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Welcome everyone in the last section we have discussed about structural equation modeling we have briefed about structural equation modeling and what is the role of structural equation molding right so in this case when you talk about structural equation molding which is now a day's highly used in all kind of researchers structural equation molding is build upon basically 3 kind statistical techniques you can say right.

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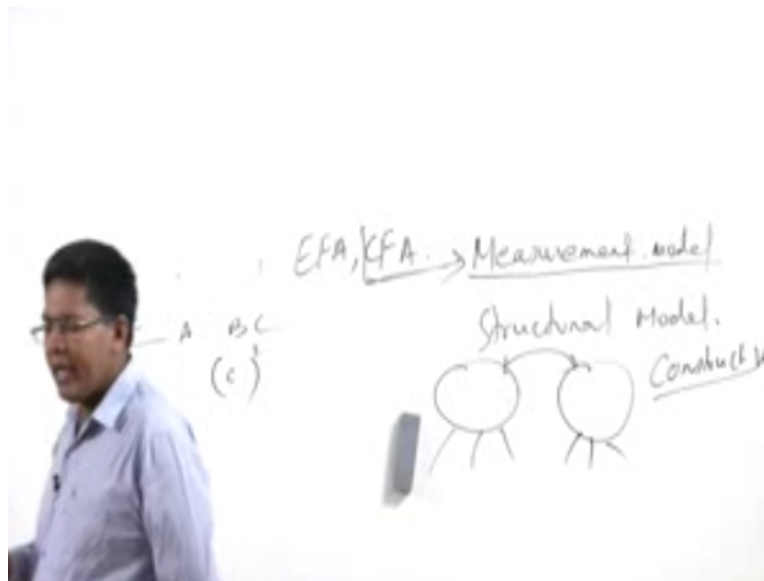
Basically the 3 are regression or if I say it is multiple regression right so multiple regression factor analysis right factor analysis and the 3rd I say is the χ 2 the 3 value the statistical measures that are highly used in structural modeling are these 3 right $\chi 2$ so the $\chi 2$ talks about the goodness

of it right so goodness of in this so it tell about the weather 2 the observe expected model the observed model and the expected model are they more or less same or different and if they are same then it is a good thing right.

If they are close or same that is good but if there is a lot of difference between the observer and the excepted then it is not good okay so what in the first part we talked about the measurement model right so we said that the entire structural equation modeling can be said as a combination of the measurement model and then the structural model okay so the measurement model is what you say is the confirmatory factor analysis right so apart if you can go understand the word so there are exploratory factor analysis and other was confirmatory factor analysis okay.

So this part confirmatory factor analysis part is a measurement model okay so this confirmatory factor analysis is used as measure to reduce the measurement error of the study right that means what when you have a measured certain things and that those things could have been measured and the you know the researcher the respondent might not have taken seriousness say interest or something on something is happened right.

So in a CFA a case what happens is here it tries to take build a latrine construct basically a latrine construct which is made up of certain variables right so this variables together will represent the construct let us say okay so this construct in the measurement models we say what we do is we basically create a covariance matrix or a covariance structure right in covariance structure if you remember we have also discussed that it is like a correlation structure only.

But a correlation is special case of covariance right so here we try to see okay weather the model there is a covariant relationship between the constructs right and finally what we do is we try to see in the CFA in the CFA case we first check the construct and for it is liability and validity okay so you checked for validity through different construct you know we say the construct validity.

So to do the construct validly we use certain ways for example we convergence validity, discriminant validity, right and homological validity right so converge validity though I am sure you are very clear because in convergence validity only thing you want to see is that weather the items are converging towards the main construct okay, so if the items are sufficiently have a larger value right the correlation between the item and the construct is high, or in the item correlation you can say is high.

Then we say this is high reliability so that helps us also to understand the convergent validity there is an convergent convergence but discriminant validity occurs when we try to measure weather two constructs are sufficiently separate from each other okay so construct A and B should be sufficiently different from each other so to do that what we use is the average values extraction right.

Value and compare it with the let us say the correlation right and we always say that the average values extraction should be high than the squared correlation value right the squared correlation value whatever it comes it should be the heavy should be higher than that then there it shows the discriminant validity okay but let us say now comes a case once we have done the measurement we have it is a measurement model so we have measured and we found that the construct is justifying and it is explaining what it should explain okay it is doing it is job with the help of the model fit indices we have said now the model fir indices are.

Basically we use the χ^2 by χ^2 by degree of freedom which we always say should be as less as possible so in between let say anything less than three is good visit right then we have taken a magic value of 3 right but some people some let also say anything up to 5 is still good right so what does it mean the χ^2 by degree of freedom basically talks about that it compare against a base line model that means there is a model and it compares.

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Okay what is saying is the observed and the expected model the observed model in the expected model the difference should not be very high right, so when we are measuring the χ^2 by degree of freedom and sufficiently is around less than 3 the we say that the model is a fit model okay, there are other fit indices also for example the goodness of it 05 ifi incremental fit indices right and you have see if I right confirmatory indices so these are some of the absolute indices which are used and we have a magical number we say.

Of 0.9 so 0.9 so if it is if this values are above 0.9 and you can you might not take all the values you might take only one of from the absolute fit indices and one from the incremental fit indices right, so if you take these values right so if you take this values and see that this is above 0.9 then along with the χ^2 by degree of freedom and these we say that the model is a fit model right and we also find something call the RMCA this is also an important thing which takes the$\sqrt{}$ mean square error.

Basically and the RMR right so these this is the residual the $\sqrt{}$ mean of the residuals right, so the residuals are the unexplained so unexplained part the residual the square of the unexplained right basically it takes right and the RMCA now in these two values are all sufficiently go to below 0.8 we say now for RMCA is 0.08 8% below 85 less than 8% then it is a fit model, so after doing all this we have understood that there is a measurement model the measurement model has been used to check for the constructs validity and reliability.

But now consist a situation where we have to check whether there is a relationship between the constructs or not or what kind of a relationship exist between the constructs right, so to do that we use the path analysis this is the path the path analysis right, so the path analysis basically is the structural part only right so what is happening here we are saying model construct a is affecting let say construct V this is a simple case like a regression only but suppose now we are adding a third variable.

Let say C the third construct now we are saying that if in this case it is becoming more than a simple multiple regression in a multiple regression case you had this was the let say dependent variable is the independent variable, but now in this case this has change it is characteristics and it has become a new independent variable and this is become a final dependent variable so in such a condition which is actually what it is happening in real life right so one becomes the father of a house is dependent the family is depend on the father.

But the father is maybe dependent on his on this office or the you know his office ambient office the climate or his let say the boss right or but wherever his working so if we more or less say suspended from his job then his family will get affected or if he is given a promotion then his family will produce a positively affected so let say if I take it all though it is a very crud way of understanding this is the boss or the employer let say the boss is a bad word the employer the father and the let say the children.

So the children are dependent on the father the father is dependent on the employer right so this is the case where we want to establish such kind of relationships to do that we use structural equation modeling so it is a process for testing a structure theory.

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Structural Equations Modeling Defined

Structural Equations Modeling ... is a process for testing a structural theory. A structural theory is a conceptual representation of the hypothesized relationships between constructs. It can be expressed in terms of a structural model that represents the theory with a set of structural equations and is usually depicted with a visual diagram.

Right a structural theory is a conceptual representation of the hypothesis relationships the hypothesis relationships between the constructs now this relationships that we have built their hypothesis relationships they are yet to prove it right, so how do we prove it now we will see that how do we prove it, so after you know the mechanism becomes like exactly like a multiple regression only okay so it can be expressed in terms of a construct model structure model that represents a theory.

With the set of structural equations so everywhere there is a new equation it is alike simultaneously equation right so you are creating different equations right, here to here so this equation that you have building and testing down with the it represents the structural model theory the set of structural equations which is set of structural equations and use different with the visual diagram is this okay so what are we focusing here.

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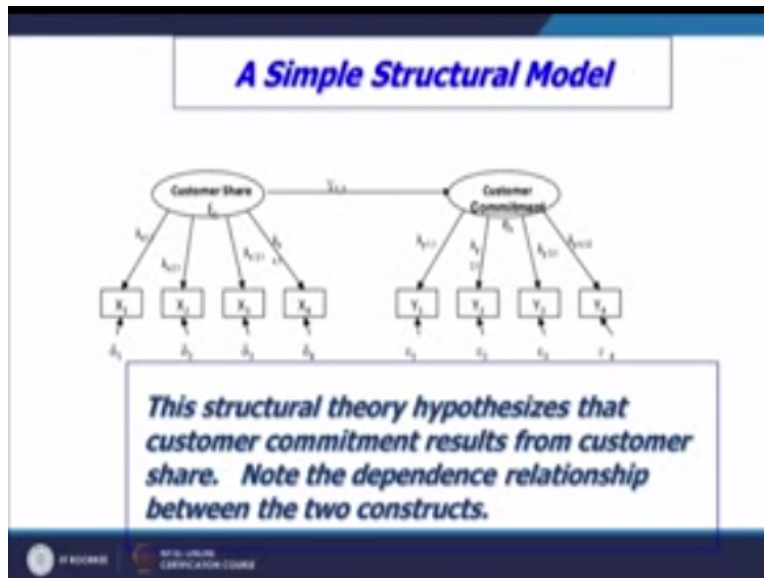
An Overview of Theory Testing with SEM

The testing of theoretical models using SEM focuses on two issues:

- The overall and relative model fit.
- The size, direction and significance of the structural parameter estimates, depicted with one-headed arrows on a path diagram.

So what are we focusing here they are focusing on the overall and the relative model fit right and the size direction and significant of the structural parameters estimates now the estimates the word estimates if you this is are the simple the regression estimates they are the regression coefficients right now the help of estimates we can say whether a hypothesis is to be excepted or rejected the estimates will help us to say okay whether a hypothesis is to be excepted or rejected.

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A Simple Structural Model

This structural theory hypothesizes that customer commitment results from customer share. Note the dependence relationship between the two constructs.

Now this is a structural but one thing before I we get into the structural model please remember that the structural model the relationship that you have built in this case was the C right.

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It should always emerge from an existing theory it is not that we will lied something like you know the A is effecting C we will say or C is getting effected by A, now that is something like out of basis out of reason right, so just pulling an arrow to make some you know to just prove your point or prove some bodies point is not the right thing to do, your model should be build up on well cleared structure theoretical optimize, okay.

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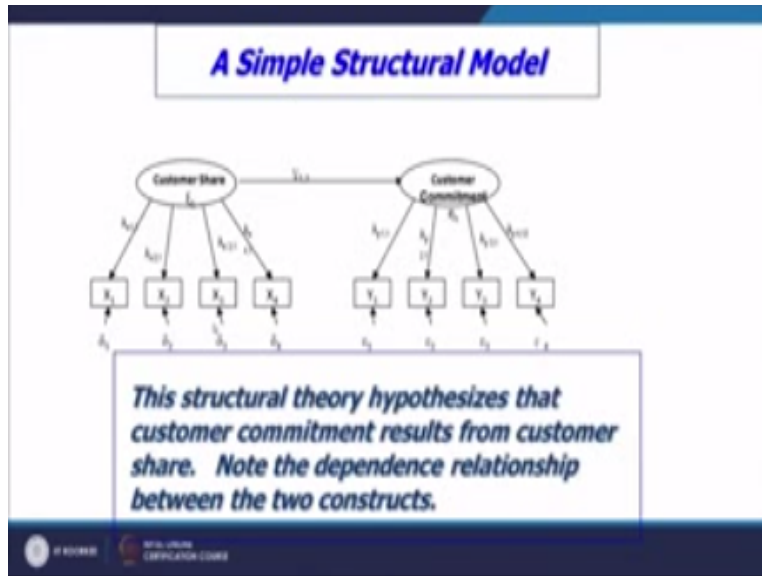
So there are two constructs here customer share and customer commitment, customer share has got four variables customer commitment has again got four variables, right. So this λ if you see the λ they are factor loadings as use of factor loadings in factor analysis explore factor analysis, similarly these are also the factor loadings okay, so the structural theory hypothesis that customer commitment results from customer share right.

So the arrow moves from that means the arrow is moving from customer share to customer commitments because the customer commitment is a dependent variable, right.

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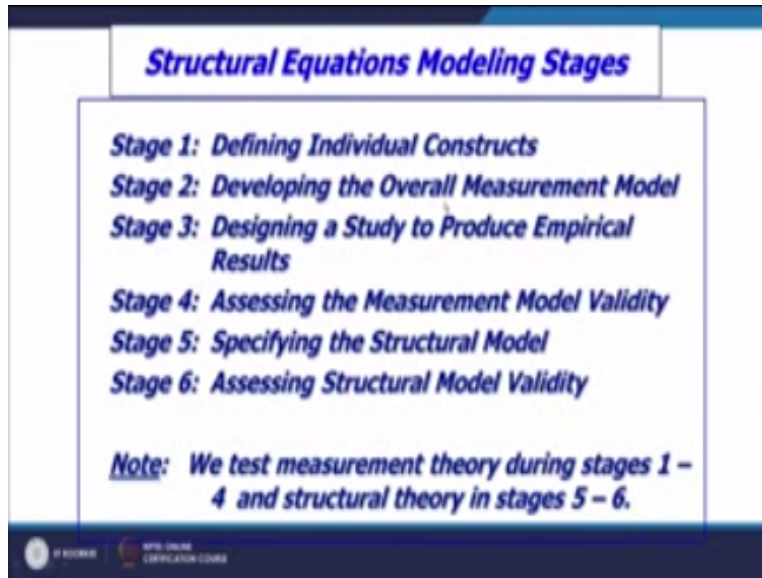
So structural equation modeling there are six stages, the 1,2,3,4, here if you see defining the construct or developing the overall measurement model designing the study to produce empirical results, assessing the measurement model validity is a part of the measurement model of the CFA right. The 5 and 6 specifying the structural model and then the assessing the structural model validity is the 5 and 6 are the part of the structural equation, right.
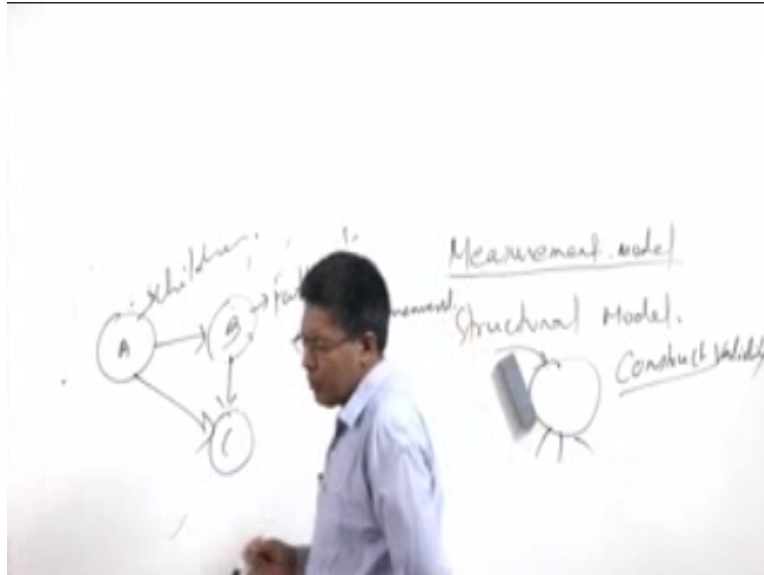
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So the structural model so remember when you have let us say after you have done the measurement model, right.

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So whatever is your the fitness indices have been generated right, the structural model should be better than the measurement model, the structural model should always be better or have a richer value or higher value then the measurement model, if it is not happening then there is not more of a significant improvement right, so we need to understand that the measurement model was only measuring the constructs but structural model you are putting in some relationships right, so the structural model has to be more powerful and you know robust then the measurement model, okay. So how do you convert a measurement model into a structural model?

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Stage 5: Converting a Measurement (CFA) Model into a Structural Model
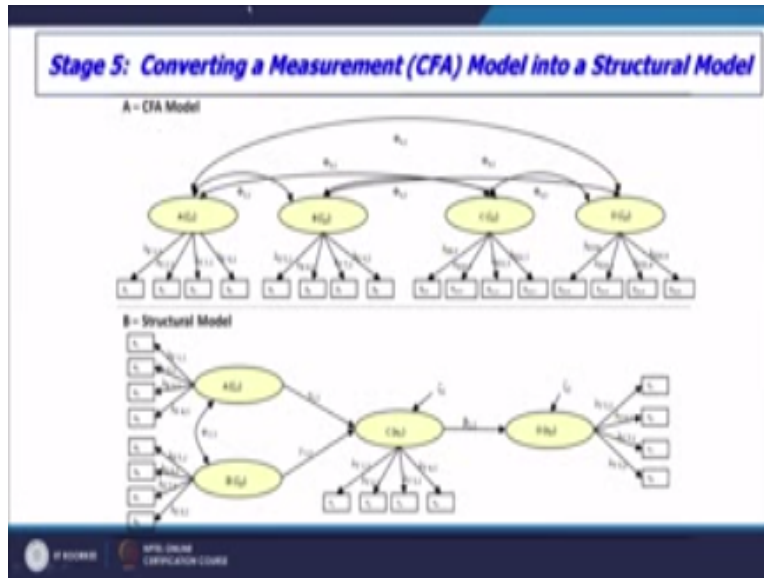
So now you see the A this is the measurement model, so A,B,C,D these are all there is a covariance relationships right, so there are there is a double headed arrow to from one construct to the other, right. So this double headed arrow is basically nothing but it tells talks about the covariance relationship, right. But here if you look at the structural model it is very clear in saying that A and B effects C, C then effects D, okay.

Now these things that you see that for example this symbols right, these are called the error terms so if you these are the sometimes we use it simple we use e1,e2, right kind of error terms.

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Now what are the error terms time and again I have been explaining the error terms are nothing but the unexplained part, right. So in this case there are four items or variables detect with each latent construct and 4,4,4,4, and there are two error terms here, right because every dependent variable will have a error term right, the dependent obviously the independent variables do not have an error term, right.

So why then this is also an independent variable then why it is having a error term now because it is also a dependent variable for these two okay, so that is why.

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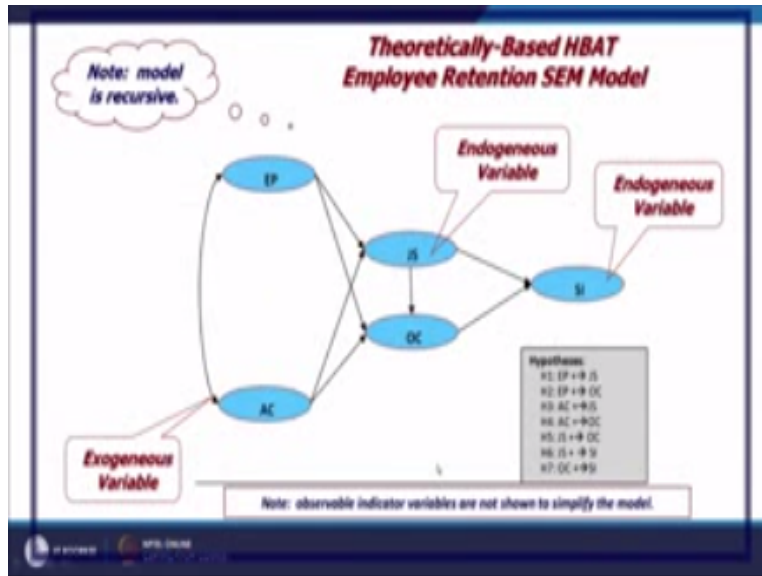
Stage 5: A Non-recursive Model

A Non-Recursive SEM Model

C is both a predictor of and a result of D.
D is both a predictor of and a result of C.
Therefore, the model is non-recursive.

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Now I am not getting into the recursive and non-recursive model base just if you want to understand because a recursive model is something where there is a if you look back this is a non-recursive model and the recursive model is the only difference is that when there is a one sided.

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When the arrow moves from one direction towards one direction only we say it is a recursive model on the other hand when there is a dyadic relationship or a double you know the path is moving both sides right, so in that case this is called a non-recursive SEM model, right. So now let us look at this case, this is HBAT from the book of that hamen black Harlene Anderson so from there we have brought.

So these are some of the constructs and the relationships so these are the endogenous variable this is the endogenous variable these two are the exogenous variables, exogenous means independent and endogenous means the dependent, okay. Now hypothesis is there are several hypothesis if you can see the h1 is saying EP now what is EP if you want to see then I think it will be here.
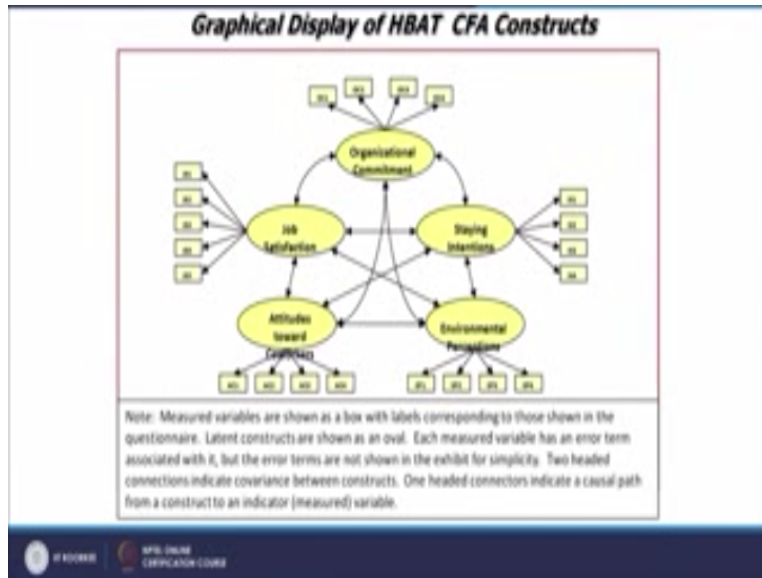
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EP is environmental perception AC is attitude towards co-workers, SI is staying intention, OC is organizational commitment and JS is job satisfaction, okay. So environmental and what about this co-workers I think attitude towards co-workers are effecting the job satisfaction and the organizational climate finally effecting the staying intention, so the hypothesis is that environmental effects JS job satisfaction, environmental also positively effects OC, AC effects JS, AC effects OC, right.

And then JC sorry JS effects SI and OC effects SI, so 1,2,2 here 4, 5,6,7 right and JS and OC there must be 1 so if you see job satisfaction leads to organizational commitment this is 1 word right kind of a relationship so this is very complex relationship right so I am not getting into back into CFA now.

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Graphical Display of HBAT CFA Constructs

Note: Measured variables are shown as a box with labels corresponding to those shown in the questionnaire. Latent constructs are shown as an oval. Each measured variable has an error term associated with it, but the error terms are not shown in the exhibit for simplicity. Two headed connections indicate covariance between constructs. One headed connectors indicate a causal path from a construct to an indicator (measured) variable.

So yes so let us look at this right so if you are having such a condition now you have a establish in relationship now what should you do after you have got structural model in that then what you need to do is you and to find out to first the module fit right so as you did in the measurement model similarly you need to find the modified for this case also and I said that the module fit should be better than the measurement model right.

So once you have the measurement model then what you do is after you check for the model fit suppose your module is fit then you do to the next thing that is to check for the fitness and indices now in the fitness indices also you have suppose you have check and they all coming .9 and above so the piece the model is now clear.

It is fit model right there is no problem with that but in case, in case there si a problem of let say there is poor model fitness is showing then a most has a facility to improve the you know to improve the Amos is very popular software to improve the model you can do one thing you can use the modification indices.

So modification indices are one such value which is used to improve the model fit now if you have the modification indices then this indices what is does is basically tries to find to which are the error terms which have got lot of you know which is a lot of unexplained part into it so that those two errors are combined.

So that unnecessary unexplained part will get reduced and the model will improve better right so okay so once you have done this then what happens is let us go back to the hypothesis now what

you do is the you need to go for the estimates right the estimates so the estimates will assume in Amos at least helps you in providing this estimates the estimates as I told you as nothing but the coefficient regression coefficients for each value.

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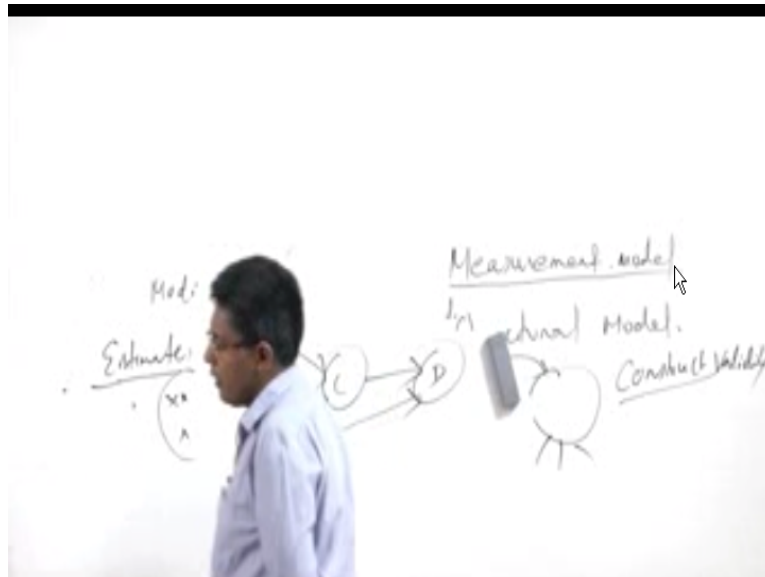
Now it will also give you with it the estimates as well as the significance right so when it gives you the significance right from the significance if suppose something is significant right the significance is showed in people star or double star look at depending on .01 or .05 or .001 right kind of significance level.

So when you are going through that estimates you need to check but relationships suppose JS EP to JS now if that relationship is it will give you in you know significant or non significant relationship it will explain that so if your significant level is your relationship is significant then we say that yes JS is really getting effected by EP and it is not due to chance that it is happen in this time right.

Similarly suppose out of it suppose you found only one of them is JS and OC JS job satisfaction leading to organizational climate this is not coming significant that means what in this model we have theoretically assumed that job staid faction aloes leads to organizational climate and thus it affects sustaining intention right.

So this is not coming true that means this hypothesis is a first hypothesis we cannot say that JS is actually affects OC and then that affects aside right OS this is one thing that you are given right so after the end you will get all the estimates and with the significant values and through that you can accept or reject your hypothesis right.

So in this case as 7 hypothesis and we said tentatively let say only one of the hypothesis is not accepted or it is rejected let say so it is rejected so we say in this study there are 6, 7 hypothesis out of which the first 6 hypothesis where significant and they were it showed a positive effect as relationship you to explain to the relationship.

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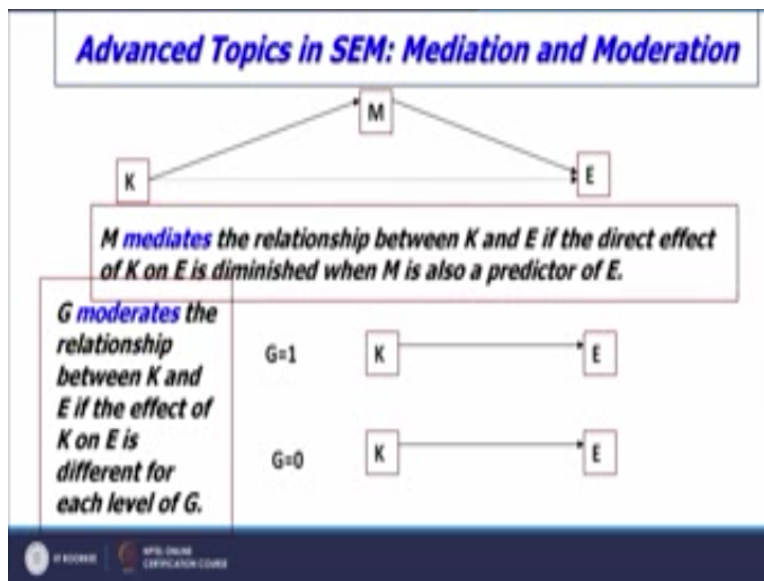
But only one of them did not show significance relationship that means it showed there is no effect okay so when you do this when you do this you need to understand that there is something

also for example let say two constraints let say two constructs this is third constructs let say this is the fourth constructs let say right.
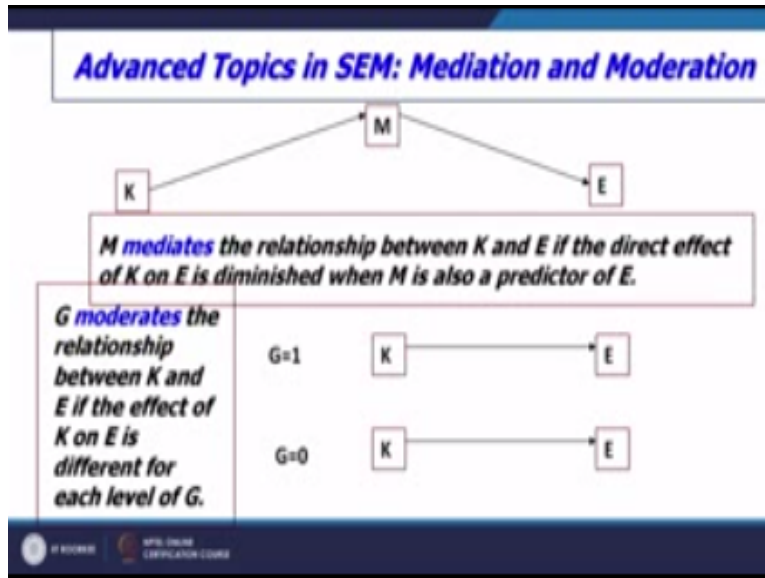
Now there is something we need to understand A B C D for example okay so now if you see in this case A is effecting B also through C okay B is also effecting B through C and as well as directly in this case if you look at it right so B has a direct effect also and B has a indirect effect also so let us say this two are point to factor loading are .5 and .5 right.

And this is .4 right and this is let us say .3 this is the factor loadings I am giving now what will you understand from here the two types of effects one called the direct effect and other called the indirect effect. Now in this case, you have to understand that the indirect affect from A to B through C, indirect effect means when the variables passes through an intervening variable that means a mediating variable, which is behaving like a mediator in-between right, so 0.5 x 0.4 = 0.2.

So the indirect effect is 0.2 for to A to D, and similarly from B to D, it is also this could be 0.4 also, so 0.16. So this from what is direct effect from the B to D in 0.3, so here we say that the direct effect from B to D is higher than the indirect effect and in this case the total indirect effect, the indirect effect is 0.2 + 0.16 okay. So when it is of the interest to a researcher to know, whether the mediating variables come into the picture, where it is advantages or it is not required sometimes it is like catalyst to understand.
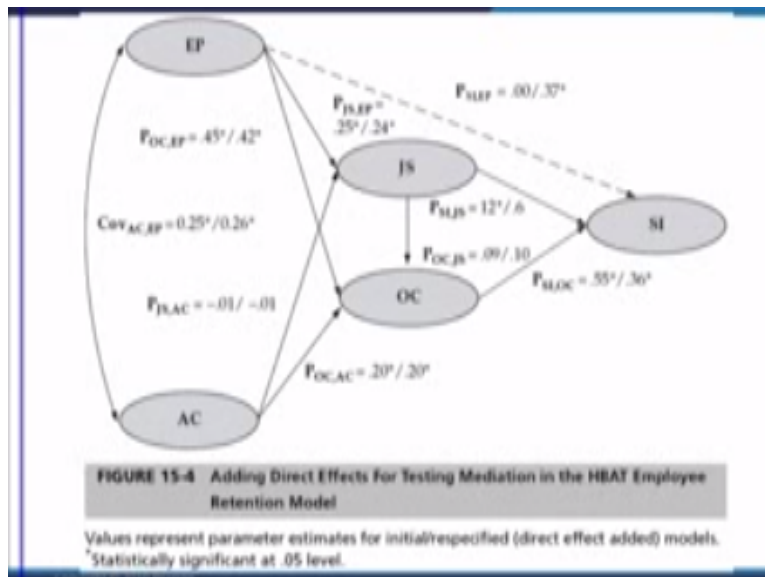
Like in the catalyst the presence of the catalyst will change the reaction right, so direct effect might be significant might not be significant right, so if it is what ever and the value could be less or more whatever but suppose if it goes through the mediating effect, then suppose if we see it is significantly improving, the value is improving, then we say there is a presence of a mediation effect. So let us what is mediation, as you can see here right.

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Advanced Topics in SEM: Mediation and Moderation

M mediates the relationship between K and E if the direct effect of K on E is diminished when M is also a predictor of E.

G moderates the relationship between K and E if the effect of K on E is different for each level of G.

K goes through E through M, M being the mediator right, so M mediates the relationship K and E, if the direct effect K on E is diminished, when M is also the predictor of E. so if suppose if you have the direct effect, nobody wants the mediator unless the direct effect is not so good right. So if your mediator adds to the explanation or adds to the strength to the relationship then only the mediator is the justification otherwise there is justification for the mediation okay.

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FIGURE 15-4 Adding Direct Effects For Testing Mediation in the HBAT Employee Retention Model

Values represent parameter estimates for initial/respecified (direct effect added) models.
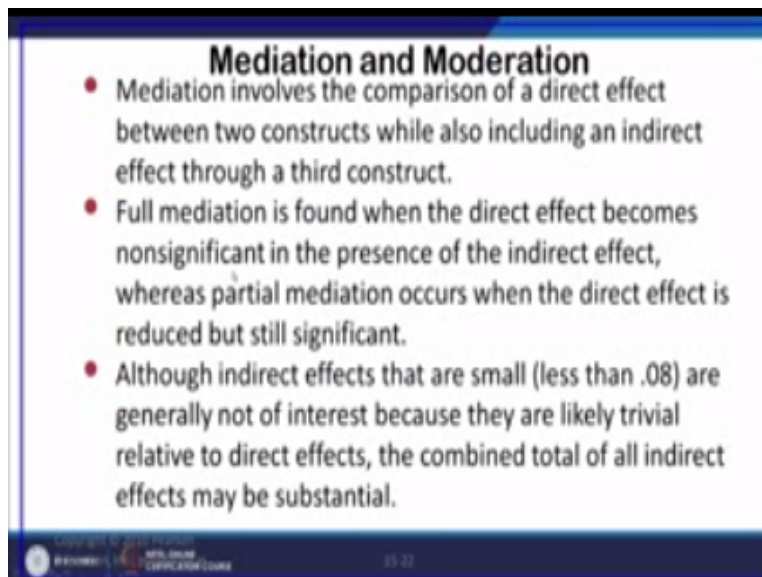*Statistically significant at .05 level.

Now adding direct effects, so how do you check for the mediation although it will not explain, I will go directly here, let say there are two types of mediation on is the partial mediation and

other is the full mediation. The mediator has the partial effect and other has the full effect, now what is this full and partial. Let say A M B okay, so this is something like this. So when A has the significant effect on the mediator, M has the significant effect on the dependent variable right.

Then A and B also although some people say it is real method but still it is very basic method and it is very clear method. Suppose the presence of the mediator and the absence of the mediator if the significance layer changes let say the direct effect, let say when you bring in the mediator, let say the mediator becomes strongly significant and direct effect show not strong then we say it is the case of full mediation right that means when suppose A to B was earlier significant now also.

And through this is becoming significant right then we say it is the power full mediation, at suppose both are significant but this has got lesser value then this is the partial mediation, so this at the ways of justifying or identifying.

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So mediation involves comparison of a direct effect between two constructs, while also including an indirect effect through a third construct. Full mediation is found when the direct becomes nonsignificant as I said. So when it is nonsignificant in the presence of the indirect effect, where as full mediation is when it is nonsignificant, whereas partial mediator occurs when the direct effect is reduced but still significant.

That means what if I go directly I will also get money for example, but if I go through somebody I will get more money that is the partial mediation, but suppose if I go directly I will get more money but I go through somebody I will get full money, the it is a full mediation, as good as that right you have to understand.
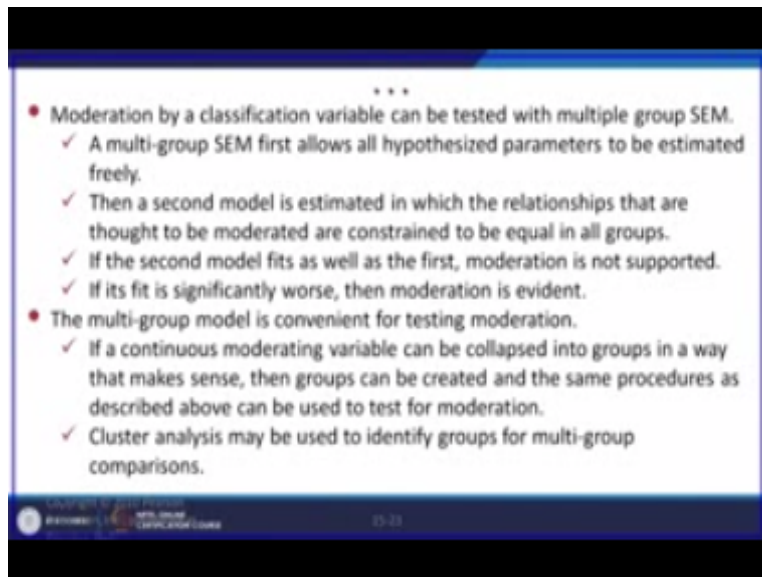
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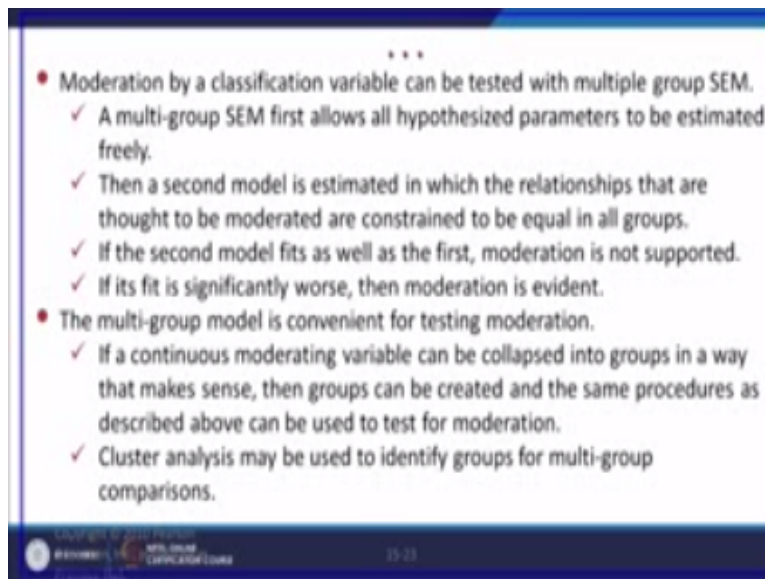
These are some other things okay, there is one more important thing this is called a after the mediation there is something called as the moderation also. Now what is the moderator? A moderator is always you know the something like; there is something which are used as a moderator. Now something automatically moderates the relationship okay. Now what is moderating the relationship?

Now for example many cases, gender is a moderating variable, now what do you mean by moderating that means, whatever the relationship you studied in this case for example the 7 hypothesis that might behave differently for male and differently for female okay so if you have if you exercise the same thing for male and you exercise the same relationship and test the relationships for female that means it is different, so if you take only gender as one that means there is you are not able to get into deep and you are not explaining it well so if you do a modulation test then we can easily explain that whether gender also modulate it also modulating.

The relationship between let us say I am saying here I am putting in a moderator okay now I am saying the relationship between a and b is moderated there is a mediator also but there is mediating and moderating effect both are there right so the moderator is effecting the relationship right it is effectively the relationship so how do you check for modulation it is very simple the nothing very complicated.

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- Moderation by a classification variable can be tested with multiple group SEM.
  - ✓ A multi-group SEM first allows all hypothesized parameters to be estimated freely.
  - ✓ Then a second model is estimated in which the relationships that are thought to be moderated are constrained to be equal in all groups.
  - ✓ If the second model fits as well as the first, moderation is not supported.
  - ✓ If its fit is significantly worse, then moderation is evident.
- The multi-group model is convenient for testing moderation.
  - ✓ If a continuous moderating variable can be collapsed into groups in a way that makes sense, then groups can be created and the same procedures as described above can be used to test for moderation.
  - ✓ Cluster analysis may be used to identify groups for multi-group comparisons.

In case you have continuous variables also you can use a moderator because generally there is a confusing between researchers that moderator should be a categorical variable or not right if you have a continuous variable also what you can do is you can user some logic and create some categories in it for example let us say income from 0 to let us say any value 0 to 10lakhs is let us say one

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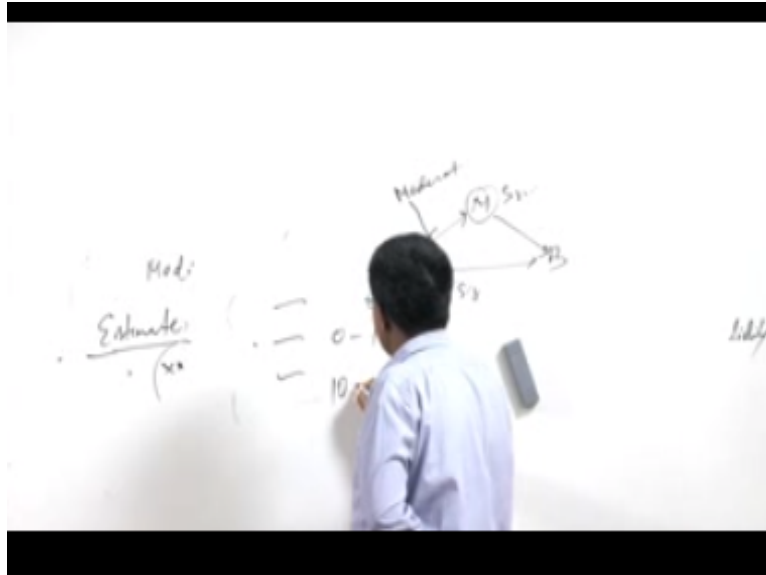
Let us say 20 lakhs is 2 let us say above is 3 now while doing this what I have done is I have categorized the variables right so modulation can be tested with multi group SEM right so what you do is in a modulation test you first define the groups and then you run it by taking each part of the each group you know individually so by taking it will have two value will generate one suppose in this case the all seven hypothesis that seven you know all these things.

So if you have for male you will have particular seven hypothesis the relationships right similarly for female also you will get it right now how do you know the moderator what should we do to look at the effect of modulation the best is to see is there any variable or any relationship that is significant in male and not significant in female or vice versa only pick up those relationships which are significant in both the cases the once which are not significant in either one of them they are items for deletion okay.

So by doing this basically what you are doing is you are using a modulation technique that is another way also which I was saying modulation variable can be collapsed in groups which I explain or cluster ally this is also can be used to identify the groups right that is also by the hierarchical clustering you can identify the groups also that is one more method so whatever it is so you have understood that structural model helps in identifying the relationships how they go and there is if there is any mediating effect we can check and finally is there a moderator how is the moderator effected in the relationship that also can be checked right so this is all we have for SEM now thank you.

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