Econometric Modelling

Prof. Rudra P. Pradhan

Department of Management

Indian Institute of Technology, Kharagpur

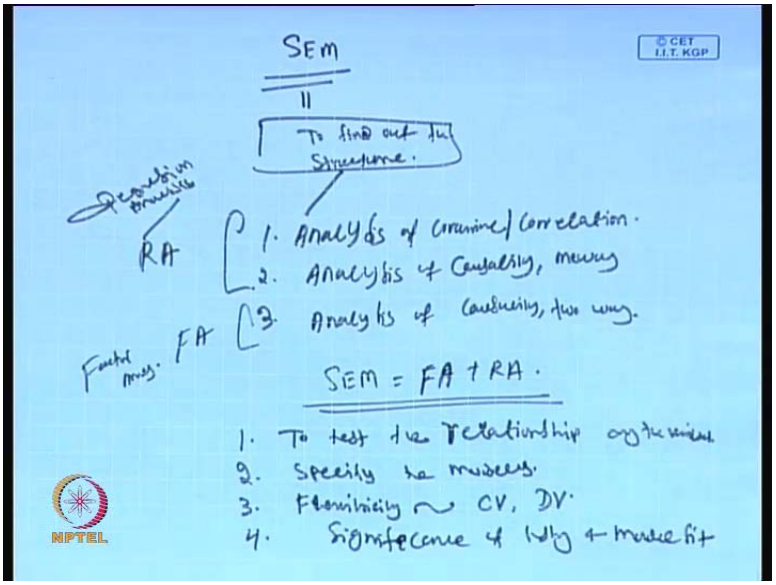
Lecture No. # 35

Structural Equation Modelling (Contd.)

Good evening, Doctor. Pradhan here. Welcome to NPTEL project on econometric modelling. Today, we will continue the structural equation modelling. In the last class, we have briefly highlighted the issues or you can say various concepts behind structural equation modelling. So, today we will specifically highlight the methodological issue and its applications.

Structural equation modelling is a generalization approach to multivariate data analysis. We are jumping from single equation to simultaneous equation and simultaneous equation to structural equation. Structural equations modelling structure is very, very important. We have to see how is the, you know setup of structural equation modelling.

(Refer Slide Time: 01:17)



Here the most important agenda is to find out the proper structure to find out to find out the proper structure, find out the structure is the main agenda of structural equation

modelling. I have already mentioned structural equation modelling it is approach to analysis of covariance. It is the structure of analysis of covariance, then analysis of causality, this is analysis of covariance, analysis of causality, covariance or you can say that we can mention that is covariance analysis of correlation, analysis of causality one way and third analysis of causality to which, this is one way causality, this is two way causality.

You see these particular two things will be called as this is clearly on regression analysis. It is nothing but the root of regression analysis. In fact, correlation regression is the same groups, so here we means obviously, it will say the regressions then we are discussing the r square and which the correlation coefficient for a bivariate setup. In fact, multivariate setup it may be multiple correlation coefficient.

Regression analysis basically deals with the causality issue and you know correlation issue then there is analysis of causality in the two way interdependent techniques, so that is what we will called as a F A factor analysis. It is called as a Factor Analysis. Structural equation modelling is the integration of Factor analysis plus regression analysis. Now if you will integrate this two then obviously we have to highlight a certain things here. That means, first thing is to test the to test the to test the relationship among the variable to test the a relationship what to examine the relationship relationship relationship among the variables variables to test the relationship among variables this is the first objective and specify the models that explains the data specify the models specify the models that can incorporate the existing data then you need to have a flexibility you need to have a flexibility you need to have a flexibility with respect to a continuous variables and discrete variables, because structure cannot be directly connect with either continuous variable or discrete variables, so you need to have a integration about continuous variable and discrete variables.

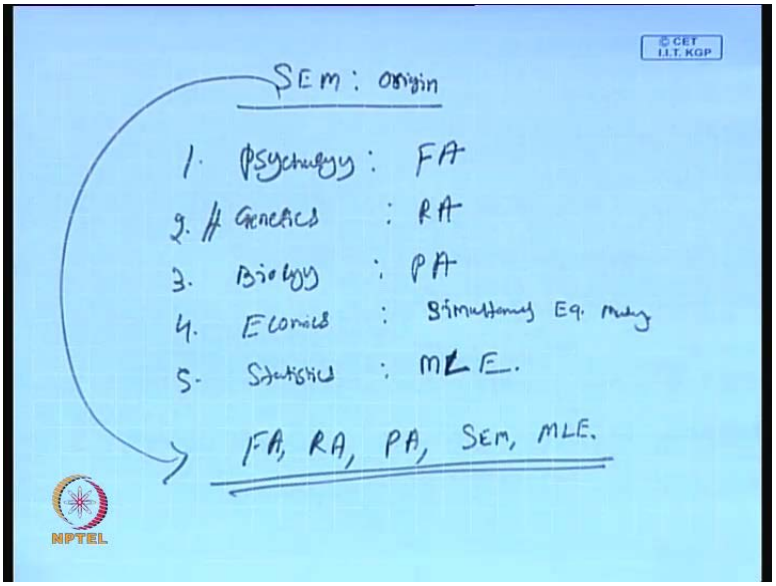
For instance, that is how sometimes we use be dummy variables. Some of the variables we cannot you can say quantify properly, so we have to go for quality way and we have to categorize in such a way by using plus c, so as a result the modelling structure can be a properly evaluated. This is this is another interesting agenda of flexibility.

Then significance of testing significance of testing significance significance significance of testing and you can say model fit model fit significance of testing and model fit. These

are the specific requirements, so we need to have in the case of structural equation modelling. Structure is very important, you know within the structure we like to know or we like to establish the relationship relationship among the various variables and specify the exact models, so we usually called as a path model then to have that one, so you need to have a little bit the flexibility of compromised between continuous variable and discrete variables. Then then obviously you have to highlight the significance of this testing and you know model fitness.

With this basic framework, we have to highlight the detail structure about the structural equation modelling. Before I highlight, I will let let you know little with the historical background behind the structural equation modelling.

(Refer Slide Time: 06:24)



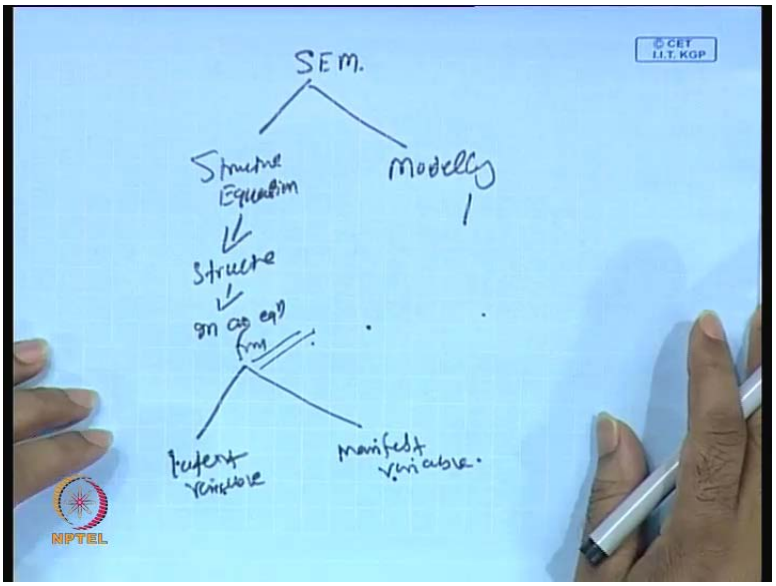
The structural equation modelling root is from psychology. Structural equation modelling origin structural equation modelling origin, once you know the origin then you can get to know these features why these features are already means you need to have in the case of structural equation modelling. For instance, flexibility (( )) flexibility between continuous and discrete is there, so most of the variables in the psychology is very discrete in natures. Once you will have a sometimes you know structures, we need to have integration or otherwise or flexibility or otherwise it is very difficult to handles.

The first origin is psychology psychology. It is called as because the origin before we going to the structural equation modelling, I will give you the historical background how

this structural equation modelling coming into the picture. In the psychology the most interdependence technique is called as a factor analysis. Then we have a genetic genetic human genetics human genetics. Human genetics will give you the approach of regression analysis where the Dalton has started the you know (( )) the height of (( )), so they proposed the idea of the regression analysis. Then biology it is the detection of path analysis. Then forth economics, it will give you the structural equation modelling simultaneous equation modelling simultaneous equation modelling. Then we have the integration of the statistics. The statistics it is the you know methods of maximum likelihood estimation. It is the method of maximum likelihood estimation maximum likelihood estimation that means you see here.

To know the structural equation modelling you must have knowledge on factor analysis, regression analysis, path analysis, simultaneous equation modelling and maximum likelihood estimations. The integration all this together is called as a structural equation modelling. That means you understand yourself how complexity is this particular problem. Structural equation modelling is the highest setup of this econometric modelling, so where so there is use of various individual techniques like factor analysis, regression analysis, path analysis, simultaneous equation systems then maximum likelihood estimations. That means it is the core area where psychologist, human genetics, biology economics, then statistician can work together or you can say integrated together to have a particular solutions. This is the basic framework of this simultaneous equation modelling.

(Refer Slide Time: 09:40)



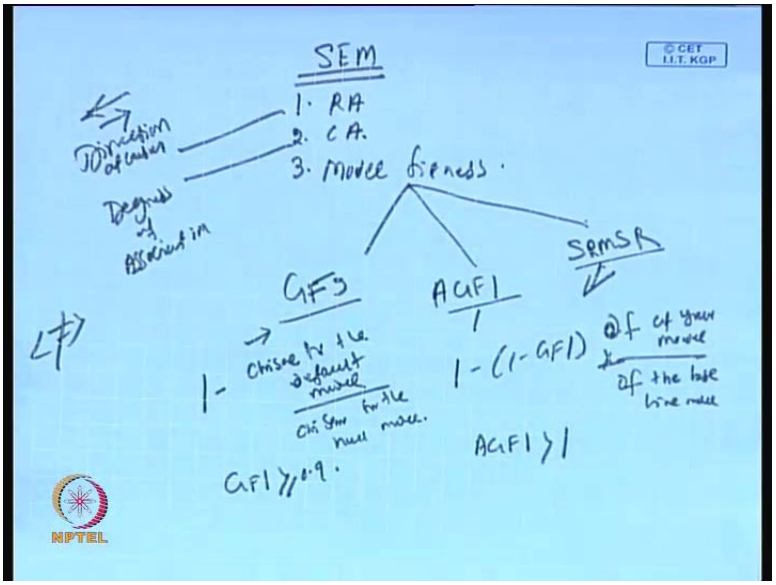
Now what is what is exactly the you can say you can say this particular structural equation modelling. Structural equation modelling as I have already mentioned structural equation modelling as I have already mentioned there are two sets of structures; one is called the structural equation structural equation and another setup is called as a modelling. That means, here we have to find out the proper structure in an equation form in an equation form and modelling here you have to transfer the you know generalization problem critical problem into mathematical form. In this mathematical equation you must have some structures, so that how it is called as, so that means you bring the structure and you bring the modelling then it will integrate you will get the structural equation modelling.

Now the issue of structural equation modelling is consists of two things, it is called as a latent variable and manifest variables. So, now for as a structure structure is concerned, it is the root for two things here is called as latent variables and manifest variables manifest variables manifest variables latent variables and manifest variables.

Now the structure is that you have to find out the proper structure here in between the latent variable and manifest variables. Manifest variables means a observe variables, which which are in the form of both exogenous and endogenous. They are very much observed. It is readily available means that is why it is called as a data files then within the data files we have to find out structures, so that is in the form of a latent variable

latent variables. We have to find out how latent variables has a cross connection to each other again. That means it is altogether three pillars of the system. One pillar is endogenous setup then latent endogenous and another pillar is exogenous setups and exogenous latent. It is integration between endogenous setup and you can say exogenous setup, endogenous latent and exogenous latent. Within basic within the basic step setup then we have to highlight this particular setup.

(Refer Slide Time: 12:23)



So far as a structural equation modelling equation is concerned, as I have already mentioned basically we look for regression analysis, then second thing is you know correlation analysis then; obviously, third thing we like to highlight the overall model fitness model overall model fitness overall model fitness. Generally you see here, it is a very interesting thing, because it is integration of so many things together, so starting with regression analysis, factor analysis, then path analysis and then you know simultaneous equation systems then maximum likelihood estimation etcetera etcetera. But basically our observation is very limited here means we like to know where is the means once you will apply the particular structures, where we will set the regression and where we will set the correlations.

Obviously, it is the game between the regression and correlations, but factor analysis and path analysis will give you the entire setup of structure only. The generally framework, which we can highlight here is like this. When will go for correlation then it will give

you degree of association degree of association. When will go for regression analysis, it will give you direction of causality it will give you direction of causality, it is obviously one way causality. It is not like, it is should not be like this, because this is not allowed here in the case of structural equation volume, which is very much allowed in the case of time series modelling pure time series modelling.

Here certain means core objective is which to find out the degree of association that is our degree of means degree of relationship between two variables means within the of course it is the multivariate framework, so every time we like to know how these two variables are related to each others, so that means it is the degree of association within that particular systems we have to, there may be many variables certain variables, so we like to (( )). We like to know one variable endo with another variable endo how they are related whether they the structure is causality equal of structure or it is the association relation only simple relations without any causality issue. That is how we have to bring this issue.

Now in the simple setup you see in the simple setup, we like to know what is the degree of association among the variables then causality issue then model fitness test. Just like you when you will go for the regression analysis. Regression analysis is two specific objectives; one specific objective is what is the direction of the causality and another specific objective is the you know goodness of fit that is you know the goodness of fit, which we did measure in the form of r squares. That means the value of r square is lies the value of r square lies between 0 to 1, so close to 1 or equal to 1 will give you higher accuracy, higher model fitness then the you know r square is equal to 0. If it is close to 0 it is unfit or it is the you can say not suitable for this modelling. This is how we have to represent this.

Altogether we have to find out the regression coefficient, correlation coefficient, the significant of regression coefficient, significant of correlation coefficient, and then finally overall fitness of the model. When we will go for the regression analysis, so here we have to find out the regression coefficient then when you will to go for correlation you have to find out the association coefficients. Then finally, if you go together then we have to find out the model fitness test, so like you know in the case of regression model fitness test is the usually you can say not usually every time it is with respect to r square

only coefficient of the determination. Here model fitness can be observed with many indicators.

I just briefly highlight (( )) indicator through, which we can represent the model model accuracy; that means, once you prepare the structure ultimately the complete model with you, so whether that model is systematically or not systematically, it is very difficult to say without having sufficient indicators in your mind. Here is the sufficient indicator. There is some kind of reliable indicators through which we have to justify the model reliability, means fitness of the models that is why I have mentioned here model fitness. How do you observe this model fitness? There are many indicators are there, but briefly I will highlight three indicators; one is called as a goodness of fit index goodness of fit index then adjusted goodness of fit index then third one is called as a standardized root mean square residual standardized root mean square residual. Goodness of fit index it is nothing but the formalized 1 minus chi squares chi squares for the default models for the default models divided by chi square for the null models null models, so this is the G F I goodness of fit index.

If G F I G F I is greater than to 0.9 then model is will be considered will be accepted or it is considered as the reliable models. If G F I that means G F I is higher the G F I greater the possibility of accuracy of the model. If lower the G F I and obviously model accuracy or model reliability is very low. This is one of the indicators through which we have to justify the model fitness of the structural equation modelling.

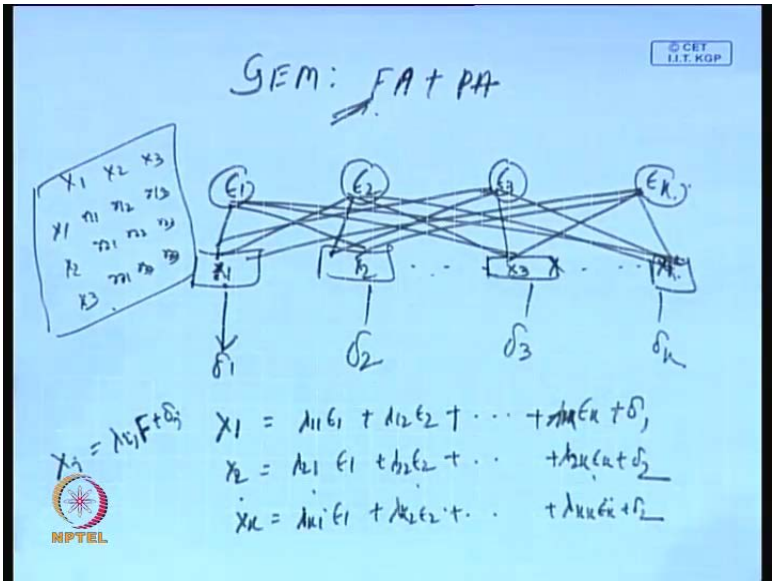
Then second is adjusted adjusted goodness fitness index, which is nothing but 1 minus 1 minus G F I goodness fit index multiplied by degrees of freedom degrees of freedom of your model of your model divided by degrees of freedom for the baseline model baseline model baseline model. That means, in the case of regression analysis we use r square and adjusted r square, adjusted r square is nothing but the 1 minus 1 minus r square into m minus 1 by n minus square that is (( )) r square means we have to adjust with the degrees of the freedom, here also we are just doing the same thing. Generally the component is goodness of fit index. Now it has to be adjusted to proper degrees of freedom, because ultimately it is many variables game. Once you involve more and more variables in the system and obviously it will affect the degrees of freedom. That degrees of freedom has to be taken care. As a result as GFI will be another indicator has to be used, which can

which can take care the overall fitness of the model and in the same times it can take care you can say degrees of freedom.

If AGFI is greater than to 1 or equal equal to 1 means it is perfectly fit of the models, mean say model perfect perfectly fit if it is greater than into 1 then if it is the less than to 0 then model is poorly fit, that that is why you have to be careful how you have to find out. Then you see a standardized root means square residuals, which is the average difference between the predict ant and observe variance covariance in the models based on this you know standard based on this a standardized residuals.

You know when this S R M S R is equal to 0 then obviously, it is perfectly fit. When it is you know greater than to 0 then obviously it is the totally unfit. That is why it should be close to 0 it should be close to 1 and it should be also greater than to 1. In this scenario, we have to observe the model fitness of this particular you can say a structural equation modelling.

(Refer Slide Time: 21:32)



With this basic framework, we we like to highlight the structural equation modelling. The structural equation modelling, you see here it is it is, I will give you two different models. With a simple structures and then we will go for a complicated structures. You see, I have mentioned structural equation modelling structural equation modelling is the GEM between factor analysis plus you can say path analysis. It is GEM between you

know path models and factor models factor models factor analysis or path analysis or you can say factor model and path model.

Let me highlight, what is a factor model? Factor model means, we start with like this few variables say X 1 X 1 then X 2 like say I will take for simplicity, I will put three variables and X 3 X 3. Since I mentioned you, we will let say go for X k (( )) X k. Then similarly similarly, you see here corresponding to this once we have to create epsilon 1 epsilon 2 epsilon 3 epsilon k. Then these are all latent symbols these are all latent symbols, these are all observe symbols these are all latent symbols, these are all observe symbols. Then followed by delta 1, delta 2, delta 3 delta k. Now how it is related, epsilon 1 depends upon X 1, X 2, X 3, X k. Similarly, epsilon 2 depends upon X 1, X 2, X 3, X k. Epsilon 3 depends upon X 1, X 2, X 3, X k. Similarly, epsilon k depends upon X 1, X 2, X 3 and X k. This is how the structure of factor modelling.

It is altogether very interdependent. That means, what is the basic agenda of factor analysis is that, so you have set of observe variables. We have to create a latent variable latent variables means you have to set find out a new form of the variables you have to create a set of variables, which is the linear combination of original variables. Of course, we have to assign with some weightage. I will mention here how the weightage can be considered here. Let us say here X 1 is equal to here is lambda 1 1, epsilon 1 plus lambda 1 2, epsilon 2 plus you can say continue, lambda 1 k, epsilon k plus delta 1. Similarly, X 2 equal to lambda 2 1, epsilon 1, lambda 2 2, epsilon 2 continue lambda k, lambda this is 1 k, this is 2 k, epsilon k plus deltas 2. Similarly, continue then X k is equal to lambda lambda k 1, epsilon 1, lambda k 2, epsilon 2 continue lambda plus (( )) is lambda k k k k epsilon k plus delta k. This is how the systems will you operate. That means, it is nothing but the picture will be like this X i equal to lambda I j F plus delta e. This is how it is called as factors.

That means, this factor has means this is the variable, which is integrated with some factors and its weightage with the error terms. Obviously, as per any type of testicular analysis error will be error will be obviously must, so whether you will go for the regression analysis or whether you will go for factor analysis or whether you will go for structural equation modelling, so error will be always must. With particular setup we have to bring how how quickly you have to setup the structure to analyze the particular relationship. This is how you have to observe. How do you construct all these things,

means so far factor is concerned, so there are many methods you can use to transfer original variable to new form of the variables. You can apply maximum likelihood estimation methods and thread methods or you can say you can apply principle component analysis.

Generally principle component which is the popularly known as P C A, is the most important technique, which can transfer the original set of variable to smaller number of variables, which is the linear combination of original variables. Now how do how do you proceed with mathematically it is better when you have observe variables then you find out the variance covariance matrix. With the basis of variance covariance matrix then we means variance covariance matrix with respect to its correlations; that means which correlation variance covariance means like you know suppose there are three variables X 1, X 2, X 3 then this side X 1, X 2, X 3. Then obviously, we have correlation r 1 1, r 1 2, r 1 3, r 2 1, r 2 2, r 2 3, r 3 1, r 3 2, r 3 3. This is how the co matrix can be designed.

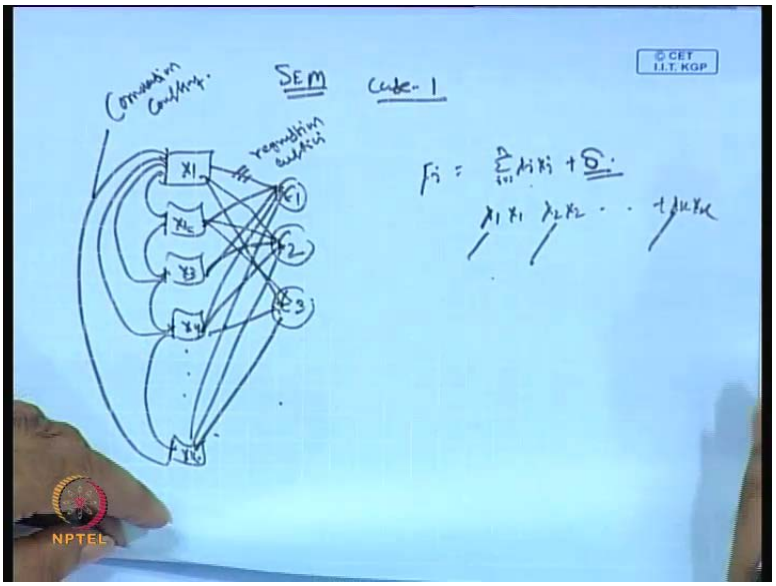
Now with the moment you have you have a number of variables forget about endogenous variable or exogenous variable, for factor analysis it is not required at also. so factor analysis we are assuming that all variables are interdependent to each other. There is no way to classify, which one is dependent structure and independent structure, but when will you go for the regression analysis there is such classification. Now you see here, the structural equation modelling is the integration of two techniques where 1 1 is the need of the classification with respect to the dependent and independent another technique, which does not require the classification dependent and independent. We have to find out you know just we have to the aim of the factor analysis is to transport original variables into some latent variables.

Then regression analysis will be observed, so how the latent variable has a relationship with the other variables various latent variables and other variables. This is how the structure is all to gather we have to discuss in the case of structural equation modelling. You you you get to know what is the factor analysis and how you to construct the factors. Factor factor analysis which is the weightage of various observes variables and the error terms. Here our agenda is to minimize error terms that is you know. The latent variable variance of latent variable depends upon two variance, one is common variance another (( )) error variance. Every time, you have to minimize the error variance, so that

the construct of a particular factor will be more practical, more physicals and it can be useful for you can say model forecasting or execution policy use.

With this particular setup, we like to highlight means, I will highlight here two different structural equation modelling, so one is a simple one another is little bit complex one.

(Refer Slide Time: 28:49)



Let us we start with simple models, so you see here. Let say this is structural equation modelling you know case one case one structural modelling case one. I will take few variables say like you know this is X 1, this is X 2, this is X 3 and this is X 4, like you know let us say X k. Then I will quality here just I am integrating this, what we have discussed in the case of factor analysis. Right now, with the help of this factor analysis. I if you know briefly highlight little bit something more and we like to integrate with respect to structural equation modelling. Now I will put it here, let say epsilon 1, epsilon 2 then epsilon 3, then you can say you put it epsilon 3 only 3. There are three items only. That means, it is not like that way if there are n number of variables you will create n number of factors, it is not like that way. There is proper technique how many factors you have to construct actually. With the basis of you know technical it is. We have to we have to find out how many factors we can able to construct in this particular available information or available data.

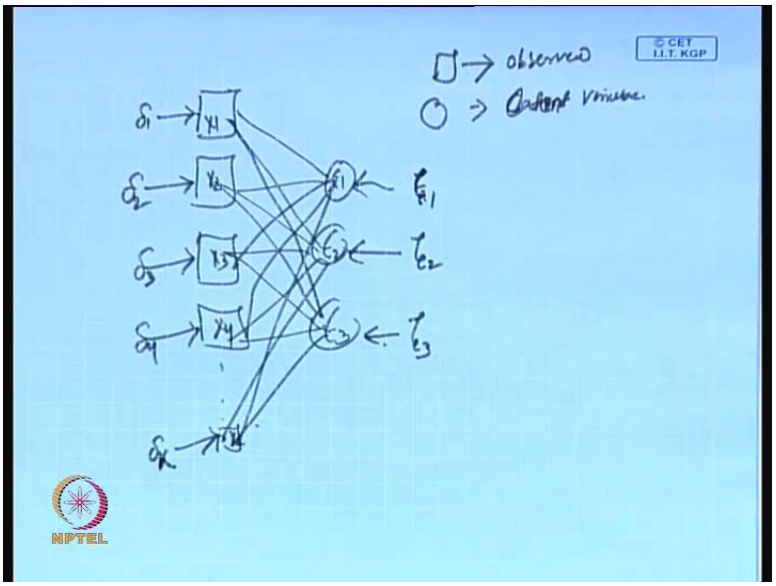
Now if this is the case then obviously you have to make an integration you see here, X 1 has a connection is like this, X 2, X 1 has a connection like this X 1, X 3 has a

connection like this. Similarly, we have we have X 1 like this, then we have X 3 like this, then you have X 2 like this, X 3 like this. It is better you connect like this. Similarly, this is connected this is connected then this is to be connected, this is to be connected. Similarly, this is already connected, this is already connected, so you have to connect like this way. This is how the factor analysis.

Now what you have to do? You like to know this is the relationship we have to see here. How quickly they are related to each other. So many relations you can find out in between all these to, so this is how the picture all about this. This is simple structure of you can says structural equation modelling. How this system are correlated to each other. Here here what you have to do this particular line will give you the indication of regression coefficient. This particular line will give you regression coefficient. That means, you see when will go for factor analysis then obviously every factor has a summation of let say lambda i x i. The lambda is the coefficient to particular independent variable like this. F i equal to summation lambda i x i equal to 1 plus you can say delta plus delta. Then you have to you have to minimize then obviously delta will be removed then finally you will get lambda 1 X 1, lambda 2 X 2 up to lambda k X k. So, lambda 1, lambda 2, lambda k these are all weightage.

In the regression analysis these are the coefficient, which you have to observe. Now this is how the lines are these straight lines are means it is an indication that we have to means it will recognize the regression coefficient. That means, it is the causality issue from this to this. How they are integrated and what is the weightage factor. Is it high or is it low, so this how you have to observe. That means, this lambda i all this things will be coming here only, so this in the straight line only. This is the regression weightage or otherwise called as a regression coefficient; however, this row or you know this row the indication this is one is a correlation coefficient. This is the indication of correlation coefficient this is the indication of correlation coefficient correlation coefficient. This how we have to observers like this to you can say prepare a structural equation modelling. I I will go little bit advanced then this particular structure.

(Refer Slide Time: 33:39)



Once I will go little bit advanced then obviously, I will put like this. Let say this is X 1, X 2, X 3 then X 4 then continue up to X k then obviously, we have to same same latent variables lambda epsilon 1, epsilon 2 then epsilon 3, but you remember this one. This particular symbol this particular symbol is the observe symbols. Observe, this means it is a readily available. This particular symbol means it is a creative, it is latent variables latent variables. We we have to artificially create this once latent variable, which is not directly available or observable. This is the connected. Now we have to connect like this way epsilon 1 depends upon X 1, X 2, X 3, X 4, X k. Similarly, it is going to depends upon X 1, X 2, X 3, X 4, X k. Similarly, it is depends upon X 1, X 2, X 3, X 4 and X k. Corresponding X 1 then obviously, we called it delta 1; this is called it delta 2; this is called it delta 3; this is called it delta 4; this is called as a delta k. This will be supported by delta k.

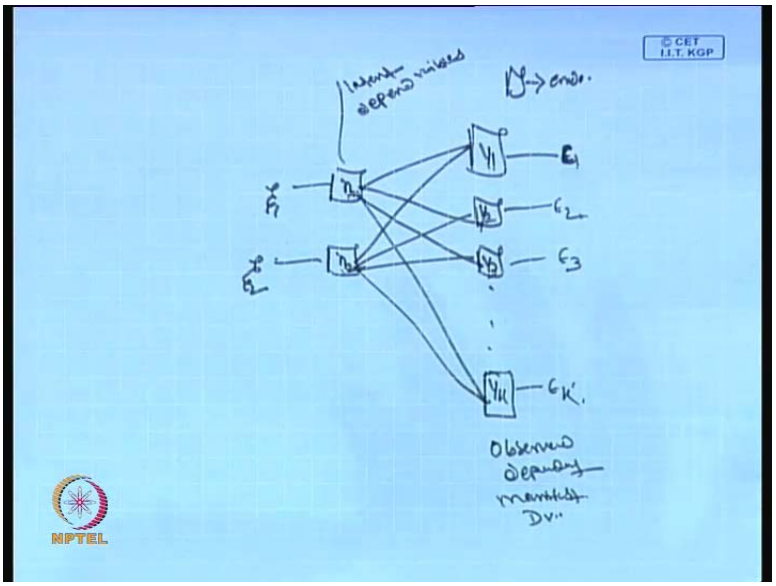
Obviously obviously this is also this has some you can say let say zeta, so zeta 1 then this is zeta 2, this is zeta 3. This is this is how the indications this is how the indications all about this is how the indications all about. That means you see it. Now, I have already mentioned when will go for structurally equation modelling then obviously there are four different steps; one step is a dependent independent with the independent latent, independent observe or independent manifest with a independent latent then another setup is a dependent manifest or dependent observe then a dependent latent.

There are four four pillars to altogether, independent observes, independent latent, dependent observe and dependent latent. Then we have to see how this finally independent latent and dependent latent are integrated. The integration of independent latent and dependent latent is called as a path analysis; however, the moment you will integrate you know observe independent observes with independent latent is called as a factor models. Similarly, dependent dependent observes and dependent latent latent when will go it is called as another factor model. Now we have factor model from the endogenous sides and we have you know factor model from exogenous side.

Now together when will endogenous latent and exogenous latent if will integrate then that will (( )) path model that means structural equation modelling is the integration of factor modelling and path modelling. We have to find out particular you know structures, so that structure will give you means will be analyze with the help of factor analysis and path analysis. This is one part of the problem where we have observes the dependent independent clusters with independent latent that means, it is you know lambda 1 is a you know you have to calculate like that way X 1 equal to means when will calculate latent latent variable one then obviously here the error term is involves and here the error term is involve, that means you see. These are all variables, so these are variables are not fully involves. It is error component is delta 1, this is error component is delta 2, this is error component delta 3, this is error component delta 4, this is error component delta k. Similarly, in the case of latent variable 1 epsilon 1, epsilon 2 and epsilon 3, so the error which we insert is a zeta 1, zeta 2 and zeta 3.

This is one part of the problems where we are integrating exogenous cluster with the exogenous latent. Similarly, we have to create another another factor models where endogenous cluster with integrate with endogenous latent.

(Refer Slide Time: 38:39)



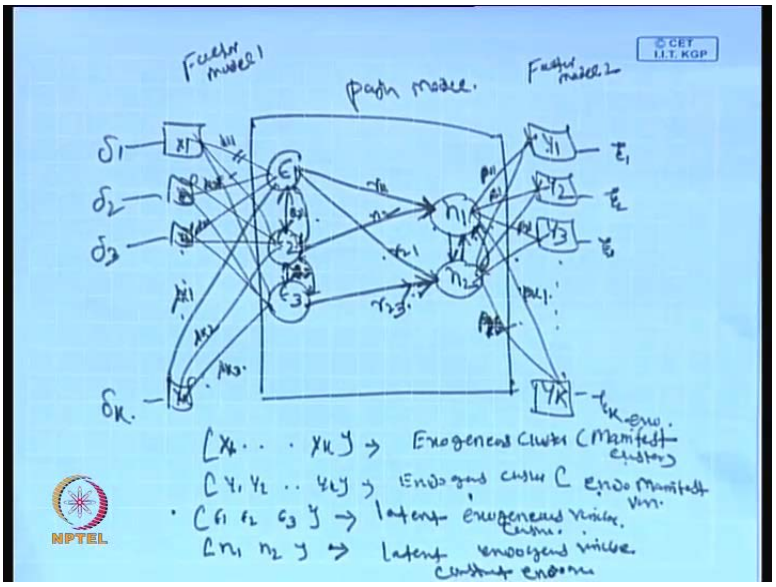
Let me highlight here. This is another way, so I will put some variables Y 1, Y 2 Y 2 then Y 3, so it will continue say Y k. These are all you can say endogenous variables this is endogenous variables Y. This symbol will be indicates endogenous variables, that means it is observe variables. Then we have to create a latent we have to create a latent. Let say this is you know eta eta 1 then this is eta 2, eta 1 and eta 2. Now how the connection eta 1 has a connection with Y 1, Y 2, Y 3 then Y k; similarly, eta 2 has a connection with Y 1, Y 2, Y 3 and Y k. So this is how then obviously it is error component is you can say epsilon 1, epsilon 2, epsilon 3 epsilon you can say k. This is you know the error component, which you put it is a zeta 1 and zeta 2 zeta 2. This is error component. That means, this is this is called as eta 1 and eta 2 is called as a latent latent dependent variables latent dependent variables and Y 1, Y 2 is called as a is called as a observe dependent variables is called as a observe dependent variables or manifest or manifest dependent variables dependent variables. These are all error terms, these are terms called dependent clusters; these error terms are latent dependent variables. This is another side of the problems. This is one part of the structural equation modelling and which we have just discussed another part of the regression modelling means structural equation modelling.

Now we have to integrate the both (( )) you know latent independent to latent dependent then will find out is there any structure between the latent independent to latent dependent. If that is so then it is called as a it is called as a path model and we like to

integrate this factor model with path model then we will highlight the of issue means it is the question of the structural equation modelling. That means, there is a need of some path, so that path is nothing but a structure. If there is any structure then obviously path model and factor model will give you the structural equation modelling. If there is no such path then obviously there is no question of structural equation modelling. You have to just and with this factor analysis only transfer the variable find out the weightage then you have to analyze with the different issues.

Now here we have to see whether factor analysis can be applied to this particular problems that means we have to transfer the original variable to into some latent variables then similarly means in the independents side similar in the case of dependent side you have to transfer the original setup into the you may dependent many you know latent variable. Now, I will clock this to gather then we will see what is the result here is.

(Refer Slide Time: 42:23)



Now the moment I will clock this to together then it will come like this way. What I will do here you check it here is this is X 1; this is X 2; this is X 3 continue this is X k this is X k. Similarly, what I have done I have put epsilon 1, epsilon 2 and epsilon 3, so this is latent, so this symbol will be like this. Then other sides we have Y 1, Y 2, Y 3 then Y k. It is not necessary that both will be same. It may be it may be different it may be different it may be different. Then corresponding to dependent variable dependent observe variables there is a latent variable call eta 1 and eta 2. So these are symbols like

these circles. Now we will connect here, so we will connect like this will connect like this will connect like this.

Similarly, with connect here like this. This is this is you know structure of this is the structure of this is the structure of you know this is factor model 1, this is factor model 2 factor model 2. That means, this is independent variables, independent latent, dependent variable, dependent latent. Now we have to find out whether there is any path. Let us assume that there is any n such there is a path. This connection will be like this and the connection will be like this. Then the correction will be the connection will be like this the connection will be like this the connection will be like this.

This is how then obviously there is a relationship by directional there is by directional, so this is by directional this is by directional then obviously a there is a relationship there is a relationship, so then we have to know the relationship like this. Similarly, we can have also here the relationship like this; generally it will come like this it will come like this. This is the complete form of this structural equation modelling. This is the complete framework of structural equation modelling.

Altogether, we have four different setups. First setup is independent clusters, independent latents, dependent cluster, dependent latent then we have to observe this particular structures. Now you know you have to see here, so this particular setup this particular setup this particular setup this particular setup is called as a path models this particular setup is called as a path models this particular setup is called as a path models. We we highlight here is you see here error term will be delta 1, error term will be delta 2, error term will be delta 3, error term will be delta k, then it will be zeta 1, zeta 2 then zeta 3, then zeta k.

Similarly, there is error terms here. In fact you know these are all regression coefficient these are all regression coefficient. I I can site it here is this one is lambda 1 1, this is lambda 1 2, lambda 1 2 this is lambda 2 1, this is lambda 3 1, this is this is epsilon e 1, so this will be connected here again, so, this will be lambda K 1. This is this is how the structure is all about this is lambda K 2, this is lambda K 3. This is how these are all regression coefficient. Similarly, this is you can say I I will call this one is beta 1 1, then beta 2 1, then beta 3 1, then this is beta K 1. Similarly, beta n k this is 2 k 2 k, this is beta k 2. This is how you have to connect like this and so then this is I will call it gamma 1 1,

then this is gamma 1 2, then this is gamma 2 1, gamma gamma 2 3. Then this is this is theta 2 1, this is theta 2 2, 2 2, this is theta 2 3 theta 2 2 3 this is theta 2 3 like this.

This is how in fact it is very the model is very complicated, means ultimately what is our aim is, so the way we have given these structures that is how it is called as a structural equation modelling, here a certain things are very much important here. The structure is itself very important then every connection is connected with same weightage that is we call is coefficient. We like to the moment means here the main main objective is to to find out what are this weightage all these regression coefficient. The coefficient will be highlight what are the variable influence on the latent variable. Similarly, you have to find out the weightage of all these factors here, then you have to find out the weightage of all these factors here then obviously we have to find out the relationship here. That means, we altogether, we have to find out the regression coefficients and we have to find out the correlation coefficient.

For summary you know for summarization (( )) summarize this particular you can say model then obviously, there are certain cluster here, so the cluster will be like this way, so one cluster will be X 1 up to X k. This particular cluster is called as a exogenous clusters, it is called exogenous exogenous cluster or sometimes it is called as a manifest clusters manifest clusters. Similarly, then Y 1 Y 2 up to Y k it is called as a endogenous clusters endogenous clusters and again it is called as endo manifest variables. This is endo manifest variables endo manifest variables. This is called as exo manifest variables variable exo manifest variables clusters. Similarly, then epsilon 1, epsilon 2, epsilon 3, so this particular structure is called as latent variables latent latent this is called as a latent latent latent exogenous variables then then another set is eta 1 and eta 2 eta 1 eta 2. This is how eta 1 eta 2, this is called as this is called as latent latent endogenous variable endogenous variable (( )) or sometimes it is called as construct construct exogenous variables this is also called as a construct exogenous variable construct exogenous variable.

This is how the full you know you know structural equation modelling. So far as a structure is concerned it is very beauty, it is looks likes very beautiful. This structure identification is very you know also very beautiful, but the thing is mathematical derivation or mathematical simplicity is little bit complex. It is not so easy mathematically to calculate all these parameters at a time, but you know so far that

classroom angel is concerned structurally equation modelling to handle in the classroom problem is very difficult. It requires lots of estimation, lots of connections, lots of integration; it is not so easy. That is why there is you know particular proper softwares, so with the help of softwares you have to get these results very easily. It is sometimes it is very windows based programming like you know there are two beautiful packages you can say that is a AMOS package and LISREL, these two packages very useful for handling structural equation modelling.

Once the important thing is that you have to come up with your proper structures without having structure it is very difficult to handle such type of problem because it is very interesting problem, very accurate problems so far as you know societal problem is concerned or business problem is concerned, because in a societal problems or business problem lots of thing very integrated and within that particular setups there may be different structures, so we need to have a close integration with difference structure and the different integrations, so that we can generalize that problems and that generalize model can be utilized for forecasting and also policy use. Without having proper without knowing anything about the proper structure or you can say proper interdependent interdependent relationship it is very difficult to handle that which we have highlighted in the case of simultaneous equation modelling, because if you will apply directly o l s technique to particular equations without having sufficient other information about that particular model and it is very difficult to estimate the parameters.

You can do that once, but the estimated parameter will be give you by the results and that model cannot be used for forecasting or policy use, that is why it is better to find out either you find you directly handle the structural equation modelling with the proper structure with the integration of path model and factor model, so then you will come out with various results of all regression coefficients, correlation coefficient that is causality and correlation, so that we can generalize in a systematic way.

So far as a reporting is concerned it is very easy to get the moment you enter the data and obviously you can get the results, but the thing is that this interpretation is very interesting here, because so many coefficients are there; so many relationships are there. It is not so easy to interpret at a times, so it requires lots of intelligent how you to handle such type of problem. This is very complicated problem. The diagram itself is very eye catching, but so far as mathematical derivation is concerned it is it becomes too difficult

to handle manually, so you have to be very careful how you prove handle that particular problem in a softwares.

In fact, this situation is more dangerous when you have series of variables independent variable and series of dependent variables and within that particular series you have number of number of you know latent independent variables and latent independent variables then in that case it is more and more complicated, but you know the most important thing is that you cannot arbitrarily cerate so many latent independent variable and so many latent dependent variables. It is depends upon here problem for formulation and within the problem formulation how how many ways you can prepare the structure and that structure can be highlighted with the help of structural equation modelling. So with this, because of lack of time, I have not touch any application part, in fact briefly I highlighted that issue of education experience and that dependence etcetera, but in a real world you have to come out with a very proper problem and you have to analyze. In the meantime, we have to stop this particular class. Thank you very much. Have a nice day.