind of you know stability to predict certain things.

So, that means, statistically or econometrics in a econometrics angles larger the volatility which you theoretically predict through the standard deviations or variance of the variables. Then you know lower the reliability lower is the accuracy and lower is the efficiency of the model so, far as a prediction forecasting is concerned.

So, what we usually do in normal case we try to transfer or you know restructure the data and the kind of you know problem in such a way. So, that the type of you know variation and the volatility may be reduce some extent at the first instance. If that is the case then you know we may not necessarily require the ARCH kind of you know modelling and GARCH kind of you know modelling. But, the effect is that you know some of the engineering problems and management problems are such a complex where we may not actually you know predict properly.

So, as a result we need actually such kind of you know models that is the ARCH model and GARCH models. So, typically there are number of motivations for this you know lines of you know research and discussion. First one is the volatility is one of the most important concepts in engineering and management because, it you know brings uncertainty and it is the kind of you know component which can you know brings the risk factors. Theoretically or literally larger the risk lower is the prediction accuracy with you know high risks you cannot predict the things very accurately very effectively and very efficiently. That is what and that is what the deal and that is what the need actually in the first instance.

Since, you know most of the things actually risk taking or you know attachment of you know risks. So, this kind of you know models are very user friendly to predict some of the engineering concept or engineering outputs as we have already discussed volatility as a measured by the standard deviations or variation of a variables.

So, that is why it is not a big deal or you know it is not a big issue in fact, it is not sort not at all a complex just you know bring the volatility and you know variations and then you predict this requirement that is what the you know kind of you know requirement and that is what the nature of this you know volatility modelling that to ARCH cluster

and GARCH clusters. Which we will discuss in details in the next lecture in the meantime we will stop here.

Thank you very much have a nice day.