Urban Transportation Systems Planning
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Lecture-33
Disaggregate Mode Choice Models-II

Welcome to module E, lecture 3. In this lecture, we shall continue our discussion about disaggregate mode choice models.

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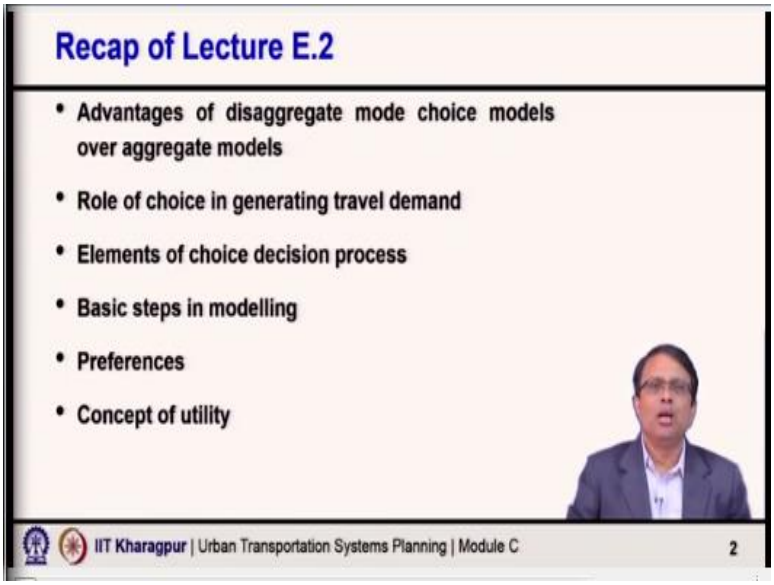

In lecture 2, we discussed about various advantages of disaggregate mode choice models over aggregate mode choice models. Then, we talked about the role of choice in generating travel demand, then various elements of the choice decision process, we said that what are the key 4 elements, then discussed about the basic steps in modeling the 3 key steps that we highlighted.

And then, we mentioned that modeling the choice is equivalent to modeling the preferences and introduced to you the concept of utility. And we said that also in travel context, nothing is really utility but everything is disutility because it includes variables such as travel time, travel cost, waiting time. So, any value, any time we incur, any cost we incur, any walking we incur, it is all disutility, the higher the value higher will be the disutility.

And we said also that if the utility value changes from -10 to -5 or -10 to -7, then we say it is an improvement because overall disutility is reduced now. So, a change in the disutility could be still a considered as a benefit to the trip makers.

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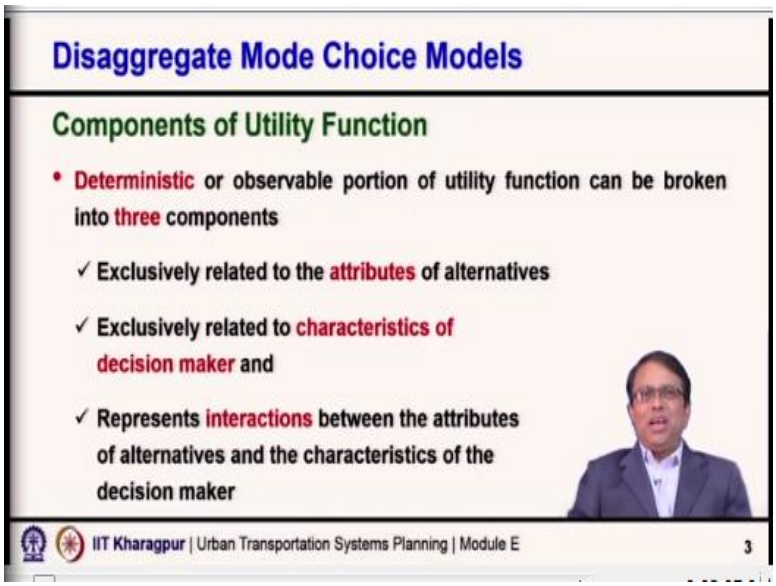

With this background, let us continue our discussion today. First, about the various components of utility function. So, deterministic or observable portion of utility functions can be broken into 3 major components. Now, one thing it might appear to you a little disconnect that we talked about utility. But why suddenly I am saying deterministic or observable portion of utility?

For the moment you consider that it is utility, but actually it is that deterministic component of the utility, why am saying deterministic component? Then what could be the other component that we shall bring slowly in the context of our discussion, not in today's lecture or not in this lecture but it will come in some other lecture subsequently. For the moment, let us consider what are the components of utility?

But in the back of your mind know that it is actually we are talking about the deterministic component of the utility. One is a set of attributes which are exclusively related to the alternatives, we are talking about bus, talking about car, talking about metro, taxi. So, exclusively related to attributes of alternatives, the second, what is the other component, attributes of or the characteristics of individual?

So, exclusively related to the characteristics of decision maker, that is another type of attribute. Third is something interesting. I am not bringing really a completely new component, because I have told a number of times that the utility depends on the attributes of alternatives and attributes of individual, I have not mentioned anything else. So, there cannot be anything a completely new, but still something interesting and new.

The other component represents interaction between the attributes of alternatives and the characteristics of decision maker. So, we say part A, related to attributes of alternatives, part B, related to the characteristics of decision maker and Part C, it is A and B together. They are interacting somehow, how? Further explanations will be given to you.

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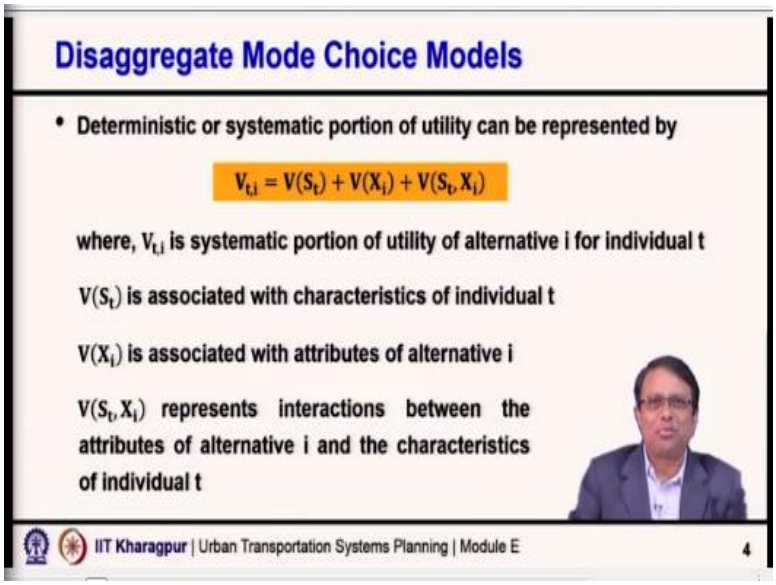

First let us take the as per this as we said that part A, B and C, I have shown it here. So, you can say if the systematic portion of the utility for individual t and alternative i is V t i, that means it is person's specific individual t, and it is alternative specific because the values will attribute values like travel time, travel cost will be etc. for will be for alternative i. So, it is for individual and for a given alternative what is the value of the utility?

That will have 3 components, first thing is related to the characteristics of individual that we say that is something V as a function of S t, S t is the socioeconomic characteristics, S may be

considered as socioeconomic characteristics of individual t. V X i, this may be considered X attributes multiple attributes as a function of that of alternative i. And the third component is V S t X i represents interaction between the attributes of alternative i and the characteristics of individual t.

Attributes and characteristics they are interacting, that interaction component, that is getting represented. So, that is the major 3 components of an utility function.

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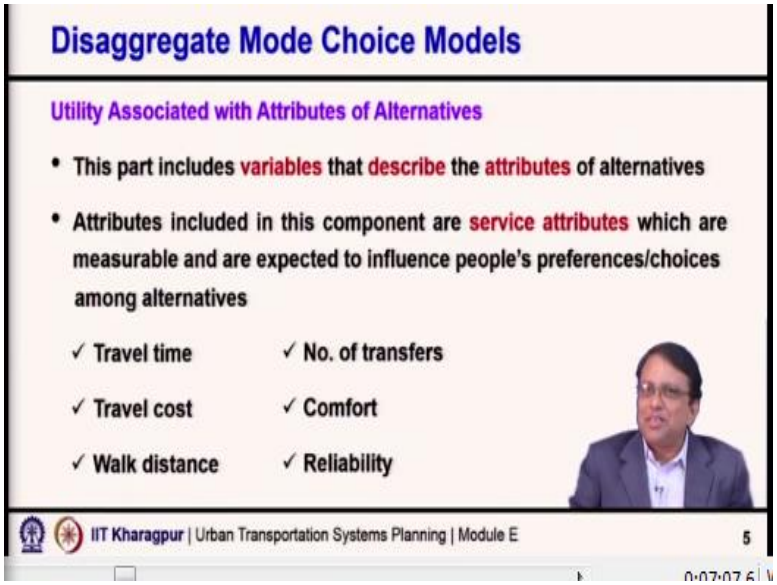

Let us discuss little bit about each of these components. First is utility associated with attributes of alternatives. Now this part obviously as I explained includes variables that describe the attributes of alternatives. You have different alternatives one may travel by car, one may travel by taxi, one may travel by bus, one may travel by you mean underground metro. So, attributes included in these components are essentially service attributes which are miserable.

And are expected to influence people's preferences or choices among alternatives, obviously if some attributes does not influence the choice, why to bring it here? It is not a list building activity, we want to model that choice accurately or as accurately as possible. So, obviously we want to bring those variables which are likely to influence the choice decision of individual. So, examples are given here, travel time, travel cost, walking distance, number of transfer, what is the comfort? What is the reliability?

And interestingly here, what you can observe it includes both quantitative and qualitative attributes. Now in Indian context, gradually we are finding that along with the quantitative attributes, the qualitative attributes are also getting a lot of importance. Comfort, it is a qualitative attributes, safety it is the qualitative attributes, security is the qualitative attributes, not like travel time 5 minute, 10 minute, 15 minute**.**

But they influence the decision, particularly they kind of crowding what we see here in our public transport during the peak hour so many people inside and it struggled to really even stand, forget about getting a seat. So, that kind of thing, comfort matters, security matters, security has emerged in Indian condition as a requirement which is very interesting also. So, that is about the utility associated with the attributes of alternatives.

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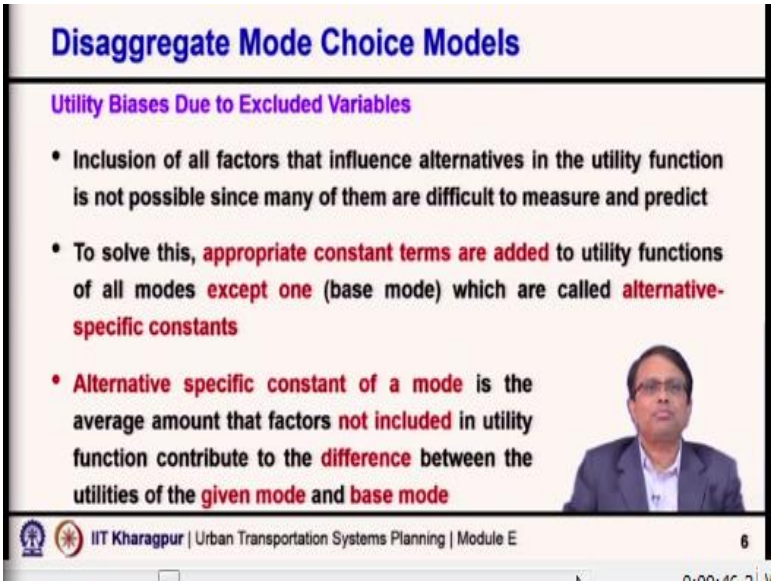

Then, here I would like to bring one slightly new dimension for you. We are talking here about utility biases due to excluded variables, what is that? Now, let us consider we are talking about different alternative modes of transport. Can you really consider every possible attribute in your model? We cannot, simply**,** there are many challenges, many I mean, there are and the more things like you want to design your experiment.

You need to have consider certain variables and you need to collect the data, people need to give their response**,** how many attributes they can consider, whether you can get reasonably good data also, how much effort will be there, how much burden will be there on respondent? So many, availability of the data, so many things are there. So, let us accept that we cannot consider many things.

But, say for example, I will say whether you would like to travel by bus or by train I give you travel time, travel cost everything. But, one thing also will be there in your mind probably that if I have to travel by bus there will be so much air quality will be so bad actually in urban area, road transport case. So, you will see that I have to probably inhale lot of pollutants, the pollution level air pollution levels would be so high and so.

Whereas, maybe if I travel by train the crowding everything will be there, but I can probably get much better quality air, I can get fresh air. So, when you are giving you a decision or expressing your mode choice decision in some form or other are actually reflecting your decision in reality those things will be in your mind. Because you know that this is train and that is bus.

So, such kind of things will be there and that will also impact the decision or the utility. So, we do not take variables to represent that, but somewhere all such kind of effects, how they are totally contributing the utility, maybe utility will be slightly higher or lesser because of all these components. So, they are considered here as alternate specific constant. So, what I said here, now look at this write up.

Inclusion of all factors that influence alternatives in the utility function is not possible, since many of them are difficult to measure and predict, also maybe getting the data many other challenges could be there. To solve this appropriate constant terms are added to utility functions of all modes, except one it could be any one of the modes under consideration, but that mode where we will not consider the AC or rather it will be 0 value of alternate specific constant there, that is actually for the base mode.

So, any mode you can take as a base mode, it does not really matter, because it is then with reference to base mode, what is the additional utility or disutility for another mode. So, for all other mode except for base mode, it will have a value other than 0, it may be negative, it may be positive. Because relative to your base mode, the overall value could be a disutility then it will come with a minus sign, a constant with a minus sign.

Relative to base mode it may be a kind of utility, so it will come with a plus value of constant, so you will have a constant value. Now alternate specific constant of a mode is the average amount of factors not included in utility function. As I said that we whatever we included those will get reflected inside the model as variables they are there but which are not included are getting reflected here.

So, in utility functions factors not included in utility function contribute to difference between the utilities of given mode and the base mode. So, it is with reference to base mode, so the base mode this value is 0. So, with reference to base body, base body is 0 then what is the additional utility or additional disutility to the other mode that is taken into consideration by this constant term which is called as you can call it that utility biases due to excluded variable or generally you call it as alternate specific constant.

So, one thing is that wherever we know there is a brand, there is a this kind of bias will always be there**.** As I told you the environmental part, the pollution maybe you know that if you travel by train your pollution will be less. So, that will be there somewhere in the decision making. So, compared to maybe bus, it will be positive value or if I consider rail as my base mode then compared to rail the bus will have a negative value.

Similarly it is there, this is the branding actually. So, if I tell you that 2 brands of laptop and say that which laptop you are going to buy, your decision will get influenced by the brands I have given you. You will say no this is Sony, that is Toshiba that is HP, so these brands will influence your decision. So, that biasness whatever is there that will get captured with this AC in the model or in the utility.

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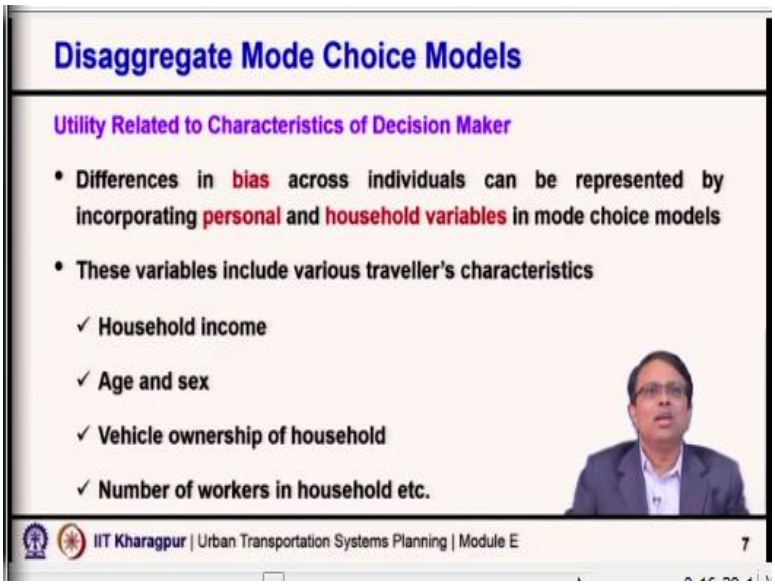

The other part is utility related to the characteristics of decision maker, this was again explained earlier. So, it may be personal and household variables, say for example household income, sometimes people take personal income, sometimes in Indian society it is more of the household income, it is age and gender, it could be vehicle ownership of household, how many vehicles are there, private vehicles are there or not? If they are how many vehicles are there, the number of workers in the household all this will influence the mode choice decisions.

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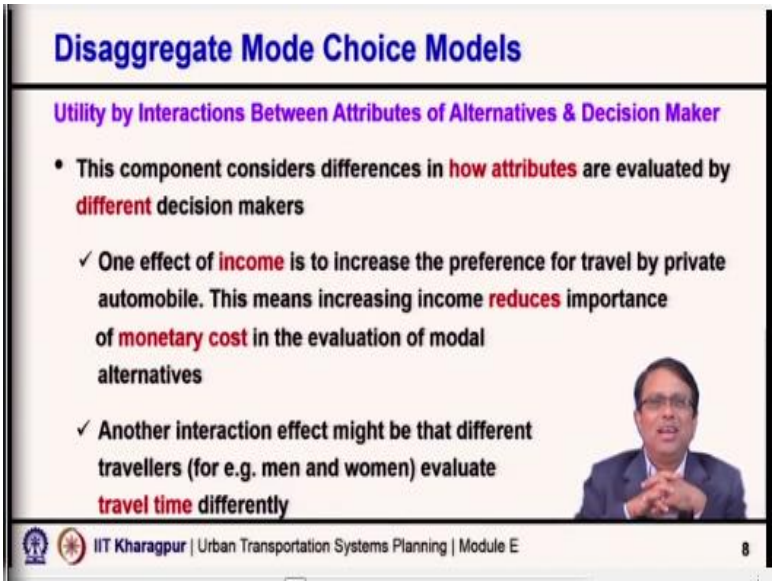

Now the other part, what was or what is apparently not very clear that what is this component? Utility by interactions between attributes of alternatives and decision maker, this is an interesting component. This component considers differences in how attributes are evaluated by different

decision makers. So, attributes and characteristics or decision makers are interacting with each other.

I have to give an example to tell you more clearly the suspect, so that you can really understand and appreciate. Let us consider one effect of income is to increase the preference for travel by private automobile. That means, the more the income, more people will be inclined to use private vehicle. That is why we say that high income people they actually use more private vehicle.

In a way this means that increasing income if your income is going up, it reduces the importance of monetary cost. Normally you will see the public transport fare is a very, very socially sensitive issue. So, if the fare increases, there is a chance how people will travel and marginally weaker section of the community what will happen to them all those. But then preference as the income goes, preference is going more for the car that means the cost is becoming less important.

So, can we have this introduction in the model? Think of a variable where this interaction effect can be captured, that means we say, what is the weightage associated with the cost. Now instead of cost, I will take it maybe cost by income, that is brings the interaction. So, it is not only the cost, it depends on some function of cost and income that is the interaction date. When if we take only the income separately, then it is the socioeconomic characteristics, it goes at that set of variable.

If I take only fare, then it is describing the attributes of alternative. But here I am taking interaction, the function of fare and income. Another example could be, so normally women they have to do in our traditional Indian society they always have to, did, always take more responsibilities, they always take more work in home. Generally their time is really very tight, if they are working outside and then after coming back home also, immediately all this working women you will find that they are literally immediately getting busy with household work, lot of things they take care.

Now it may happen that when you were talking about the travel time, the way that interacts with the traveler's man and women is not same. So, the way the women probably will wait the time,

men may wait in a different way**.** Or preference for getting a seat may also like that, maybe have some interaction with the age**.** Preference for a seat, when I am travelling my comfort condition, how important it is to for me to get a seat**.** This may again have with growing age or higher age, people will have probably higher preference and higher weightage for the seat availability.

I mean, young person may not really bother but something may be different when you are considering an old person. So, there are in a many different ways these interactions can take place. So, we can use directly variables which are related to socioeconomic characteristics, we can directly use variables which are related to the characteristics of alternatives**.** We can also use variables in a different way I would say you can be little bit innovative also**.** Keeping the logic in mind to design your variables in a way that it is actually taking the interaction, it is reflecting the interactions, that way it can come inside the model**.**

For that detail we will give you when you take some example and show you how you can decide. I mean, so many ways you can bring this interaction effect, not just in one way maybe the income effect you will bring in one form and maybe in some other way you can bring the gender effect, you can if you are talking about the qualitative attributes, maybe in some other way you will consider the effect on a qualitative attributes. So, remember that, it is involving both attributes related to one from the alternatives and another for the socio economic characteristics of individual or the trip purpose.

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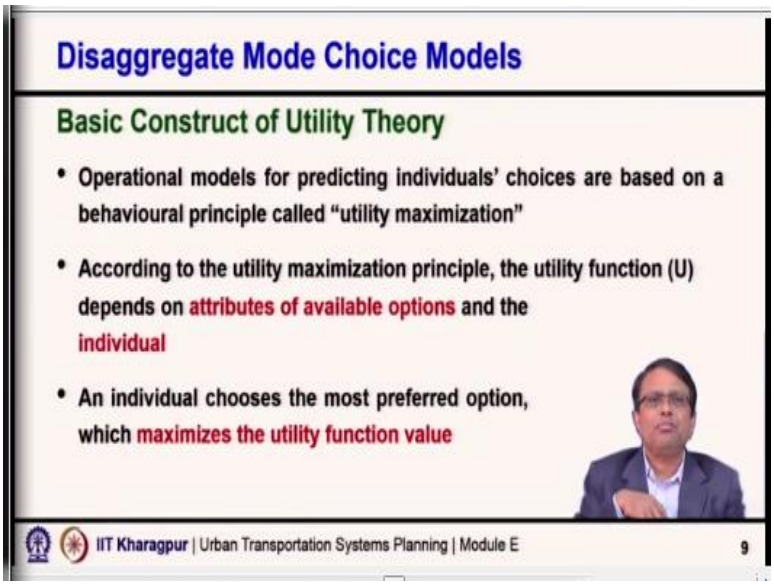

Now let us look at the basic concept of utility theory. Now operational models for predicting individual choices are based on a behavioural principle, what is called utility maximization, very, very interesting and very, very important for you. So, what does it say? What is utility maximization? Now according to this principle, the utility function you depends on the attributes of available option and the individual, number of times I have said this.

And then here it does not end, then an individual choose the most preferred option which maximizes the utility function value. That means given different alternative, what is the utility maximization? The preferred one or the chosen alternative will be that one which will maximize the utility to an individual. If I am making a decision based on my socioeconomic and trip characteristics and based on the alternatives available to me at the time and their attributes and the current levels I will choose according to utility maximization.

That alternative which will maximize my utility, so if there are 3 alternatives which one is the heavy highest utility that will be chosen. Now, in transport context, as I told you that this may not give you positive values, but then among the negative values which is the least negative that will be chosen.

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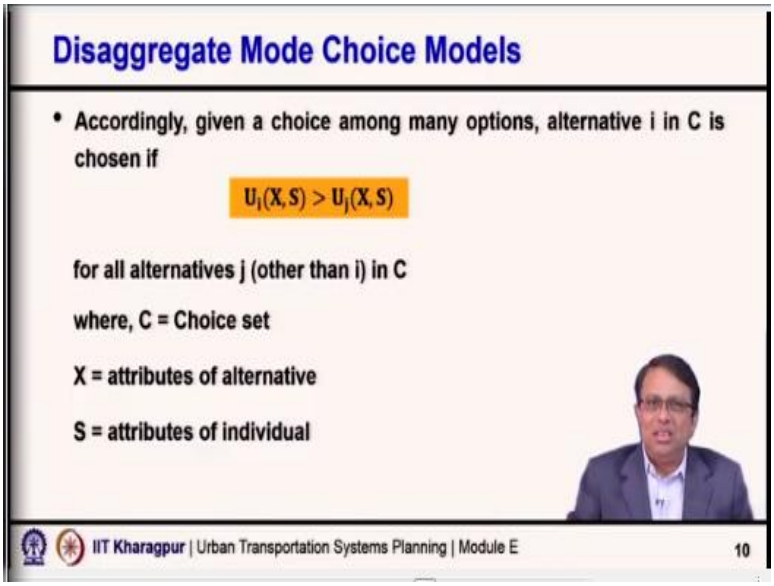

So, according to given choice among many options alternative i in choice set C is chosen if U i alternative for utility for alternative i is chosen. So, utility for alternative i, this utility is the function of X and S, attributes of alternative and attributes of individual is greater than U j X, S the utility of alternative j. So, I will be only chosen for an or utility of alternative i is greater than utility of any other alternative j.

And both cases the utility is the function of X and S that is attributes of alternative and attributes of individual, correct.

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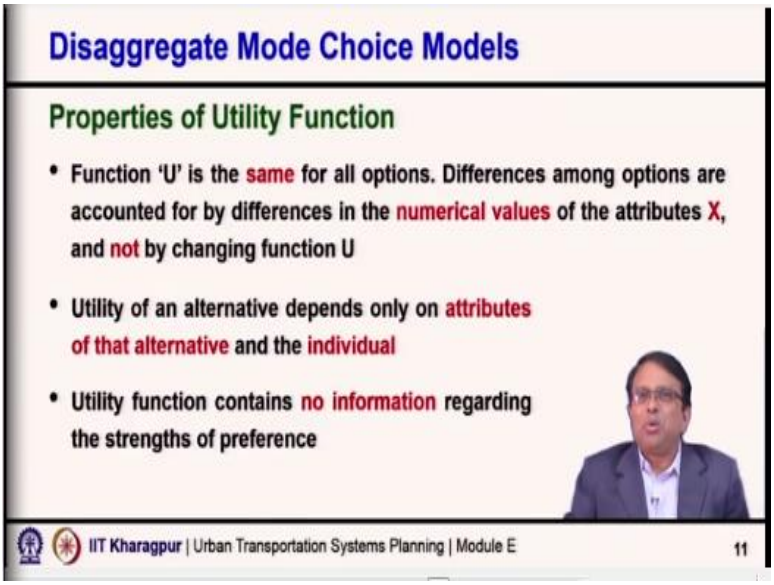

Now there are certain properties of utility function, quickly see what are the properties? The function use same for all options, I have mentioned this in some other form earlier. That utility function does not change for alternatives, coefficients are same, travel time, travel cost, waiting time all these coefficients are same. So, function of U is same for all options, differences among options are accounted for by the difference in the numerical values of the attribute takes.

Travel time by car and travel time by bus is different, cost by car and cost by metro is different, like that not by changing the function U. Second, utility of an alternative depends on attributes of that alternative only, and the attributes of individual. What will be the utility of bus that equation will not include anything about car or metro or taxi or anything. So, utility of an alternative will depends on that attributes of that alternative only and of course additionally the attributes of individual.

So, utility function contains no information regarding the strength of preference, it does not tell anything, it does not tell about strength of preference.

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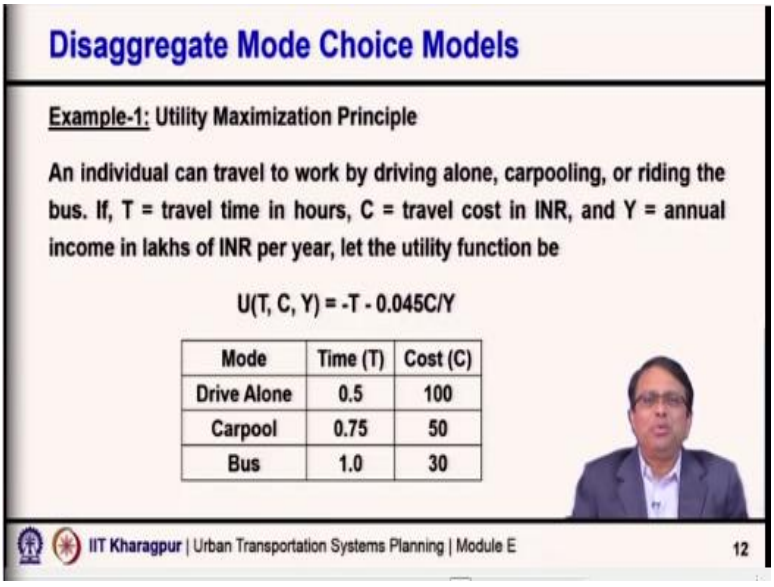

Now let us take an example before we close. An individual can travel to work by using say driving alone. Drive alone means driving in personal car, drive alone means I am taking my personal car and going to office. Carpool means maybe 3 of us all are from the same residential area, working in the same CBD area, maybe different office, maybe in the same office.

We are not taking over individual car, but one car and 3 of us we are travelling, maybe 2 days I take my car, today my one friend will take his car and today another friend will take his car. So, 3 of us we are travelling all the 6 days, but instead of taking 3 cars, we are travelling in only in one car, that is a carpool or riding in the bus maybe the 3 options. So, the travel time in hours is the cost in Indian rupees and Y is the annual income in lakhs of course in Indian rupees per year.

Then if the utility is -T -0.045 C by Y. As I said we expected - Y because the travel time is more, the disutility is more, it cannot happen the travel time is more, that means the utility is more, no, travel time the disutility is more, so it comes with a negative sign. So, a 1, a 2, a 3 whatever I mentioned earlier, they come out to be negative. Also the cost is more, so the disutility is more, higher the cost higher the disutility.

So, again cost comes with the negative sign, and I said interaction effect. In a way you can see the cost is normalized to income annual income C by Y. C by Y is my variable, not C not Y, but the C by Y that ratio is my variable. So, accordingly if it is so, we can calculate the utility, if I have given this thing drive alone, carpool, bus in each case what is the travel time? What is the travel cost? So, I have got 3 modes I have got 3 variables, 2 variables related to mode and 1 variable related to socioeconomic income.

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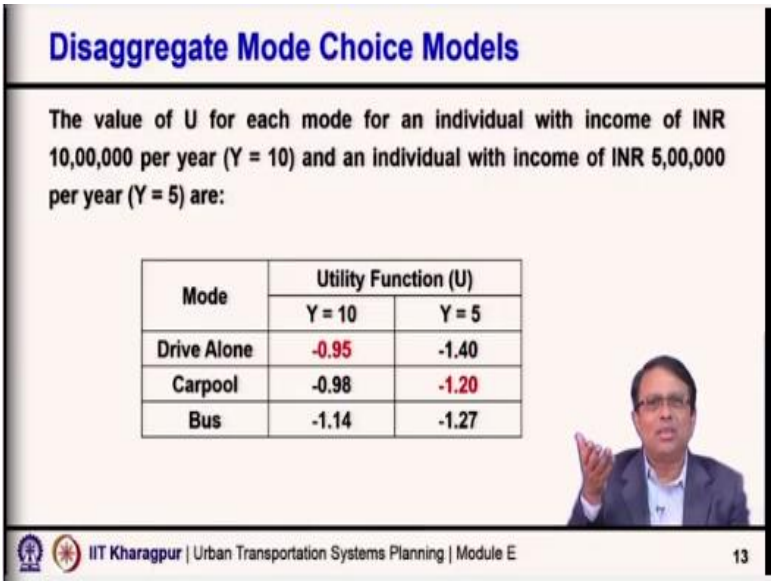

Now, if the income is 10 lakhs per year and if the income is 5 lakhs per year, one is 500,000 in another is 10,00,000. So, then Y in lakhs, that means one case Y value is 5 another case Y value is 10, both case I can calculate the utility values, all are coming in negative. So, you can see for the high income group people, or for an individual with high income let talk about only in one individual.

Individual of with high income the drive alone utility is -0.95, carpool is -0.98 and by bus -1.14. So, which one is your (()) (31:36) as per utility maximization, we want to maximize our utility, but here is all disutility. So, the least negative Y you will take -0.95 that the choice will be then drive alone. So, given this thing the choice in that case will be drive alone because drive alone maximizes the utility.

Whereas, income 5 lakhs same way you can calculate the utility values. And you can see now carpool becomes the utility maximization, as per utility maximization principle the carpool becomes a choice. So, the another person whose income is less is likely to take that carpool is the option. Say it shows interestingly if such kind of utility things are there and you have the if you apply utility maximization principle, you can evaluate different alternatives in terms of their utility, for this individual under the given circumstances.

And then accordingly you can say then given these alternatives which is to be chosen or which is to be accepted. And it also shows how given the same transportation system, same alternatives, 2 individuals one having higher income as compared to the other the choice is going to be different. That reflects the reality, probably you take a person with even lower income if you take you will probably find the bus will become the choice in that case, that is why the choice decision is made in reality.

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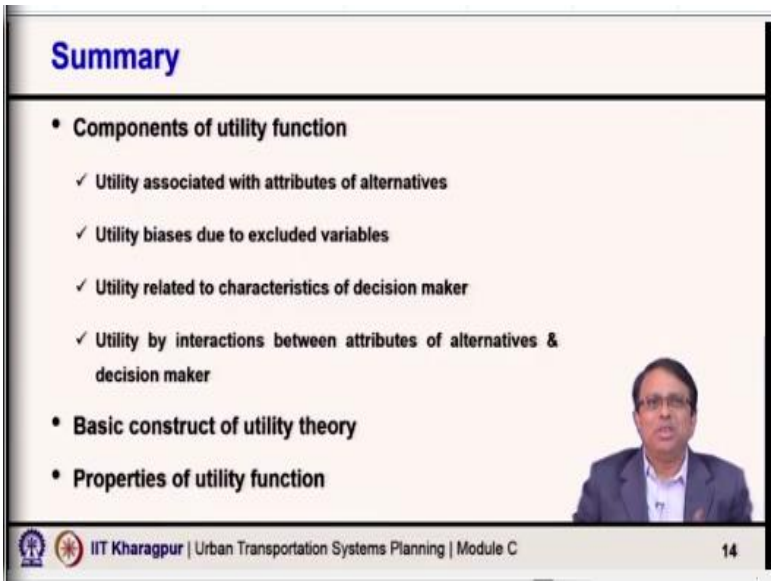

So, with this I will say what we discuss then. We discuss about the various components of utility functions, utility associated with the attributes of alternatives. Then the biased part also we can consider the constant or alternate specific constant then the characteristics of individual and also the interaction component. Then we talked about the basic construct of utility theory and also mentioned what are the basic properties of utility function and utility maximization principle. So, with this we close this lecture, we shall continue in the next lecture, thank you so much.