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Welcome everyone to the class of marketing research analysis now previous classes we have been discussing about various tools such as multiple regression then we discussed about the F distribution ANOVA basically and how they are being used in the market by marketers for predicting for predicting something for finding out some you know test some differences between two groups something similar to that.

But in the in the, next just pervious section we had started with an interdependence technique called factor analysis which basically is used most it is a it is used to you know reduce large number of variables into a few meaningful once called factors basically right so and there we said that factor analysis is of two types one called the exploratory factor analysis okay.

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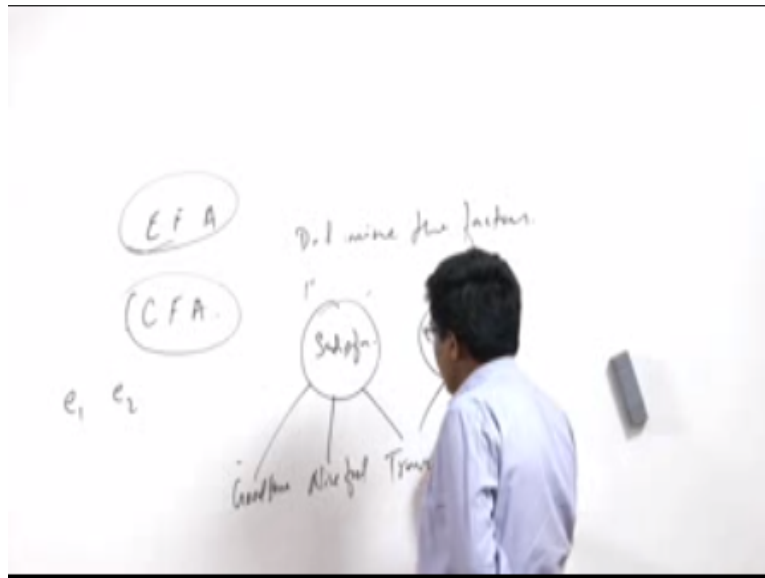
And the other being the confirmatory factor analysis the exploratory factor analysis we had discussed is that which reduces the variables to a few meaningful factors okay and the here the factor loadings are calculated right the ladings are calculated which determines okay amount of relationship exists between a variable under certain factor okay after that we also discussed how in a factor exploratory analysis we rotate factors to generate a very proper or very you know a good nice distribution,.

So that the variables are not loaded into one factor but they are distributed across two several factors right so this to have an good nice distribution we did factor rotation which is for example we said about orthogonal rotations where the we assume that the variables are uncorrelated on the other hand we had in optic rotation that we said set that the variables have some degree of correlation among them right.

So after doing a factor analysis within came out with the factors and the we thought of how could we use those factors for our further studies so first stage wad to determine factors which we had done okay determine the factors and the in the 2nd stage we said how do we use this factors so to do that we I explained that there 2 things one called factor scores right and something called summated skill right.

So by the help of factors score or submitted skill method we can use the factors the values derived from each factor let us say there are 4 factors F1, F2, F3, F4 and use them treat them as variables and use them for some kind of a predicated modeling in like a multiple regression okay

so that was the basically what we had determined what we had discussed there we had also yes the second that was the 1st part which is called the exploratory the 2nd part being the one which is called a confirmatory factor analysis.

Now why it is called as confirmatory factor analysis if we see the purpose remains the same right like in a factor analysis or purpose was to find out the loadings between the variables and the factors right so what amount of simply correlation basically what amount of correlation exists exited between the variable and the factor that was a prime importance to us.

And in case we found that certain variable was loading on to several factors which we say as cross loading then that was a problem to us one more thing was in the exploratory factor analysis we were not assuming any relationship between the error terms, we were not assuming any relationship between the error terms let say u1 and a2 so we are assuming that there is not relationship between the error terms in the exploratory facto, but in case of a confirmatory factor which we are going to now talk about.

Discuss is the confirmatory as a name suggest that the researcher already has got a prior knowledge he has a got a prior knowledge about the construct and the variables right, so he already knows okay which variables will make up to a factor or which variables together will load in to a factor and what exactly this right, so what they are trying to say here is in case of a in case of a confirmatory factor analysis let me do it like this so I know I am not exploring any more like an exploratory.

I know that suppose these are the two factors each factors has got certain variables to I know that these variables are related to the construct due to certain theoretical foundation that means by prior and knowledge from prior knowledge I know that a variable the variable is connected for example this is satisfaction, so satisfaction could be let say by good score right from nice food right tasty food travel so these are leading to let say satisfaction suppose so then I know that because of this relationship.

Exists I am only doing one thing I am trying to conform that whatever I thought as a researcher my though is correct right so if the loadings of the variables are sufficiently high on to the factor then we conformed our thinking that the we conform that our thinking is correct that our approach is correct and this is what we do in a confirmatory factor analysis okay, so this is what

basically starts with right so the entire thing but let us go slow will start with something called you know when you have a multiple now this is a case coming up slowly where you multiple relationships are coming up right.

And they need to be tested right multiple relationships are coming up and then it to be tested so in case when such an event happens when such an event happens where you have multiple relationships for example lot you can think what should I do when let us say such a relationship suppose starts.
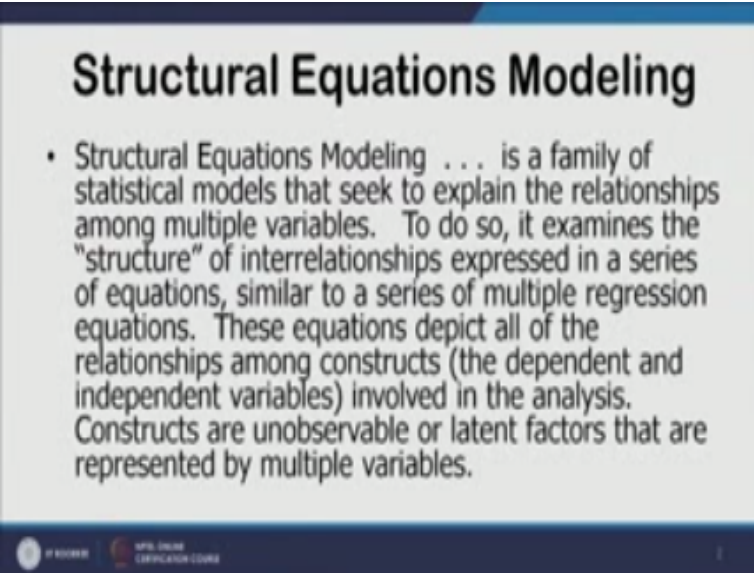
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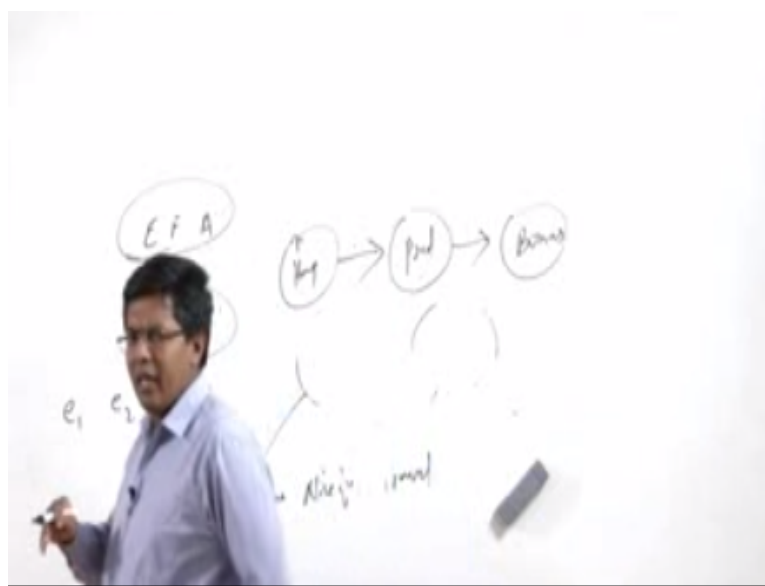
Let us say happiness leads to productivity, productivity leads to larger bounce okay, now this is a kind of relationship that I am trying to determine or I am trying to check so here there is a problem that I am having multiple relationships, now here a was big behaving as an independent variable and b as a dependent variable and then again they are reversing there science or reversing their you know the job that they are doing, basically the dependent is becoming independent and vice versa.

So let us see what is this SEM this method where you have several variables coming together that is called as is very you know likely, like it is works like a multiple regression where you try to create several equations for the different dependent variables right, so let us see what is this SEM and why it is I am connecting SEM and CFA, okay.
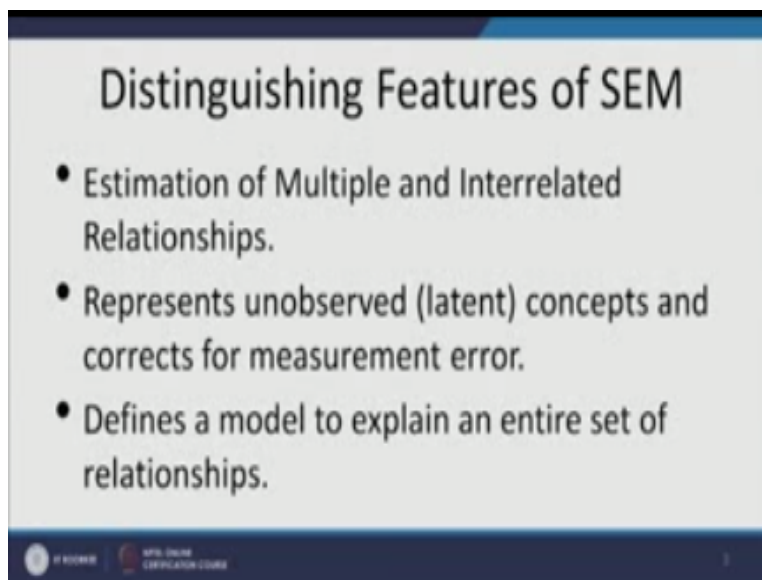
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So as it says structurally equation modeling is family of statistical models basically in my earlier classes also I have must have said that structural equation modeling basically compresses of three if important things, one the factor analysis, two the regression analysis, three there is an element of the chi square right, the chi square value which is highly used in a structural equation modeling to test the goodness of it for a model which I will explain later on.

So it says a family of statistical models that seed to explain the relationships among multiple variables, so you had multiple variables let us sat there are this a construct can also be a variable right, so if I am taking a submitted scale for example. So now I am saying there is a multiple relationship okay, to do it so it examines the structure of the inter relationships express in a series of equations similar to a multiple regression. These equations depict all the relationships among the constructs involve in an analysis right, so which we have discussed out there and what did I say the constructs are unobservable or latent variables as you can see here.

So the constructs are latent factors or unobservable as I has explained earlier that it cannot be directly measured but it is measured through some number of, some items or some variables right, so a construct can be measured by four items, three items, five items, ten items one has to be careful that sometimes through researchers take very few items to measure a construct that is not a very good thing, right.

If you take two, if you take very few items there is a fear of an you know under identification of a model that means the model will not explain itself well so that is a very not so wise thing to do all the time researcher should try to have minimum three, four or above number of items to explain a construct right, okay. So what are the distinguish features of SEM.

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Distinguishing Features of SEM

- Estimation of Multiple and Interrelated Relationships.
- Represents unobserved (latent) concepts and corrects for measurement error.
- Defines a model to explain an entire set of relationships.

What is SEM all about right, so as it says multiple and inter-related relationships so you have multiple and inter-related relationships it represent the unobserved concepts these are the concepts for measurement error. Now when I am talking about SEM there are two important things which are to be discussed we I will go one by one, one being the measurement model which will talk about and then we have something call a structural model, right.
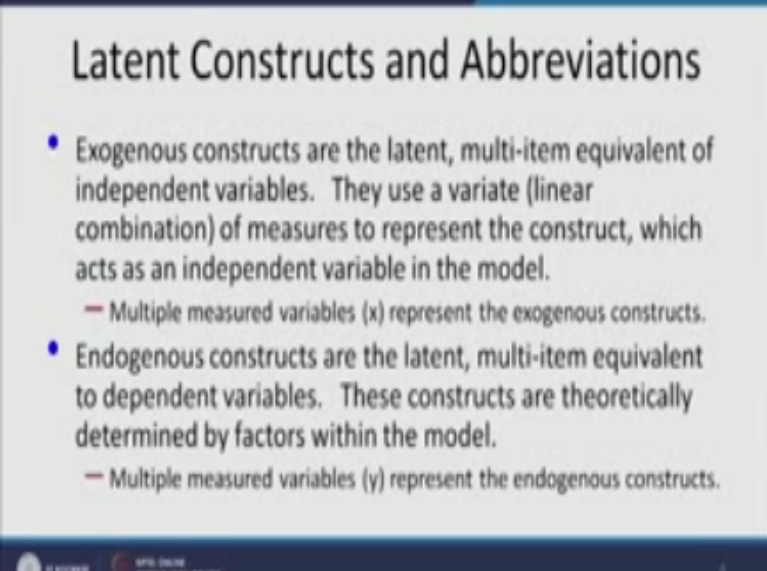
So the measurement model is where you are measuring whether the constructs are valid enough or not now that is what is the job of like a fact it is very close to the factor analysis explanatory

factor only difference being here that you know what you are doing and in exploratory and in exploratory you did not know what you are doing that is the only difference right.

So it represents unabsorbed concepts and corrects for the measurement error if there is any measurement error then it corrects for it defines a model to explain and entire set of relationships so now this entire set of relationship finally let us say it is not only happiness but happiness and let us say satisfaction okay, let us ay two difference they are together explaining right, so now this could have there could be a direct effect there could ban a indirect effect also and this case we can see there is element of an indirect effect which is present in this model right so in such a condition just doing a multiple regression we will not be effective right.

So in order to avoid that situation we use structural equation modeling okay, so let in construct basically are in the case of SEM we use this term exogenous and endogenous constructs is are nothing but this similar to the independent and the dependent variables right.

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So exogenous constructs are multi equivalent multi equivalent of the independent variables right and endogenous constructs are the latent multi item equivalent of the dependent variables. So what you are talking about in normally we talk about the independent the dependent the same becomes called as exogenous construct in the case of SEM and CFA and the dependent is known is the endogenous construct in this case okay. Now let us look at this case.

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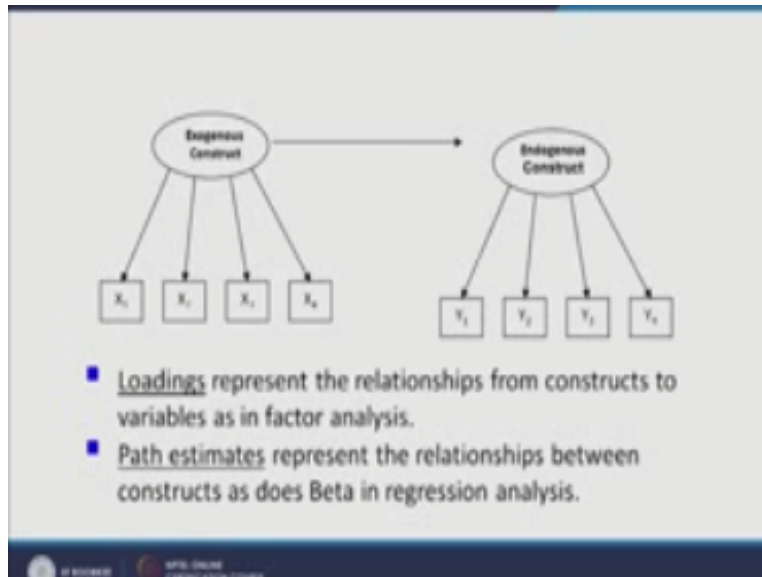
Now let us look at this case as you can see now this slide the exogenous construct here has got 4 variable right and the endogenous construct also has got 4 variable right so these arrows that you can see here 1 2 3 4 this relationship is termed as the loadings the loading now I had explained earlier that loading are the correlation among the between the variable and the factor in case of a explanatory the same role is apply the same concept applied her also.

And then we have something called a path estimate this path estimate represent the relationship between constructs as beta in regression analysis in regression analysis we were using the un-standardize or standardize beta which to you know o understand the effect he coefficient the estimates the same thing we are using her and this is this one this arrow that you see between the two contracts from the exogenous to the endogenous this estimate is nothing but the called the path estimate okay.

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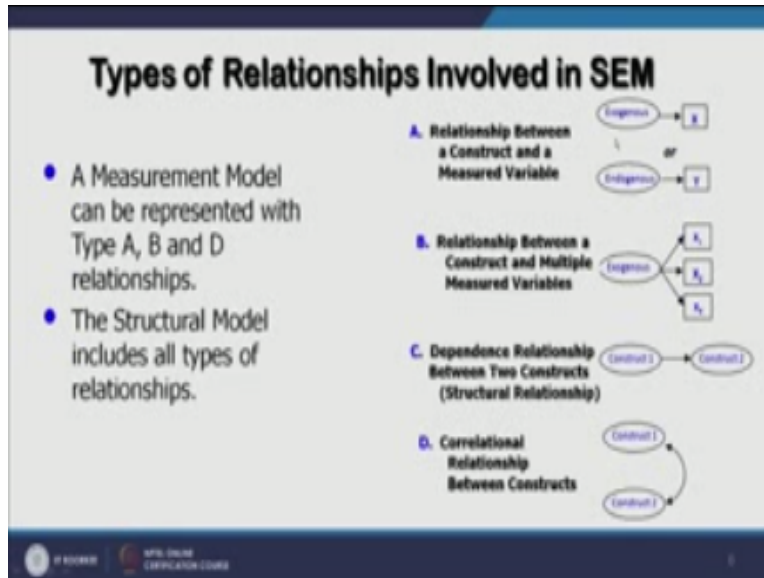
Several types of relationships are also involved in SEM this is one that I showed you let us see some of the relationships this first relationship that you can see here, a relationship between a construct and a measured variable okay, we have need to before you go where you need to remember one thing when this is for you know testing SEM we use mostly a software called Amos which is called the analysis of moment of structures or glycerol this are the two I know I use but mostly I use Amos right.

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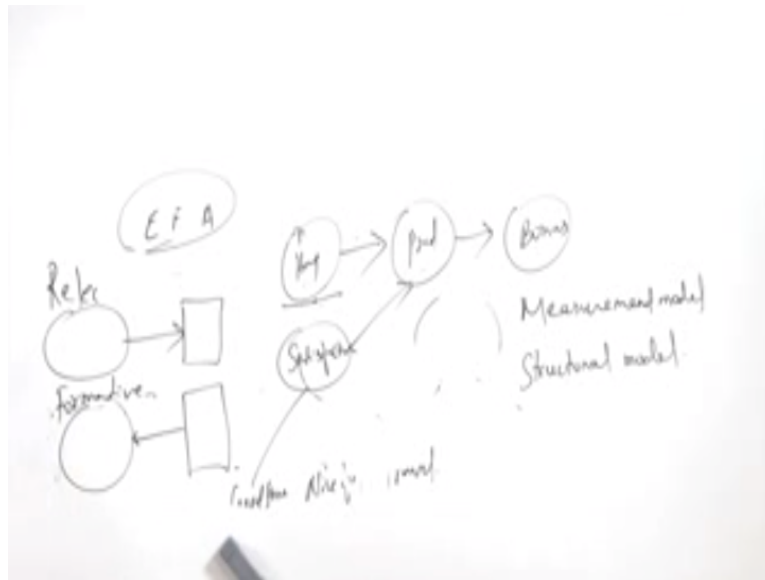
So the model when we are building the model you need to remember something a construct this is by denoted or represented it by an eclipse sorry ellipse or you can say the oval or something right and a variable is represented by a rectangle okay so these two things you need to remember okay so when I am saying that a construct is effecting the variable right.

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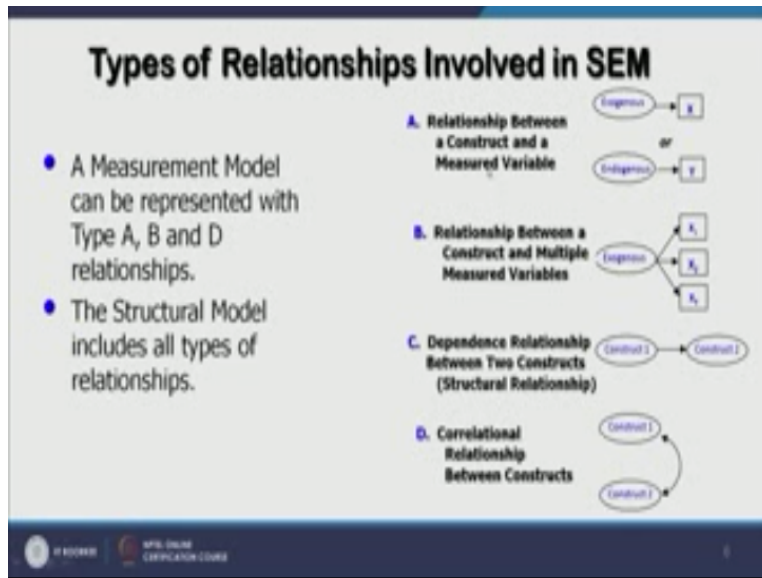
A relationship between the construct and the measured variable this is the case so if this is case of hexogenous or an independent or this is the case of a dependent okay the another case is relationship between the construct and the multiple measured variables now multiple measured variables for example now this one has got three variables x1 x2 and x3 okay.

Now this three are getting effected by the hexogenous construct okay now this is these are two types of relationships one in which you can see that the arrow is moving from the construct to the variable now when the arrow is moving from the construct to the variables this is one kind of a relationships another kind of relationships can also happen.

In which the reverse happens the reverse happens okay it means what sorry, sorry in this case what happens suppose this is the variable and this way the reverse would happens that means in this case the variable is you know effecting the is the cause is the construct and the variable is the independent variable you can say right.

But in this case it is different this is called as reflective construct you can say this is called a formative reflective and formative okay so now let us look at this now the second case is over the third case you can see that there is the relationship between the two constructs now we are saying construct 1 is effecting construct 2 right okay.

The fourth case is their sir a co variance relationship now this is the correlation this is unidirectional you can see and this is the co variance step here now we say SEM is a covariance

structure basically in SEM we the model that we SEM the model which we build SEM is a basically applies the co variance structure are a covariance matrix right.

So here what is happening is both the construct are effecting can other right so if you look at this four cases then out of this three are called the measurement model right and one of them is called as structurally model now what is these structurally model first let me explain it to you this is the structure model a structural model is one where the researcher is basically testing or set of relationships right.

So his intention is to measure the relationship which how it affects and tries to determine the path estimates and from there he can come to some kind of a conclusion or a inference which is not done in case of a measurement model in the measurement model the only intention lies in establishing the fact that variables identified are actually measuring the construct that is all right.

So in measurement model we say that the variables are measuring the construct and in the structural model we say that there is the relationship and we are trying to find the relationship among the constructs okay. Now this is very important, now what SEM basically do, students and the researchers always talk about the SEM and they do not understand what is the basic u7nderline intention behind it.

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Basics of SEM Estimation

SEM explains the observed covariance among a set of measured variables:

- It does so by estimating the observed covariance matrix with an estimated covariance matrix constructed based on the estimated relationships among variables.

| Observed Covariance Matrix | Estimated Covariance Matrix |

- The closer these are, the better the fit. When they are equal, the fit is perfect.

SEM basically explains the observed covariance among the set of measured variables, what it does is, it does the estimating the observed covariance matrix with an estimated covariance matrix right. So that means what we build a covariance matrix and we have a calculated and expected our covariance matrix and then we always want that the difference between the two models should be as minimum as possible.

If they are minimum differences exists that means what we observed and we are expect are coming to be more or less same. The closer they are the better they fit, so I am sure this words, when I am telling the words observed and expected, something else must be coming to your mind, something like if you remember.

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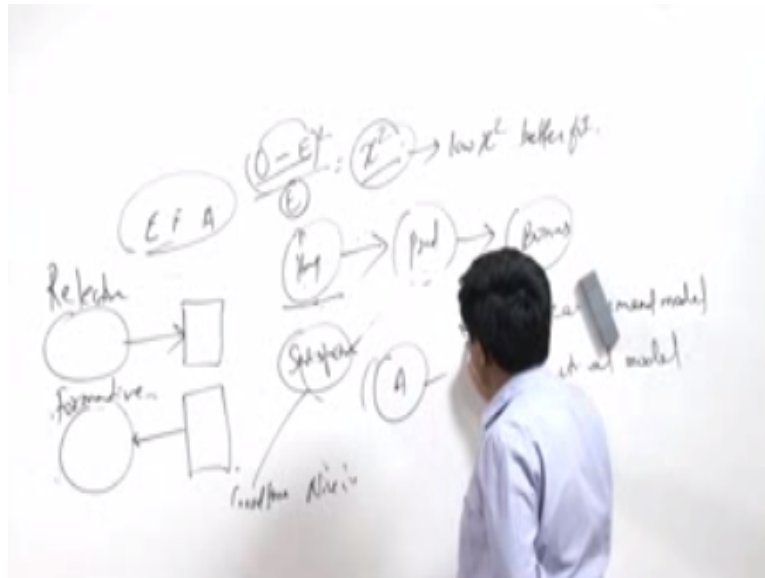
We have already discussed about the observed – expected, what was this? This was nothing but the χ^2 right, as I said in the beginning of the class even if the factor in the structural equation model χ^2 becomes one of the most important things right, it has used as important tool. Now if you χ^2 value is more, it will more only when the difference between observer and the expected is large or expected becomes very low value in that case only the χ^2 can become larger right.

We observed and the expected the difference is larger or the difference is less, then automatically we will understand there is the significant difference between the observed and the expected model, so that is what we do not want, because we do not want that there should be there is too high difference between the observed and the expected. Rather we would like in the case of SEM a low χ^2 is a better fit. And a high χ^2 is a perfect right.

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SEM Introduction

- No model should be developed for use with SEM without some underlying theory. Theory is needed to develop both the . . .
  - o Measurement model specification.
  - o Structural model specification.
- Models can be represented visually with a path diagram.
  - o Dependence relationships are represented with single headed directional arrows.
  - o Correlational (covariance) relationships are represented with two-headed arrows.

No model should be developed for the use of SEM without some underline, so this is very important. Now that if you understand many a times such as while doing a research they do something without properly utilizing any logic right, most of the time. I am not trying to blame the researchers but I seen many times people doing PhD, they try to put in variables right. They try to create some unknown relationship among the constructs right.

So if you put it in software and the software will surely will give you the results but that is not how SEM is done the basis of SEM is always an underline theory, if there is the way of theory underline, it is okay if it is not developed but still if you feel this could be a theory that can develop. Suppose experiment or after discussion you have come to a conclusion that well it should be new way of new theory that can emerge.

In those cases also it is nice but if you are not having in the mind, where as why I am trying this, I have seen this people doing such things like for example. They suppose this is A this is B and there is while doing this they do not get good result they just change it B and A without the proper understanding.

Without the proper because you are understanding cannot change all the time right so that is why it is called a confirmatory you are trying to conform what the theory that you have read or you want to proof okay so this is very wrong this is very wrong way of doing thing so you need to have so whenever you face you do something the you know you should be always asked what is the underlying theory behind it why did you do a SEM so that should be first question asked to

any researcher and if the researcher is in a position to answer why he has created this model then only he should be allowed to go ahead otherwise a researcher should be stopped from using SEM without any proper third process okay.

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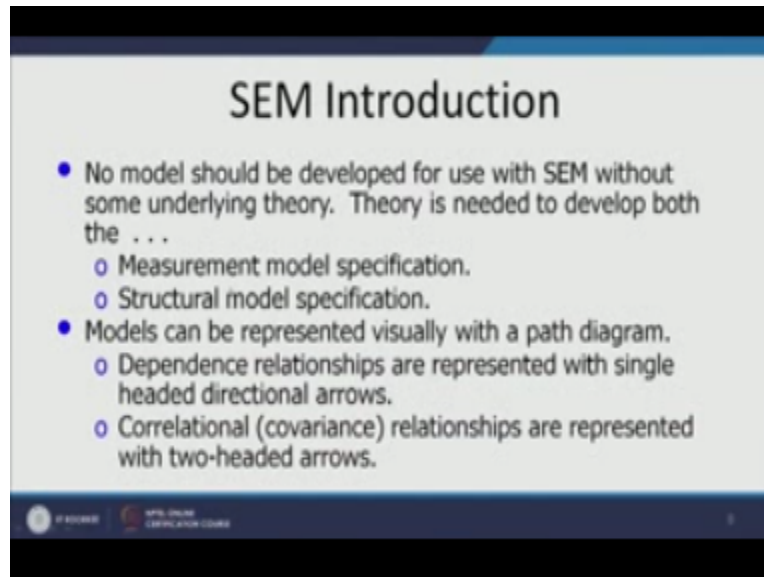
So measurement model and structural model which I have just explained right models can be represented visually with a path diagram so this is the diagram so can see this is the path diagram right the dependence relationships are represented by single headed directional arrows so if there is a dependence relationship that is a is dependent on b a effects b in that case we have a single arrow mow this is case of a single arrow right.

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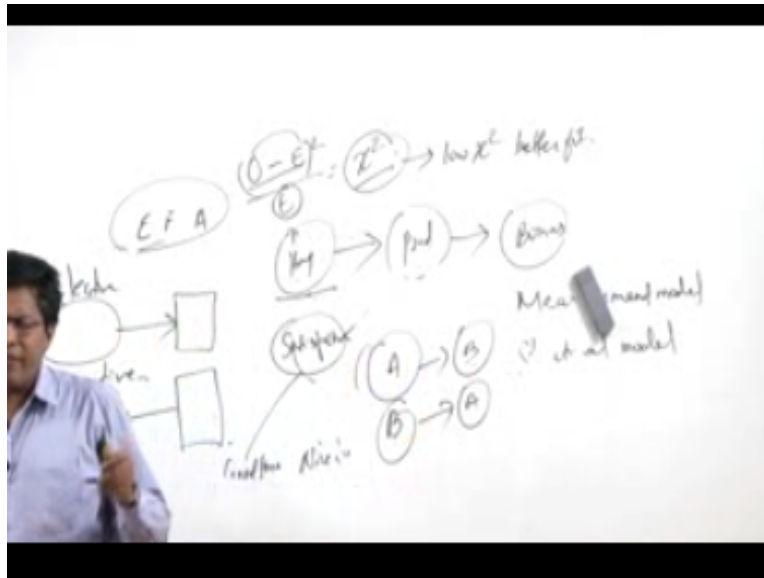
So a effects b but what if there are two relations if the relations is bidirectional or you can say both of them are effecting each other so it is case of correlation or coherent relationship that is existing right so a correlation or co variance relationship is existing and this is what we do is when we make any that is why we say it is co variance structure right that means if let say these are the two constructs so we say that these two constructs because we do not know there are Latin construct so we will say that both can effect each other okay.

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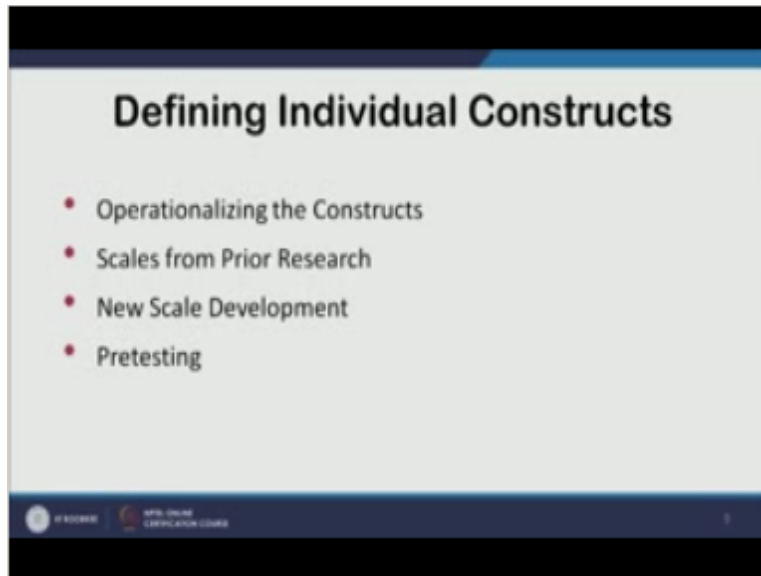
How do you define the individual constructs that is the important thing so to define the individual constructs you first have to as I said you have to go with the theory right you have to approached the constructs you have to understand what are the constructs what is the basic of the construct why this construct is required and what variables are wood effect this construct right if there is need only you can develop the construct right and then when you do you have to back it by supports sufficient literature.

And research then you can also you can either use a new scale also no issues but many of times when is the confirmatory factor we say which we are going we will see that the case from prior research can also be utilized or even I can say they are largely utilized because already the scale has been confirmed has been validated has been tested somewhere else so if you are researcher who is trying to use this particular construct for some other study may be but theoretically it has to be sound so in that case the scale from prior researcher can be taken and then they can be again checked for validation right or as I said a new scale can also be developed I always appreciate if you can develop a new scale.

And validate it because that is like adding knowledge to the adding more to the you know adding something to the body of knowledge you are contributing to the knowledge base right then after this the construct need to be pre tested okay that means you need to test whether the construct is valid whether the variables are loading on to the construct properly off because if the variables suppose if you have taken the variables and these five variables are not loading on to the

construct some of one of them are not loading to the construct then there is no point in keeping that you know variable if you find there is a case of cross loading coming up then that is extremely dangerous okay.

So well what we will do is we will start now once you have understood this basics then we will get into first we will get into the measurement model there is two parts of it is the measurement model and the structural model so in the measurement model what we talk about is the confirmatory factor analysis right we will see how a construct is checked for a measurement error right.

And how the constructs are checked or validated once the validation is over then the researcher can move on to next stage where he can test the relationships right as given in the structural model so these are the two parts of SEM 1 the confirmatory where we test the measure the model and then the next the structural the next part where we check the structural model where we check the relationships right so we will do it in the next coming session thanks thank you very much.