Urban Transportation Systems Planning
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Lecture-32
Disaggregate Mode Choice Models-I

Welcome to module E, lecture 2. In this lecture, we shall discuss about disaggregate mode choice models.

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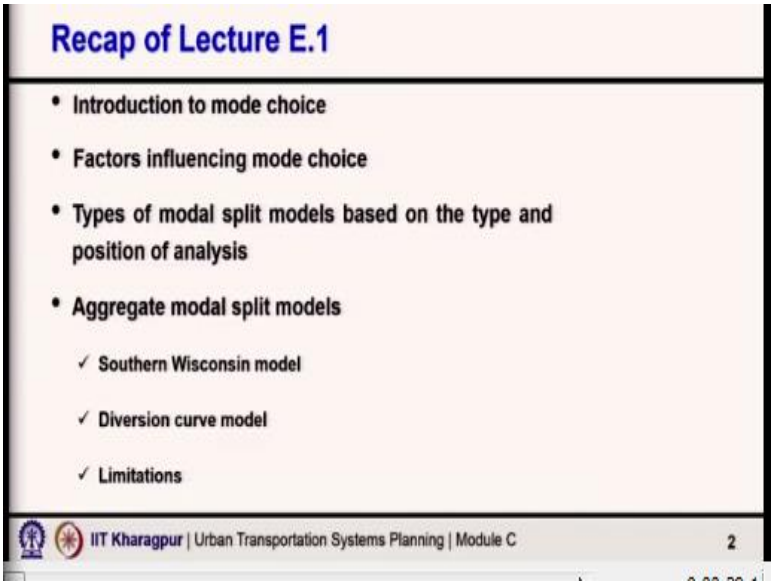

In lecture 1, we introduced you to the basic approach for mode choice analysis, then what are the factors which influence mode choice, then the type of modal split model based on the type of model aggregate, disaggregate and also based on position of analysis at which stage the mode choice analysis is done, say whether it is done after immediately after developing the trip ends or it is done after carrying out trip distribution.

Then, we discussed about aggregate modal split models, what are the basic considerations are different features. Then 2 specific model Southern Wisconsin model and the diversion curve model we discussed. And we also mentioned about some of the limitations of the aggregate mode choice models. Now with this background, today we shall discuss about that disaggregate mode choice model. In fact, today will be the first lecture on disaggregate mode choice models.

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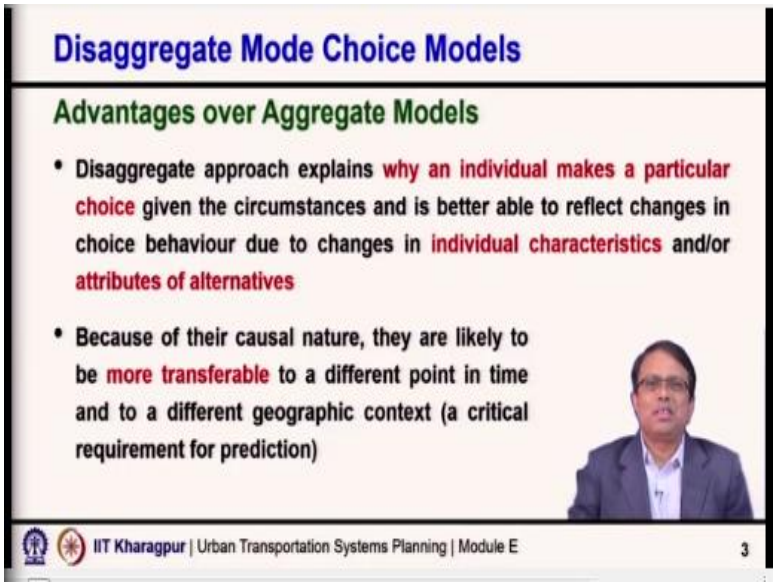

Now, let us consider, because we just discussed about the limitations of the aggregate mode choice model in our first lecture on mode choice analysis. So, in contrast to aggregate models, what are then the advantages of this aggregate model over aggregate models? First, disaggregate models explains, why an individual makes a particular choice, what is the reason? Given the circumstances and is better able to reflect the changes in the choice behaviour due to the change in individual characteristics and or attributes of alternatives.

That means, given a set of alternatives and given individual characteristics, we try to model how individual make a choice about the mode. And because then, it relates to individual characteristics, also the characteristics of the alternatives. Therefore, any change in the individual characteristics or any change in the alternatives of transport system maybe the bus system journey time is reduced or you operate buses at more frequent intervals, so the waiting time reduces.

So, then immediately how different individuals with different individual characteristics should react to those changes that can be modeled, that can be estimated. Now because of this casual or because of this causal natures, these disaggregate models are more likely to be transferable to different points in time and also to different geographical context. Because the behaviour of some kind of trip makers driven more stable.

So, the once you come to individual level characteristics, that based on income, based on gender, based on age and based on transport system characteristics, how the decisions are made? So, generally these models may not be again always, but generally are much more transferable both in terms of time and in terms of geographical region as compared to the aggregate models, because aggregate models do not consider this causal part, individual level causal relation.

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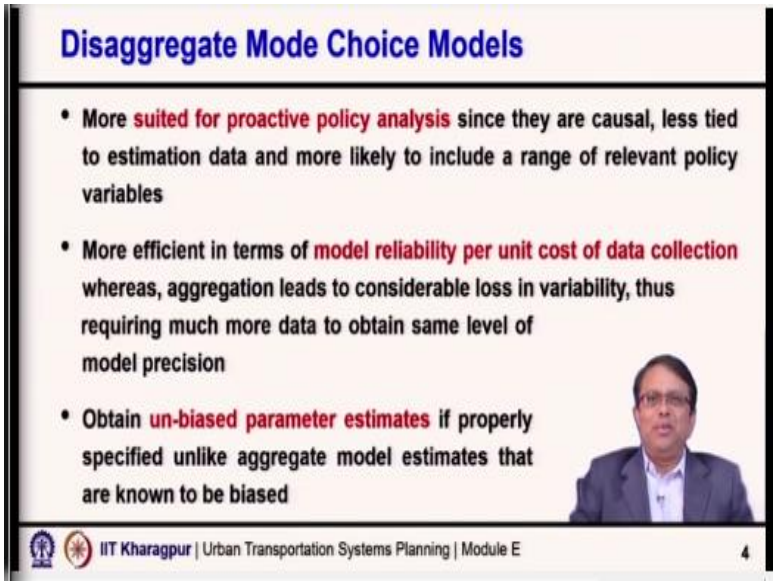

Third, because of again the causal relationship individual characteristics, alternatives and their characteristics, these types of models are more suited for proactive policy analysis**.** Since they are causal less tied to estimated data and more likely to include a range of relevant policy variables. So, I can say that what is how the choice of individual is likely to get influenced, if I reduce the fare of public transport.

Or if I provide say bus priority at signalized intersections to improve the bus journey time and then how that is going to attract more people to bus system. So, such kind of policy interventions, what we do and how then the choice decision is likely to get influence, those could be studied or investigated. These models are more efficient in terms of model reliability per unit cost of data collection.

Because once you go and once you learn more and more about the travel behaviour analysis and disaggregate modeling, you will see there are distinct advantages of behavioral based models.

So, if you see the amount of data collection per unit cost of data collection, the model reliability is much better, no model can be 100% accurate that is not really the claim.

But the claim is that per unit cost of data collection, you get a much better model. And you can appreciate this more; when we talk more about disaggregate models. Our next several lectures are going to be only on disaggregate mode choice models. In fact, out of this 10 lectures in these 2 weeks, all including today's this lecture, the 9 lectures will basically relate to disaggregate not just models.

So, only the first lecture we included aggregate mode choice models or aggregate modal split model and remaining all we are going to discuss disaggregate model. Now, disaggregate model generally obtained unbiased parameter estimates, if properly specified. Unlike aggregate models, which are known to be biased because of the inherent way the how the models are actually developed.

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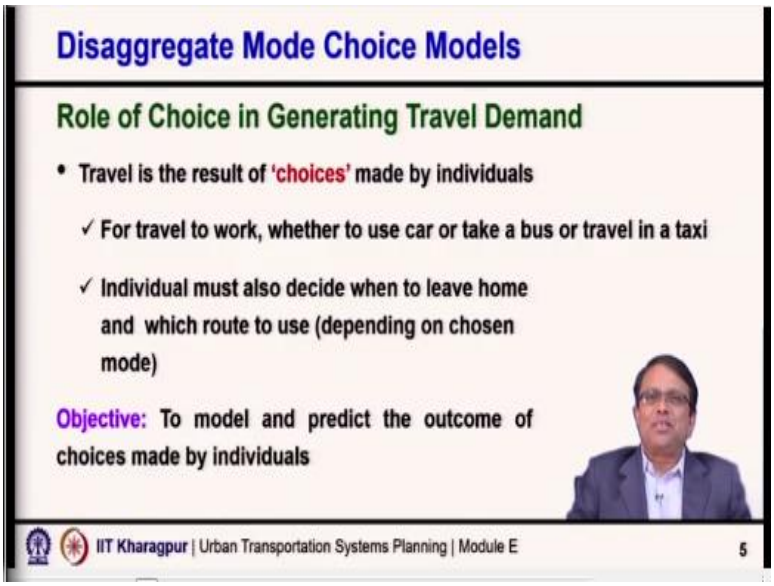

Then, with this background, so we know now why or what are the limitations of the aggregate models and what are the advantages of disaggregate model over aggregate models. Now, slowly, try to understand more things about disaggregate model. First thing, the roles of choice in generating travel demand. Actually, if you see travel is the result of choices made by individual, choice in different contexts.

In transport every stage the decision making is involved, say for travel to work whether to use car or to take a bus or to take a taxi, alternatives are available. And every individual is making decision about his or her own travel. And several such individual thousands and thousands of individual making decisions, so that is giving you so many people in the bus system, so many in their car and so many people in the taxi.

And resulting into some level of congestion, some level of vehicular emissions and so on. Also individual must decide when to leave home for this trip? And also the next level the traffic assignment you will see, the route choice is also another decision for private vehicles, those who were using private vehicle and especially in urban areas, one can travel using multiple paths, alternative routes are there.

So, which route is to be taken, again a matter of choice. So, which mode to be used is one choice, when to start the trip, departure time that is again a matter of choice, which route to take is again a matter of choice. So, the whole transport system is full of making decisions,**.** And a objective here is to model and predict the outcome of choices made by individuals, we try to see given the transport system characteristics, alternatives which are available, what are given their characteristics?

And given the characteristics of the decision maker that is the individual. How the decision is being made, **right**, we want to model that, we want to predict that.

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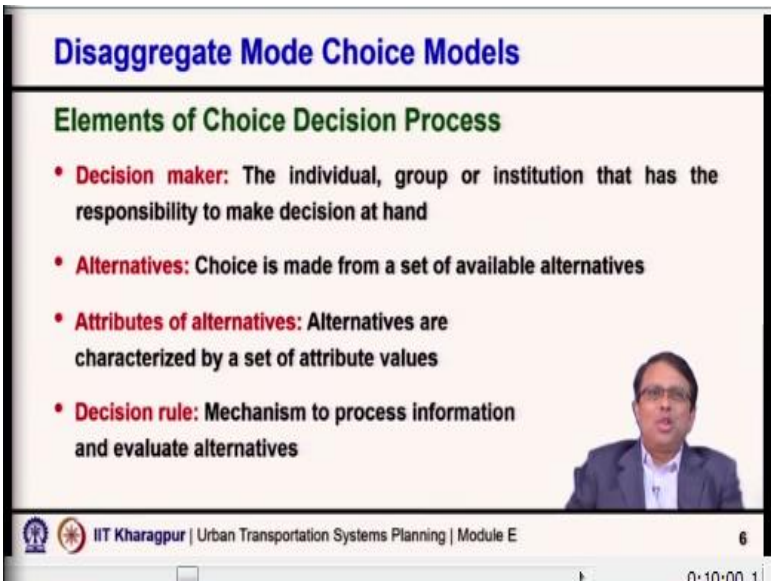

Now try to understand clearly the key 4 elements of choice decision process. There are 4 key elements in the choice decision process, what are those? First thing, there is a decision maker, a person; we are trying to model his or her decision in a given context maybe the choice of mode, maybe the choice of route. So, one is the decision maker, an individual, group or institution that has the responsibility to make decision in hand.

In disaggregate model, it is all mostly the individual that is we are interested. Second, what are the alternatives? Decision making comes because when there are alternatives, so what are the alternatives? So, choices being made from a set of available alternatives, maybe I want to travel from point A to point B and I have options to travel by car or by bus or take an underground metro and travel.

So, what are the alternatives available? Then third, is it only the alternatives? No, alternatives are described by certain attributes. So, what are the attributes of alternatives that are relevant, so alternatives are characterized by a set of attribute value? For example, how much is the travel time by each of this mode? How much is the cost? How much will be the waiting time? What is the level of crowding I will face when I am comparing multiple options for public transport?

And finally, in this whole context decision rule, mechanism to process information and evaluate alternatives because all these alternatives and their attributes, given levels are evaluated

considered by individual and then finally a decision is made. So, decision is made based on certain decision rules. So, how the decision happens, that is the mechanism. So, the decision rule includes the mechanism to process information and evaluate alternatives. So, there are 4 elements, key elements, decision maker, alternatives, attributes of alternatives, and then decision rule **ok**.

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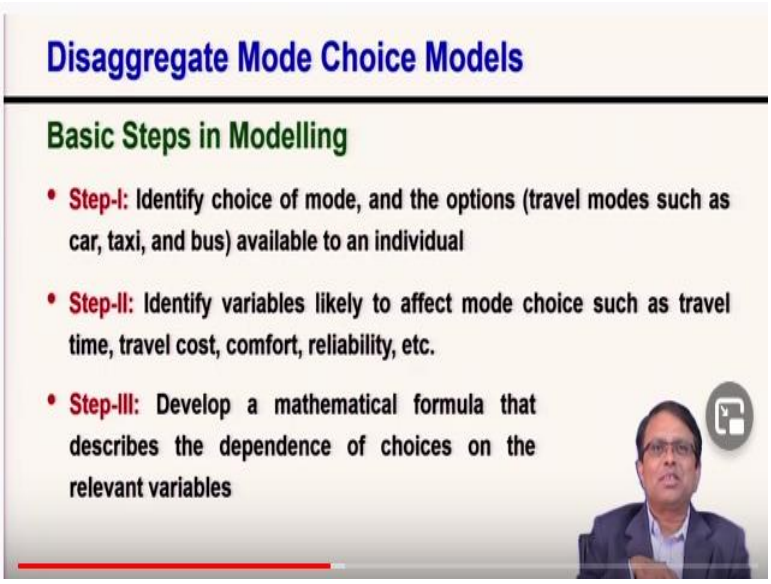

So, now with this let us try to see what are then the basic steps for modeling; because we want to develop models. So, the basic steps you can consider are 3 step I, identify choice of mode, in mode choice contexts, what mode is selected? That we need to know and we also need to know the options available to an individual that means choice maybe taxi but then what are the other alternatives?

Maybe the alternatives are other alternatives or car and bus. So, you want to know first step, what is the choice that is being made and what are the alternatives available to an individual at the time of making their decisions? Step II, identify variables likely to affect the mode choice, these alternatives are evaluated and the choice in this case is say for example taxi.

So, we need to know what are the variables that are likely to influence the choice decision, say for example, travel time, travel cost, comfort, reliability, waiting time, walking distance, all such kind of variables can come. So, you need to identify variables and then see what are their values

for the alternatives? Third, that is the most important thing, when try to develop a mathematical formula or mathematical relationship that describes the dependence of choices on the relevant variables.

These are my alternatives, these are my attributes or their values, and then how those are getting related to the choice decision finally what is being made. So, that is step I, step II and step III of the modeling process. So, first identify the choice and the alternatives, then what are the variables of all these alternatives that are likely to influence the choice and then try to connect them, decision or the choice to the alternatives available and their attributes or levels.

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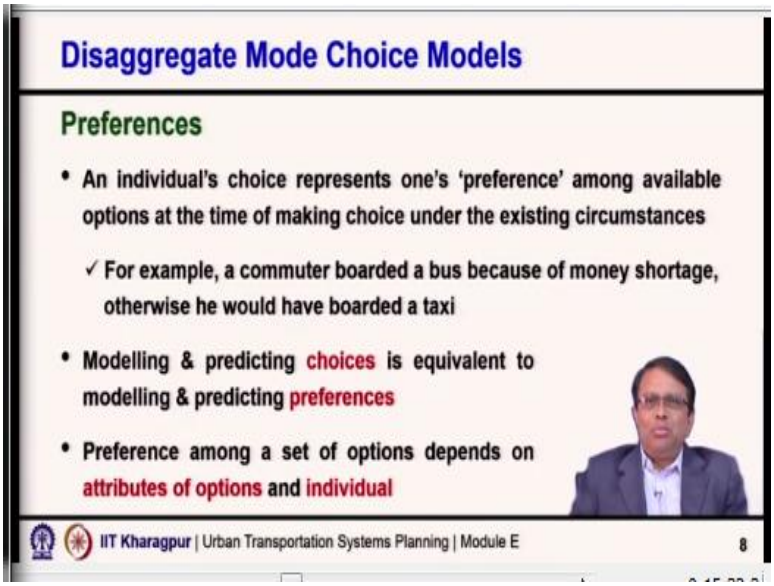

So, with this, now let us discuss about the preferences. Now, an individual's choice represents one's preference among available option. If I am choosing one my choice is taxi for a given context, then that clearly indicates my preference. So, but what is also important is the other part, at the time of making choice under the existing circumstances, that time under that condition what decision I am taking.

For example, a commuter boarded a bus because of money shortage; maybe it does not have enough money in the pocket. So, that is what his decision at the time, another time maybe if he would have got a lot of money in his purse, probably he or she could have boarded a taxi. So, the decision is very much at that time under that existing circumstance. So, we can say that modeling

and predicting choices that is what we want to do is equivalent to modeling and predicting preferences.

Say if my preference is highest that is likely to be my choice. So, preference among set of options depends on again, I have told a number of times, shall again tell it here and also previously in the other lectures, the decision depends on attributes of options means attributes of alternatives.

What is the travel time, travel cost, waiting time, walking time, if you want to use different modes of transport, which are available to you? And also the attributes of the characteristics of individual, what is the decision maker or individual's income, age, gender, trip purpose and so on. So, all these are again going to influence the decision or influence the preference.

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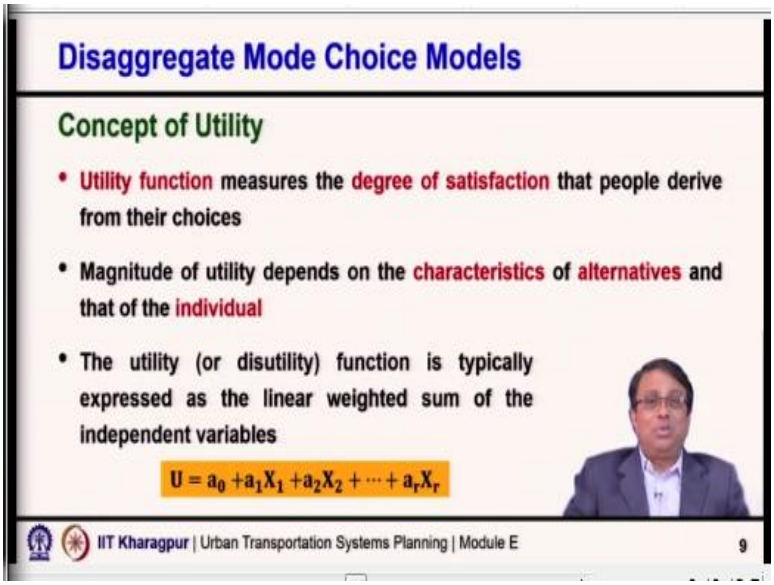

Now, let us try to understand the concept of utility, which is very, very important in the context of disaggregate mode choice models. A disaggregate models, the model choice is just an application, we are applying disaggregate model in the context of mode choice here, but same concept or similar way you can apply it for route choice. In fact, this kind of modeling choice modeling is applied in a number of fields starting from environment, to marketing, to health, to even terrorism, to even to understand the or to predict the outcome of an election.

So many ways, so many different ways we can apply this concept. So, these are used extensively in marketing, people do use it. And we are using presently or now in our context that is the context of mode choice. So, utility function measures the degree of satisfaction that people derive from their choices. So, we are talking about utility function, because a kind of message, the degree of satisfaction that people derive from their choice.

So, magnitude of alternatives, again then what are the functions, what are the in influencing factors or variables? It is basically the characteristics of alternatives and characteristics of individual. So, magnitude of utility, utility must be a function of the characteristics of alternatives and characteristics of individual. The utility function is typically expressed as the linear weighted sum of the independent variable.

We know that what are the variables, variables may be related to the characteristics of alternatives, maybe the characteristics of individual. So, those are my X factor X 1, X 2, X 3, X 4 like that. And we have certain weightage a 1, a 2, a 3 there could also be a constant a 0. And this kind of very simple linear weighted sum we are calculating and that is what is giving us the utility. So, utility function is typically expressed as a linear weighted sum of the independent variables as shown here in the screen an example.

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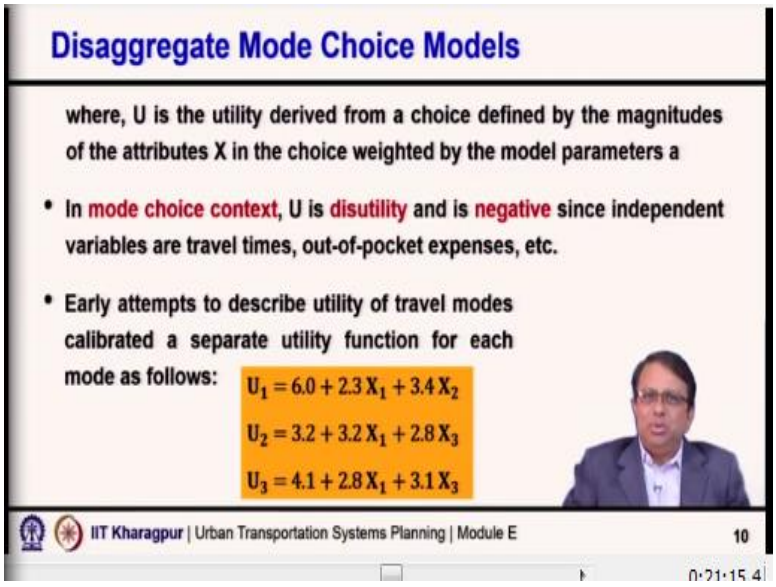

So, where, as I said U is the utility derived from a choice defined by the magnitudes of the attributes X, you have X 1, X 2, X 3, X 1 maybe waiting time, X 2 maybe the fare, X 3 maybe the in vehicle travel time, means when you are travelling inside the mode of transport that is called the in vehicle travel time and is the weighted is also weighted by the model parameter a.

So, you have a 1, a 2, a 3 waiting time the waits for in vehicle time, walking time, etc, all are not going to be the same. So, that is what we are getting actually. Now, in mode choice context let me tell you, this is very interesting and very important as well. That there is nothing called utility the concept wise it is utility anything we do even if you are thinking of buying a laptop, they are also the concept of utility is applicable.

But in the context of travel or transport, there is nothing called utility, why? Because what are the attributes or what are the variables, cost, time, walking distance like. So, ideally we would like to probably reach from one place to another place in zero time, zero waiting time, zero cost, just imagine you close your eyes and you will you were there to your dream destination place.

So, if some of you are in hostels, obviously you would like to be in your home with parents or with family. So, any money you spent is a disutility, any waiting time you spent at the bus stop, any time is disutility, any walking you have to do is disutility. So, in travel context, there is nothing called utility, everything is a disutility. And then also the benefit comes how we can change the disutility maybe 10 and now that disutility becomes 5.

So, there is an improvement, there is an improvement because earlier disutility was 10, either utility was 10 indicating disutility, and now the utility is 5. So in early attempts to describe utility of travel modes calibrated a separate utility function for each mode as indicated here. That means if you have 3 modes, U 1, U 2, U 3 they somehow calibrated how to get this equation now or later.

Again it is a matter of different, different aspects altogether, we shall discuss if time permits some of those things. But initial attempt were that every alternative separate utility equation, so you can see the constants are different, the X 1 coefficients are different, X 2 coefficients are

different. So every mode a separate equation, a separate utility function, every alternative separate utility but then there were certain problems.

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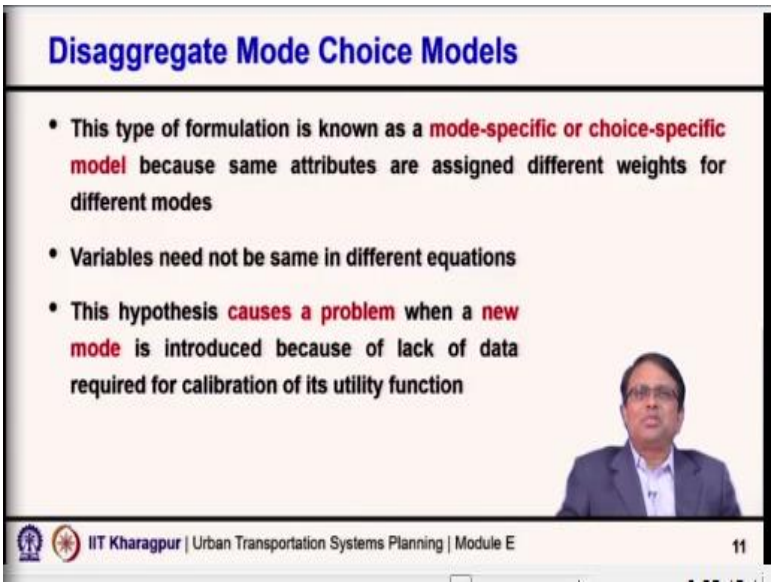

This type of formulation is known as mode specific or choice specific model, because the attributes are weighted as per the alternatives. So, the coefficient of travel time by taxi and by car, these coefficients are not same. Because car also will have X 1 and taxi also will have X 1, but the coefficient of X 1 is not going to be the same in 2 cases. So, this type of formulation is known at mode specific or choice specific model.

Now variables need not be the same in different equations. Now, this hypothesis caused a problem when we try to introduce a new mode. Because every mode wise if the coefficients are different, because just imagine that in a city metro does not exist. But metro is a public transport mode is one of the modes like car, like taxi, like bus, metro is also another mode. So, if you bring a new mode, because everywhere the coefficients are different, so you do not know what will be the coefficient values, it does not exist today. So, whenever it cause a problem when a new mode is introduced.

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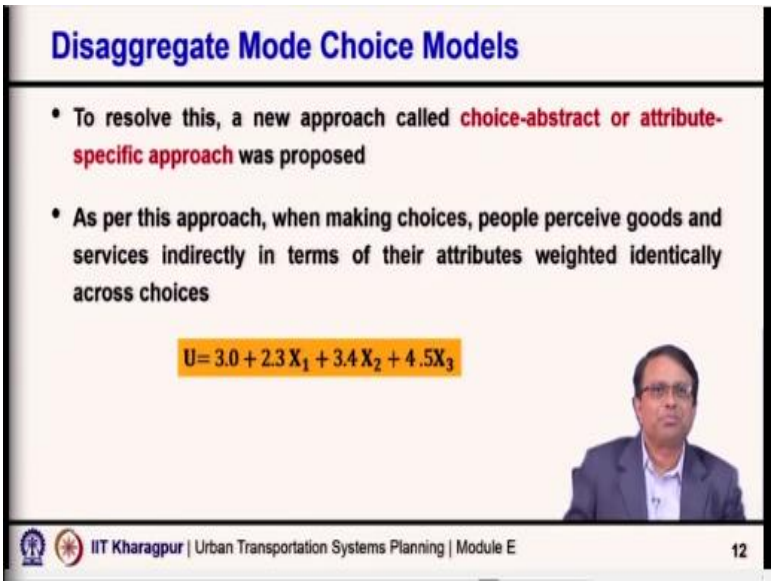

To resolve this new approach called choice based or attribute specific approach was proposed. So, what was done in this case, as per this approach when making choices, people perceive goods and services indirectly in terms of their attributes weighted identically across choices? It is me who is making decision, my decision may depend on the travel time but my weightage to travel time why in car and why in metro and bus why this weightage would be different.

So, what was told that in this approach, the X 1, X 2, X 3 the coefficients are going to be same, same across all alternatives, but then how the utility would be different? Yes, still the utility would be different, because X 1, X 2, X 3, X 4 these values are going to be different in different alternative, the travel time, travel cost, waiting time, walking distance are not going to be same for bus and metro, so obviously, my utility values also will be different.

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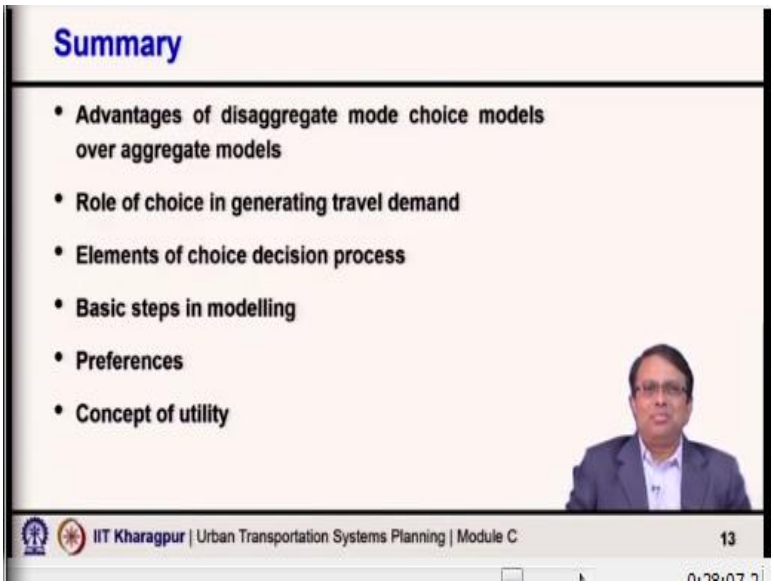

So, and with this actually the subsequent things are built up, and now it is taken like this attributes or coefficients or weights associated with attributes are same across all alternatives. Please carefully note this, this weighted identically across choices, so the coefficient of X 1, X 2, X 3, X 4 all these are not going to be same and not going to be different in different alternatives, but rather they will be exactly the same across all choices.

Still the values could be different because the value of X 1, X 2 and X 4 all these variables are going to be different for different alternatives. So, if I have to summarize I would say what we discussed in this lecture, we talked about the advantages of disaggregate mode choice model, our aggregate models, particularly the policy implication, the applicability, the reliability, the effectiveness, many questions can be answered with this kind of models, which aggregate model would not be able to answer**.**

You have seen the aggregate models, but can we say that if the bus network is a little bit more developed and walking distance is little reduced then how the choice of mode or how the bus ridership or the percentage of trips made by bus is going to change, we could not. But in this kind of models we can answer to such questions. We also discuss the role of choice in generating travel demand then what are the elements in the choice decision process the key 4 elements.

The basic steps, the 3 steps we said, and we introduced you to the concept of this preference saying that modeling choices means, modeling preferences and introduce to you the concept of utility. So, with this, we close this lecture and we shall continue in the next lecture, thank you so much.