Urban Transportation Systems Planning
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Lecture-31
Factors Influencing Mode Choice and Aggregate Modal Split Models

Welcome to module E, lecture 1. This lecture will include a brief introduction about mode choice analysis, also the factors which influence mode choice decisions. And introduction to aggregate mode choice model or modal split models.

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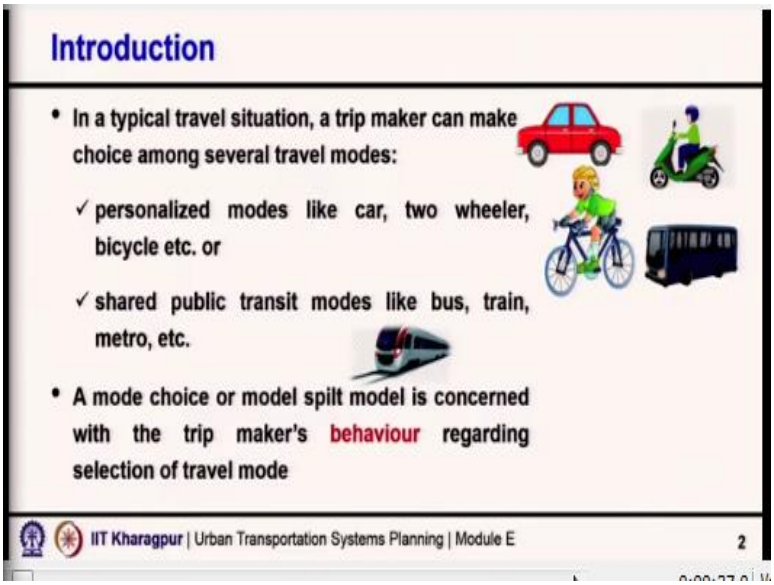

In a typical travel situation, a trip maker can make choice among several travel modes. For example, if a person is travelling from a place to another place, he or she can decide whether to use any of the personalized modes such as cars, 2 wheeler or bicycle or to use shared public transport modes such as bus, train, urban case metro service, etcetera. A mode choice or modal split model is concerned with the trip maker's behaviour regarding selection of travel mode.

How we can estimate the number of trips that will use different modes say public transport mode, private mode, even within public transport mode if there are multiple options, then how the demand will get split into different available or alternative modes of transport? The whole analysis that come under mode choice or modal split analysis.

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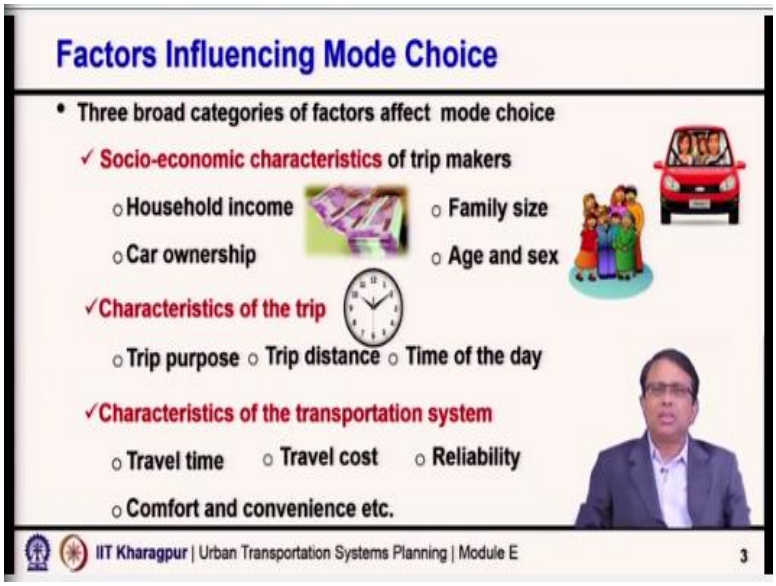

Now there are 3 broad categories of factors which affect the mode choice, 3 broad categories. One socio-economic characteristics of trip maker, what is the income level? What is the level of car ownership? What is the family size? What is the age? What is the gender? All these are going to influence the mode choice analysis. That means, the choice of mode for a male and a female may not be same, gender may play into role.

The choice of mode for a high income household and low income households may not be same. A person who is having car and a person who does not have car, again these characteristics will influence So, there are several socio economic characteristics of trip makers, which would influence the choice of mode. Second, the characteristics of trip, that also will influence, say what is the purpose of the trip? What is the distance that one is expected to travel; at what time of the day that trip is being made?

All these are again may influence the decision of the makers about the choice or selection of mode. Say for example, while going to the office, the travel time is extremely important because people have to reach to office at a particular time. But whether whereas for recreational trips, the choice of mode maybe slightly different, because people may focus more on the comfort and convenience rather than the travel time.

The trip distance influences the choice of mode. If one is struggling maybe for 1 kilometer, then maybe walking is also an possible option or use a bicycle wherever such facilities maybe used, then bicycle is also an option. But if somebody is travelling a longer distance 20 kilometer, then walking is definitely not an option. The person has to use either public transport mode or a motorized private mode say a car or a 2-wheeler, motorized 2-wheeler.

Similarly the decision maybe influenced also by the time of the day when the trip is being made. Somebody making travel in the peak hour when the public transport and the overall transport system is highly loaded. Both outside in terms of roads traffic congestion and also inside in terms of congestion inside public transport modes. And if somebody is travelling absolutely in the lean hour, the choice of mode may not be safe.

It also depends on the characteristics of the transportation system, what are the available modes then with respect to those what are the travel time, travel cost, what is the reliability, what is the level of comfort, convenience and all such kind of transport system characteristics. So, therefore the choice of mode is influenced by socio economic characteristics of trip maker, who is making a decision, what is his or her characteristics, then the characteristics of the trip and also the characteristics of the transportation system, all these factors are important.

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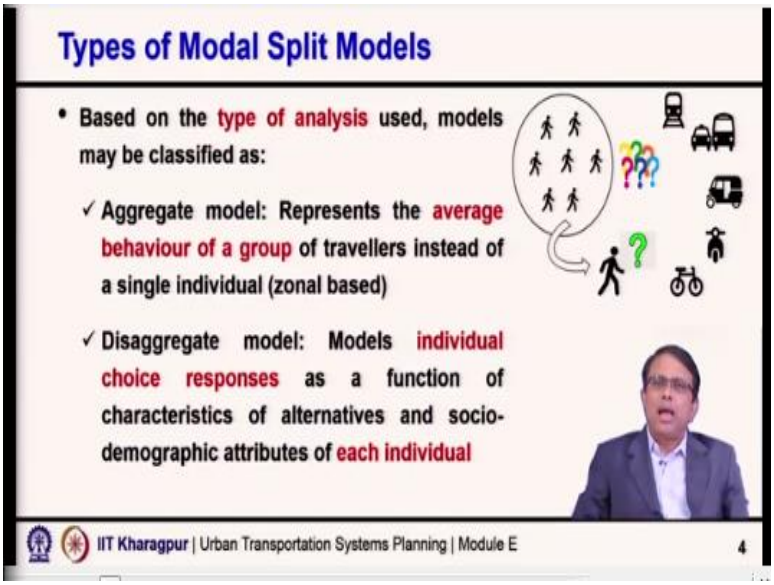

Then coming to the type of modal split models, based on the type of analysis used models can be classified as aggregate model or disaggregate model. So, I say it is based on the type of analysis used, what kind of analysis we are doing? Aggregate model represents the average behaviour of a group of travelers instead of a single individual. That means we are not here modeling the choice of every individual but at a aggregate level say that is what I say zonal based mostly.

So, at the zonal level, what are the zonal characteristics, average characteristics of people maybe average car ownership and such factors. And then we are trying to say that then how much proportion of the zonal population is expected to use public transport mode, and of course or the private modes. So, the aggregate model is actually represents the average behaviour of a group of travelers not individual travelers.

And mostly our aggregate models which are more or less you can say that these are more of zonal based model. Whereas, disaggregate model deal with individual choice responses, every individual person how his or her choice is being made. That we try to model as a function of the characteristics of alternatives. Obviously how much travel time is by car? How much travel time is by bus? How much is the cost of travel by car? How much is the cost of travel by bus? What is the waiting time? And what is the comfort level and so on so forth.

So, all these characteristics of alternatives that we use, and also the socio demographic attribute of each individual, again the income, the trip purpose, the age, the gender and all such kind of characteristics. So, aggregate model not predicting the individual behaviour but the average behaviour of a group of people. Overall how much percentage of people may use public transport based on the average characteristics of people or households in the overall zone or at aggregate level.

Whereas in desegregate level, the choice is being modeled as a function of characteristics of alternative as well as socioeconomic characteristics of each individual.

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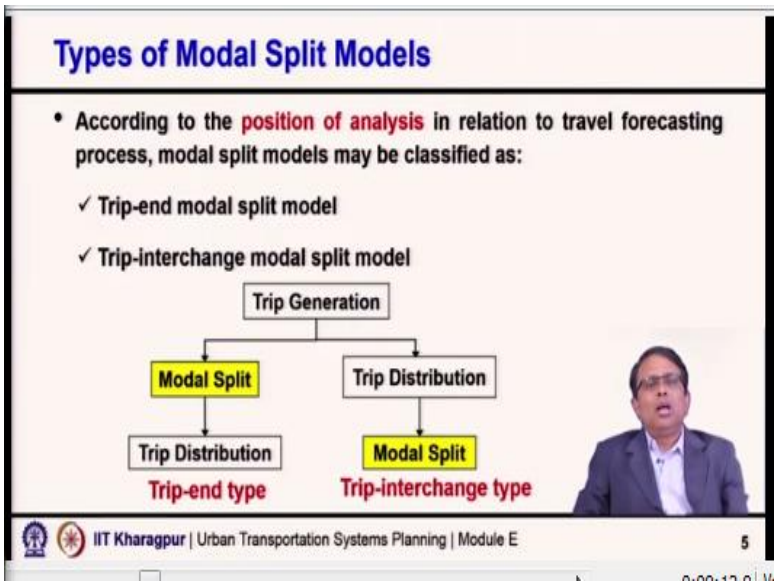

Now if you also see that according to the position of analysis in relationship to travel forecasting process. Modal split model maybe classified as trip end modal split model or trip interchange modal split model, what we mean? You are already familiar with these 4 states planning process trip generation, trip distribution, mode choice and traffic assignment. So now when we are carrying out this much choice analysis?

If we are carrying out the mode choice analysis immediately after trip generation and without carrying out the trip distribution, then that mode choice analysis or modal split model, we can say that they are trip end modal split model. That means simply we are directly taking that trip end and applying modal split on the trip ends. Whereas, if we are doing the modal split analysis or mode choice analysis after trip distribution, then it is not only the generation but the distributions are also known.

From which point or which zone to which zone, how many people are travelling all such informations are known. So, there the mode choice model or modal split model, we can call them as trip interchange modal split models. So, depending on the position that when in the 4 stage planning process, where we are actually doing the mode choice analysis, depending on that, we can call model as trip and model, split modal or trip interchange modal split model.

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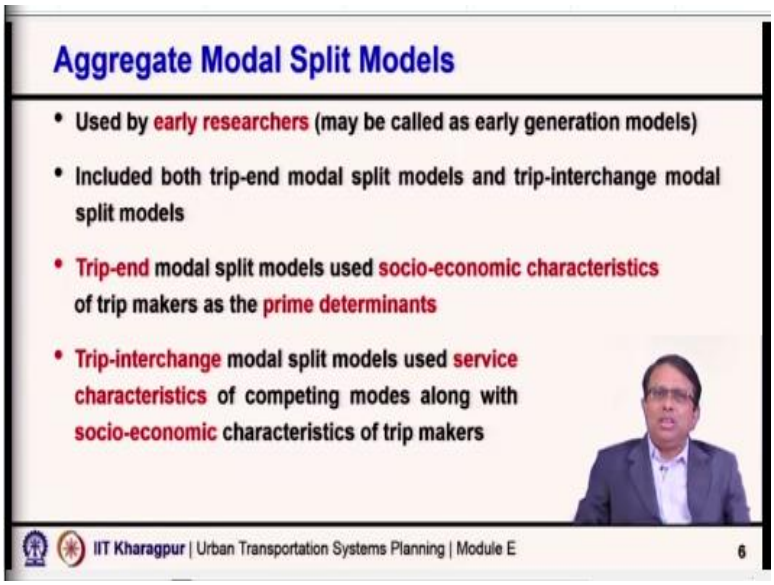

Then coming to a little bit more about the aggregate modal split models, in today's remaining time we are going to discuss this only. These aggregate models were used by early researchers and we can also call them as early generation models. So, initially whenever people started working on modal split models, initially all models were developed which are of aggregate type.

And these models included both trip end modal split model as well as trip interchange modal split models. So, some probably did the modal split aggregate level model, but did the modal split immediately after trip generation. So, they were like trip end modal split model, whereas there were also modeled which were of trip interchange modal split models. Now, the trip end modal split model used socioeconomic characteristics of trip makers as the prime determinants, why it is so?

Because we still do not know where they go, the origin destinations, destinations both are not known. So, we do not know the distribution if 1000 trips are being made, how many trips are actually going to a particular zone? That is not even known. So, what we know is only the trip ends, so every zone what is the number of trips produced maybe, that much we know. So, those trip end models, trip end modal split models used only socioeconomic characteristics, predominantly the car ownership.

Whereas the trip interchange modal split models, now we know even the destination. So, they used service characteristics of competing modes, it is a known that between this origin to this destination, what are the available modes of transport, how is the transport connectivity? So, the service characteristics of competing modes were used, along with socio economic characteristics of trip makers.

Because we know that the choice of mode or the decision about the mode also depends on the socioeconomic characteristics of individual. So, socioeconomic characteristics were used, but additionally at trip interchange modal split models at that level actually the service characteristics of competing modes could also be used in developing the aggregate modal split models.

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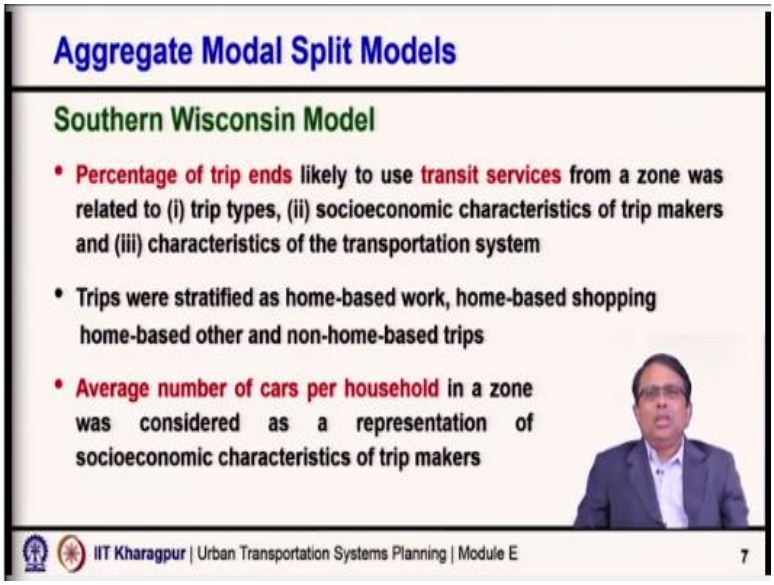

Now let us take up one of the early models aggregate type models which is known as Southern Wisconsin model. Here the percentage of trip ends likely to use transit service, that means all what was aimed that out of the total trips which are produced from a zone, how much shear or how much percentage of those trips would use actually public transport, that is all**,** not which type of people and not at individual level or desegregate level.

Because these are all aggregate models. So, what was model was the percentage of trip ends likely to use transit service from a zone. Now it was modeled as a function of what? Or related to

what? Related to trip type, type of trips one, second, socio economic characteristics of trip makers as usual what we discussed and also in this case characteristics of transportation system. That means you remember, you can understand that we are actually talking about use of both socioeconomic characteristics of trip makers as well as the characteristics of transportation system and also the trip characteristics, because the trip type was also included.

Now in this model trips were stratified as home based work, home based shopping, home based other and non home based trips. So, for every trip type separate model, because the split are unlikely to be same for all types of trips, so for each type of trip separate model was developed. Then the second part was socioeconomic characteristics of trip makers. So, to consider this aspect, what was taken was the average number of cars per household in a zone.

As I said these are aggregate model, so overall zonal characteristics are important. So, what is the average number of car per household? So, you just take how many cars are there in this zone, and how many households are there? You simply calculate then per household on an average how many cars are there? Get that number and that is used to relate the percentage of trips ends that are likely to use transit service. The third is what, the characteristics of the transportation system.

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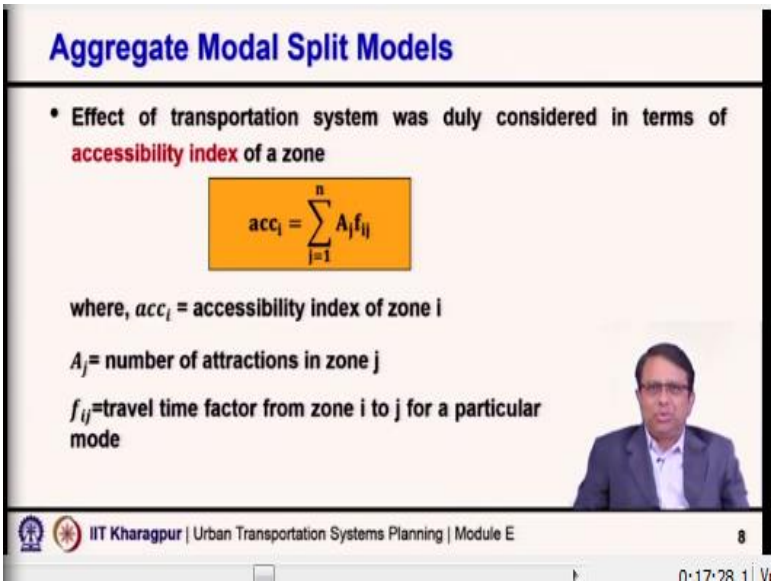

Now in order to take care of the characteristics of transportation system, what was considered was something called accessibility index of the zone. It was not taken directly the accessibility index, it was taken in a slightly different form, but I shall explain that again. But, let us first understand then what is the accessibility index of a zone? If I say for a zone, accessibility index was duly taken into consideration.

Then what is the accessibility index? Accessibility index as you can say for a zone i is sum over A j f ij, A j is what? Number of attraction in zone j, so if we are talking about zone 1, maybe 1 is connected to zone 2, zone 3, zone 4 so 2, 3, 4 are my j's here**.** And f ij is the friction factor between i the zone what we are talking about and each of the zone j. So, A j f ij we calculate and then we sum it over for all zone j which are connected to zone i.

And then that is giving me or that will give me the accessibility of zone i. Now obviously, we are talking here about private mode and also the public transit. Two travel modes we are talking because we want to find out how much percentage of the trip ends will actually use public transport. So, we are talking about 2 modes private mode and public transport mode. So, the f ij values will not be same, because the public transport availability and if you are using car the frictions may not be same, f ij may not be same.

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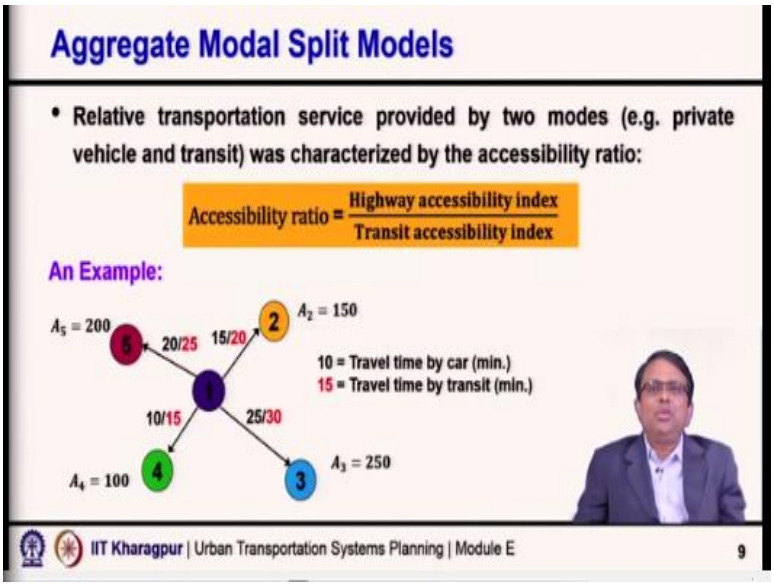

So, what was done? Actually the relative transportation service provided by these 2 modes, that is private vehicle and transit or you can say car and transit**,** this was characterized by the accessibility ratio. That means you know that how we calculated the accessibility of a zone i. So, this accessibility was calculated for private vehicle and this accessibility was also then calculated with respect to public transit or the transit.

And then the ratio of this accessibility, what is called as highway accessibility means it is the accessibility when you consider private mode or private vehicle, and transit accessibility means when you consider transit. So, take this ratio and that was termed as accessibility ratio. Now to explain this further, let us take a small example. Let us consider that there is a zone i, it is the purple one in the center that is zone i or zone 1, which is connected to zone 2 right top, zone 3 bottom right, and zone 4 and zone 5.

So, 1 is connected to 2, 3, 4 and 5, and then for all these connections travel times are given by car or by private vehicle and by transit. So, the black numbers say for example, 10, 15, 20, 25 these are actually the travel time by car. And always along with that, you find something is written in red, which are having higher values than the corresponding black numbers, they are basically the travel time by transit.

So, you know 1, 2 do the travel time by car is 15 minute and travel time by transit is 20 minute so, 1, 2, 3 you know that travel time by car is 25 minute, travel time by transit is 30 minute and so on.

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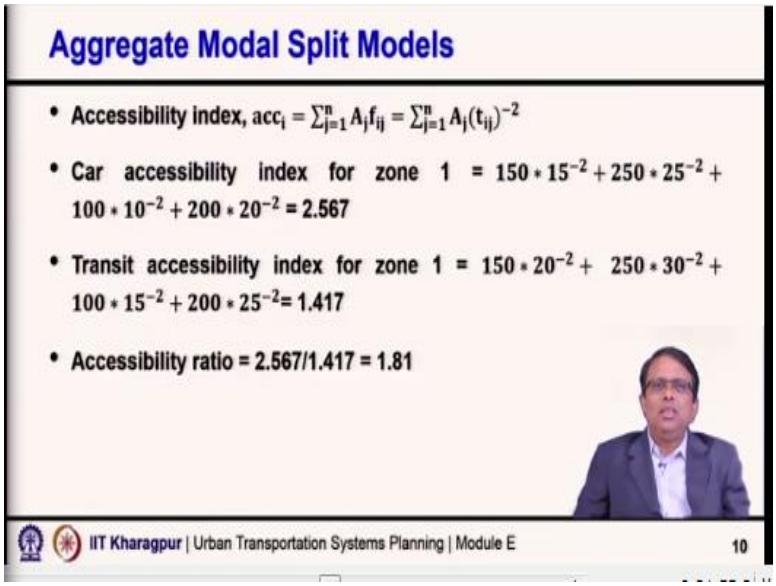

So, now once we know this, we can easily calculate the accessibility, what is accessibility? It is a f ij, but we do not know the value of the f ij, we know only the travel time. So, based on the previous understanding you know it will be some function of travel time, let us consider here that a f ij = 1 by t ij square. So, the travel time we know, so if we know the travel time then f ij can be replaced by t ij to the power -2.

So, like that we can then calculate the car accessibility index for zone 1 and we can also calculate the transit accessibility index for zone 1. So, you get one value of accessibility of zone 1 by car 1 value of accessibility by indexed by transit by transit. And then as I said in the previous one, we can calculate the accessibility ratio, how? Because we know the highway accessibility index, we also know that transit accessibility index, simply take the ratio.

That is what we have done, we know that car accessibility index here is 2.567 and the transit accessibility index is 1.417. So, take that issue you get 1.81 some value, 1.81 is really not important just to show you or to explain you how things are calculated. So, now what we do with this? We know the accessibility ratio.

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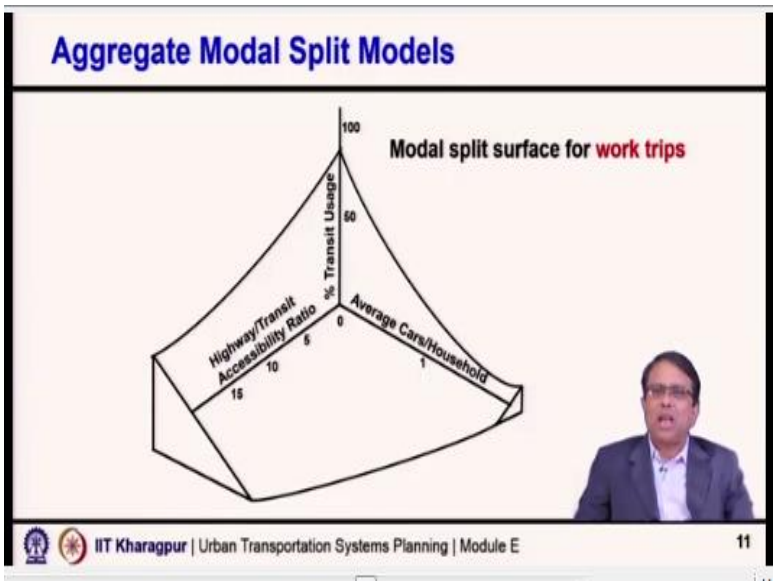

So, they developed modal split surface, and they modal split surface separately for different trips. What do you say, the trip type is also considered, work based, home based work, home based other, non home based like that. So, for each type of trip, each type of trip is separate modal split surface 3-dimensional, so we are calling it surface. What are the 3 dimensions? Obviously we want to get percentage of trips to be made or likely to be made by transit.

So that is one axis you can see clearly, the transit usage, here it is shown as a z axis then what are the other 2 axis? x and y, x and y via one is the average car per household and the other is this ratio, highway to transit accessibility ratio. So, we are considering all the 3 aspects as I said here, trip types. So, one surface for each trip type, socioeconomic characteristics that variable taken is the car ownership per household.

So, different car ownerships different values you will get, and then third is characteristics of transportation system in terms of accessibility ratio. So, you have accessibility ratio and average car per household as x and y and then z value will be the modal split or percentage of trips that are likely to use transit. And this type of surface was developed for different trips, work trips, home based work, home based other, non home based and so on.

So, that way this is an aggregate model because we are giving zonal characteristics average number of cars per household, average zone level, highway transit accessibility ratio. And we are

also considering different types of trip and then this model could give you actually the percentage of trips that are likely to use transit.

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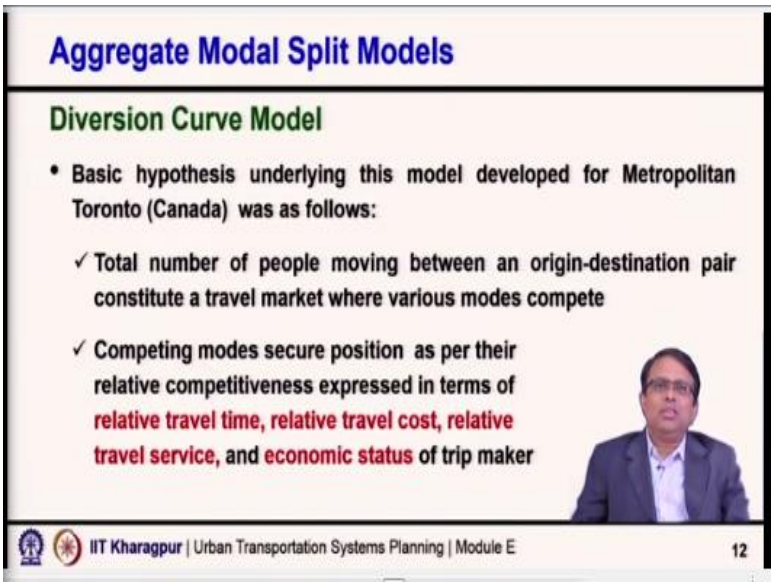

Now the second one is diversion curve model, what we do here? The basic hypothesis underlying the model development and it was developed for say Metropolitan Toronto in Canada that was as follows. One is the total number of people moving between an origin destination pair constitute a travel market where various modes compete. That means you know that so many 1000 people, say 5000 people are travelling from origin i to destination.

And now, as if different modes are competing with each other, how much the particular mode can attract, what could be it shear in the overall market? So, the competing modes secure position as per their relative competitiveness, how we are expressing that relative competitiveness? In terms of relative travel time, in terms of relative travel cost, in terms of relative travel service and also duly considering the socioeconomic status or characteristics of the trip maker.

So, relative competitiveness in terms of relative travel time, relative travel cost and relative travel service and also economic characteristics or economic status of trip maker.

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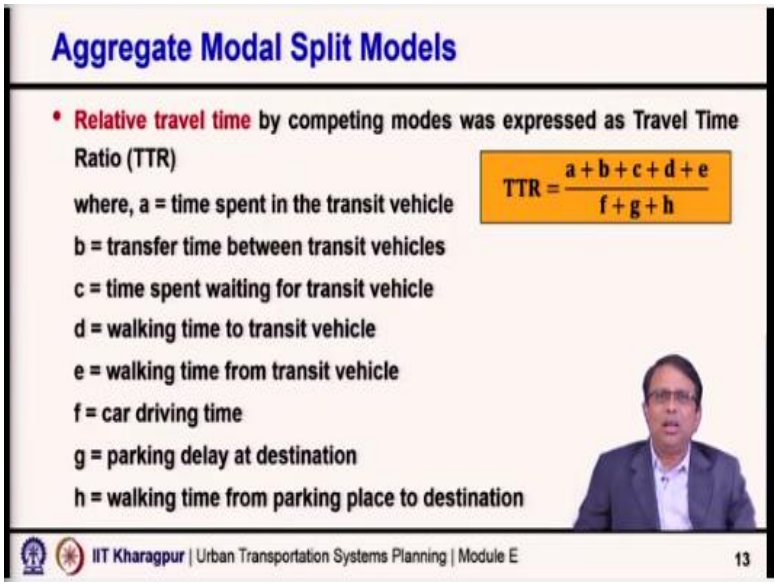

Now how the relative travel time was calculated as I have shown here, it was expressed by comparing the modes, comparing the travel time by transit as well as by car. So, taking the ratio of travel time you can say, now the overall travel time will have different components one is say to transit a is how much time you are spending inside the vehicle, b is how much time you are spending for transferring from one transit vehicle to another transit vehicle or route.

Then c is the time spent waiting for transit vehicle, how much time you are waiting at the bus stop, d is how much time you are walking to reach to the transit stop. So, all these walking to transit vehicle and then is how much one is the walking another is the waiting. So, all these components are considered together that gives you the total travel time by transit.

Similarly the denominator includes f, g and h car driving time, parking delay at destination sometimes being spent for parking as well, and then walking time for parking place to your destination. Because you may not be able to drive your car right at the destination point, maybe want to go to a shop, you cannot go directly up to the shop, but you have to park your vehicle in the nearest parking location and then you have to walk, so that take that time also. So, this struggle time ratio was one factor.

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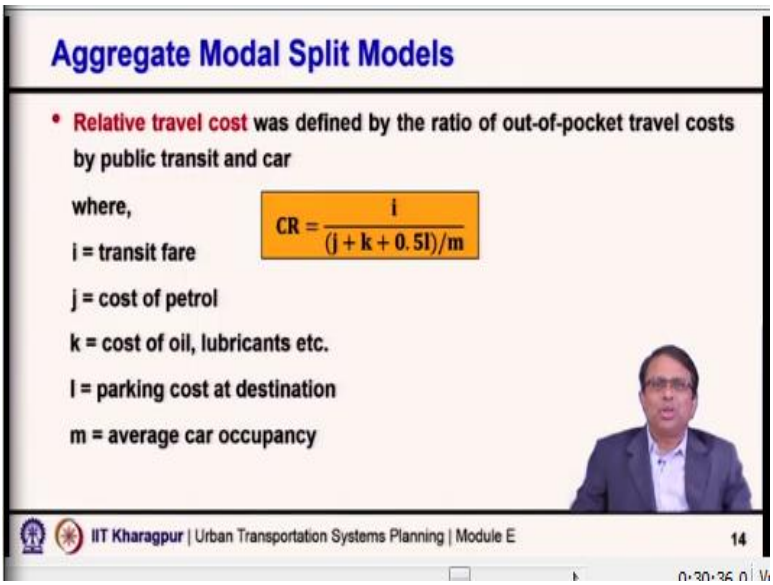

Second, relative travel cost. So, what is the direct or out of pocket expense? So, here it would be basically the transit fare because when you use transit direct or out of pocket expense is only the transit fare per person. And then if you are travelling by car that will include cost of petrol, cost of oil, lubricant etcetera. Then also the parking cost at the destination because parking may not be free you might be parking your vehicle in a paid parking location, so you have to pay some parking charges.

But in a car maybe n numbers of people are travelling. So, this overall cost, total cost j + k + whatever is the parking cost, how he is taken because you are considering one way. So, the parking cost gets distributed for up and down. So, per one way trip and divided by m to get it per person, so that ratio is the cost ratio.

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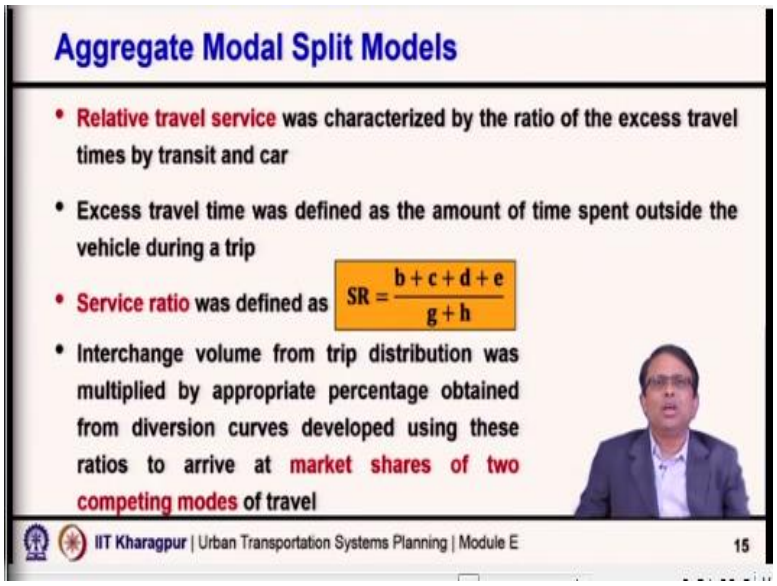

Similarly the relative service ratio, relative service or you can call it as service ratio. Now what is the service? Relative travel service was characterized by the issue of the excess travel time by transit and car, what is excess travel time? Excess travel time is nothing but the other than in vehicle time when you are inside the vehicle other than that. So, if you consider the previous one a was the time spent in transit vehicle rest are all outside.

Similarly, f is the car driving time g and h was other components. So, here also you consider other than a all other thing b + c + d + e and they are also g + h that gives you the service ratio.

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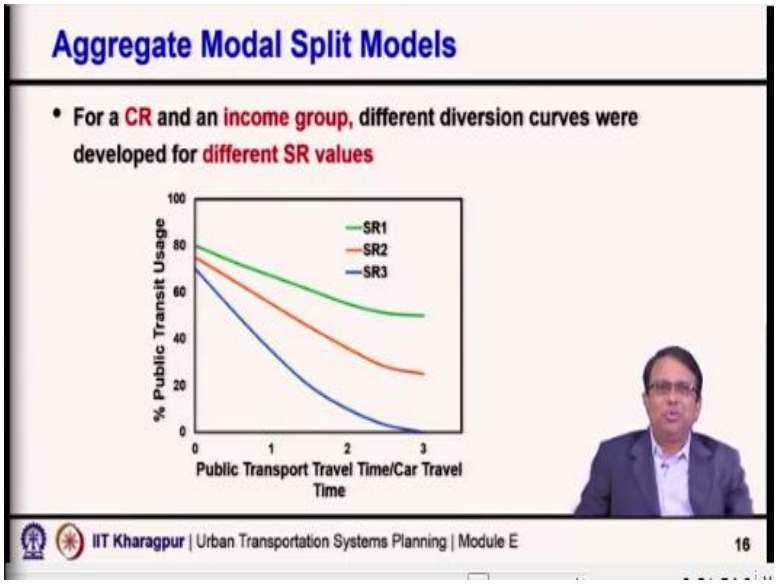

Then what we did? We have all these ratios, now we want to find out percentage of public transport usage, how much percentage of people will use public transport at a gross level, at aggregate level? So, for that for the date, for a particular cost ratio and income group different diverse and cars were developed for different service ratio value. So, we consider cost ratio, we consider different income group, and then different diversion curves as shown here were developed for different service ratio value.

For example, if you know that what is the service ratio for a particular context then you know the public transport travel time by car travel time So, the travel time ratio if you know with respect to that travel time ratio and with respect to that service ratio, you will pick up then appropriate curve. You can see here 3 different colors means 3 different lines represent 3 different service ratio, so take an appropriate curve which is relevant.

So, for the public transport travel time by car travel times it is the travel time ratio as we said earlier. With respect to that, select an appropriate curve and you can actually get the value of percentage of public transit usage. Similarly for every value of shear different values of shear, they consider. Then for each value of shear other values of shear different income groups, again different SR values.

So, multiple such cars are developed which were called as diversion curve. So, these diversion curve use travel time ratio, cost ratio, service ratio and different income group people, different curves. Because the response to all these for a particular cost ratio, a particular travel time ratio, a particular service ratio, the how much percentage would actually ship to transit will also depend on you know the socioeconomic characteristics that means the average income.

So, like that several when curves were developed, I have shown here only one and using those curves for a particular income group, particular cost ratio, particular travel time ratio for a particular service ratio, then one can easily find out select an appropriate curve and then get the value of percentage of public transit usage, that was the use.

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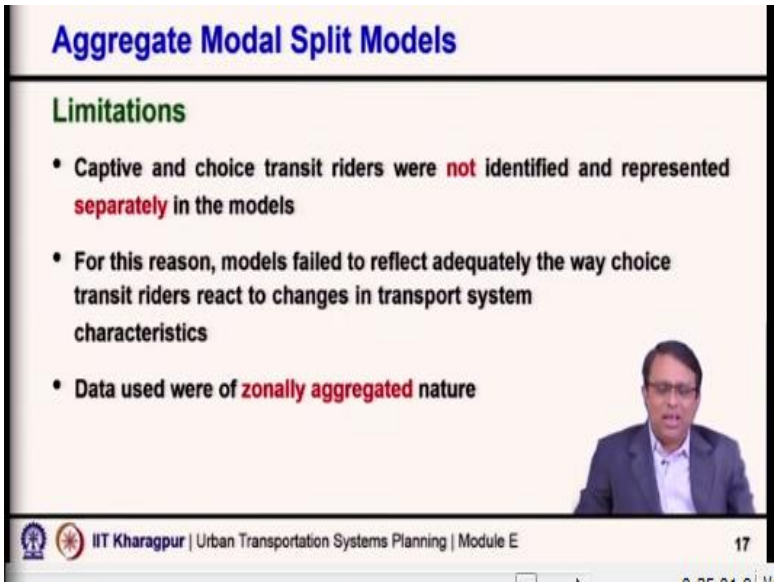

There is certain limitations one is captive and choice transit riders were not identified and represented separately in the model. Because the response if I have a car, and if I do not have car my responses are not likely to be the same, so that was not considered. And for this reason, these models failed to reflect adequately the way the choice riders react to change in the transport characteristic.

Like you improve the public transit fare or your waiting time is more, your walking time is more, your transfer time is more. Now, the response to the choice riders would be very much different under each of this when these values are changing. So, these models failed to reflect adequately the way the choice riders react to such changes. And of course, the data which were used was zonally aggregated nature.

So, average value, average characteristics and you know average does not represent the reality, because everybody is individual the decision making is done at individual layer, so the accuracy would be limited.

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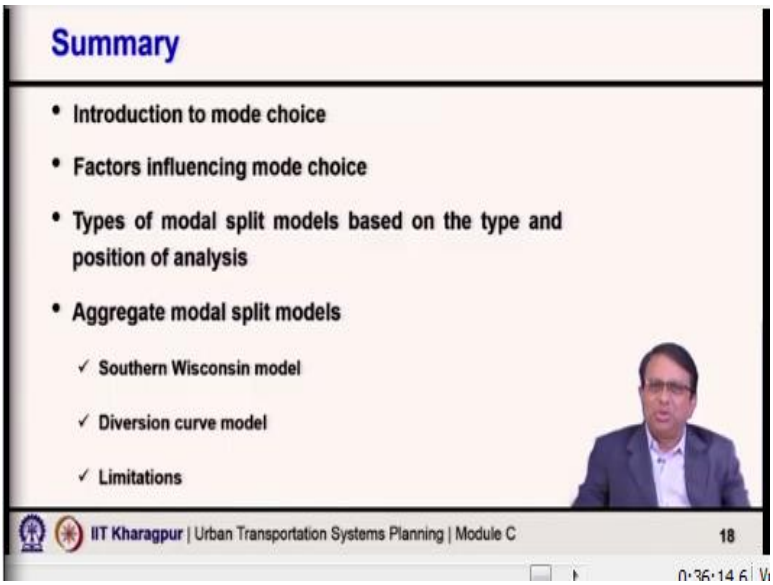

So, what we discussed today, we introduced you to the mode choice modeling, we discussed the factors influencing more choice, type of mode modal split models that we said based on the type of analysis, what is what we do aggregate, desegregate. And then depending on the position, whether we are doing it immediately after trip generation or we are doing it after trip distribution?

Then we discuss 2 aggregate modal split model, Southern Wisconsin model, and diversion curve model and also discussed about the limitations of such aggregate modal split model, with this I close this lecture, thank you so much.