Urban Transportation Planning
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Lecture No. # 15
Modal Split Analysis Contd.

This is a lecture fifteen on urban transportation planning, we will continue our discussion on modal split analysis in this lecture. Let us first recall, what we discussed in the previous lecture. First, we started our discussion on earlier modal split models with specific reference to trip interchange type model split model, and we discussed about the involved variables in the model. And finally looked at, the characteristics of the model by referring to a graph, involving all the variables including the socioeconomic characteristics of the urban dwellers.

Then we discussed about disaggregate type of mode choice modeling, and under that title we discussed about the importance of disaggregation in mode choice modeling, the reason being every individual is going to be different in their own way, while choosing mode for travel. So, it is very difficult to assume, that everyone will choose a particular mode based on the modal attributes or based on the values commonly assess assigned for the modal attributes; that is the reason why, it was felt to be more appropriate to going for disaggregate modeling of mode choice.

Under this topic we discussed about utility function, development of utility function involving a set of modal attributes. And we were specifically talking about, mode specific type of utility functions. Utility function developed for each of the alternative modes or rather separate utility functions, developed for each of the alternatives involved in the transportation system. With this briefing, let us try to specifically capture, some of the important points of the pervious lecture, by answering the following questions.

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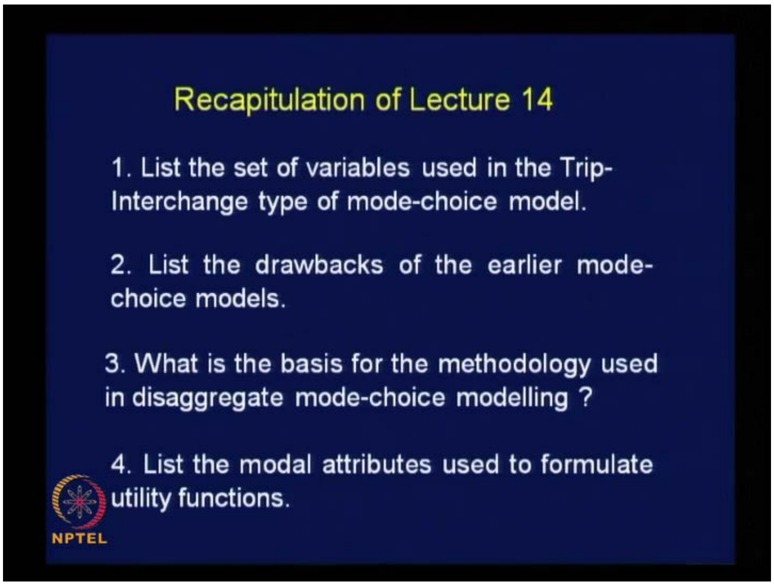

Question number one is this, list the set of variables used in the Trip-interchange type of mode-choice model; any response, let me just give you the answer for this question. You may recall, we discussed about travel time ratio, travel cost ratio, travel service ratio, and then three categories of socioeconomic groups of travelers namely low income, middle income, and high income groups. So, these are nothing but the variables involved in this particular type of model, is not it? We just express the variables in the form of ratios, because there were only two modes involved in the mode choice analysis, that is how we need to understand the answer for this particular question.

The second question is this, list the drawbacks of the earlier mode-choice models. Disadvantages, drawbacks of earlier mode choice models, we found that, there were two drawbacks of earlier mode choice models. The first one was that the captive travelers, were not segregated from the database, the model represented both, choice as well as captive riders, that is how, the model need not be a very accurate representation of reality. And second limitation or drawback is that, zonal aggregate values were considered for modeling, when you consider zonal aggregate values, it indirectly implies that, an assumption that every house hold in a zone, will behave in a similar manner. Under a given choice situation is already made, which is not correct in reality households and individuals, may differ in their perception of are the level of service offered by different alternative modes and their choice process need not strictly be based on the calculations made, using the zonal average date, so these are the two drawbacks of this particular model.

Third question is this, what is the basis for the methodology used in disaggregate mode-choice modeling, basis or the theory behind disaggregate mode-choice model.

The utility of the particular mode, which is being used by the travelers, that is the basis for this disaggregate (( ))

The basis is the disaggr discrete choice theory or the utility theory, is the basis for this particular approach for modeling right. I I suggest that, all of you try to recollect what we discussed in the previous class, so that we feel at home when we can proceed further.

The last question, list the model attributes used to formulate utility functions, you have seen utility functions for a set of three modes in the previous class, what were the attributes used, to develop utility function; attributes are nothing but, model characteristics, which are considered as causal variables, in the mode choice process, any response. On what basis, people choose modes, based on travel cost, travel time, travel comfort and so on. These are the attributes right used in the development of utility function, very simple nothing complicated clear.

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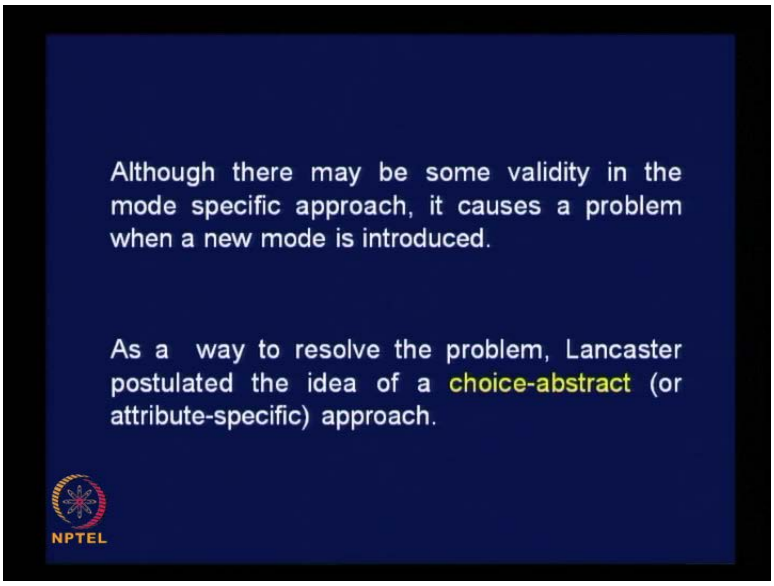

So with this understanding, let us proceed further, to see whether these mode specific utility functions were alright or there were some problems. As stated here, although there may be some validity in the mode specific approach, it causes a problem when a new mode is introduced. As I pointed out, in the previous class, what is the problem? Calibration of utility function may not be possible, because we will not have any database, for calibrating the utility function for the new mode. As per the mode specific approach, so that is the real problem. And this problem was proposed to be solved by Lancaster and based on choice-abstract or attribute specific approach. It is not specific to mode, it is going to be specific to attributes, modal attributes that is the approach proposed by Lancaster. Let us see, how to go about developing utility function based on modal attributes alone to cover all modes.

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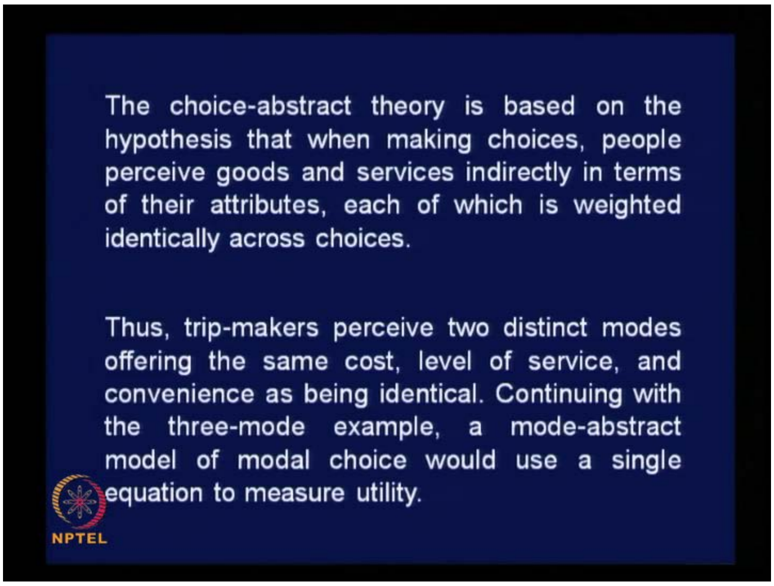

The choice abstract theory is based on the hypothesis that when making choices, people perceive goods and services in general, goods and services indirectly in terms of their attributes, each of which is waited identically across choices. They look at the attributes only, not the make or brand or something else related to the alternative modes.

Let us say, there are two service providers for cell phone BSNL and Airtel, what are the attributes that influence choice of these services, basic attributes are

Network coverage

Network coverage or effectiveness of the coverage

Coverage cost per call

Cost per unit time may be cost per minute, these are the two attributes and we look at these attributes in isolation, just we compare the cost per unit time and then effectiveness of the coverage. And, if it is same in both the cases, for user both are same or if there is a difference in these attributes then that particular service is taken, for utilization or use right. So, it is based on attributes, not based on specific alternatives available, you have different brands of cars available in the market Maruti Suzuki, Hyundai, Tata. Let us say, we fix a set of attributes, for choice of a car, for our use. First attribute, let us say the size of the engine, you want to have 1.2 liter size of the engine, for your use. If all the makes have 1.2 liters size, you do not distinguish between the three makes, all the makes are same for you, the wheel size, if you prefer a particular size say fourteen inches, if all the three makes have the same size, you do not differentiate between the alternatives.

The trunk size, if it is same for all the three makes, no difference as far as the usage is concerned. The head room inside the vehicle, if it is going to be same for all the cases then there is no difference. So, you perceive the utility of alternatives based on, a set of attributes and assign same weightage are in other words, you do not differentiate between 1.2 liter engine of Tata and 1.2 liter engine of Hyundai, even though there could be some differences, for choice purpose you treat both these makes to be same, because that attributes is same, that is the assumption made in this particular theory.

I will repeat again, the choice abstract theory is based on the hypothesis that when making choices, people perceive goods and services, indirectly not by making use of each alternative service, indirectly in terms of their attributes, each of which is weighted identically across choices right it is attribute based approach. Thus, trip-makers perceive two distinct modes offering the same cost, level of service and convenience as being identical, no difference at all, continuing with the three- mode example, that we have seen earlier, your mode-abstract model of modal choice would be a just single equation to measure utility is not it, when we just consider only of the attributes, there is no need to have specific equations for each of the alternatives, we can have single equation.

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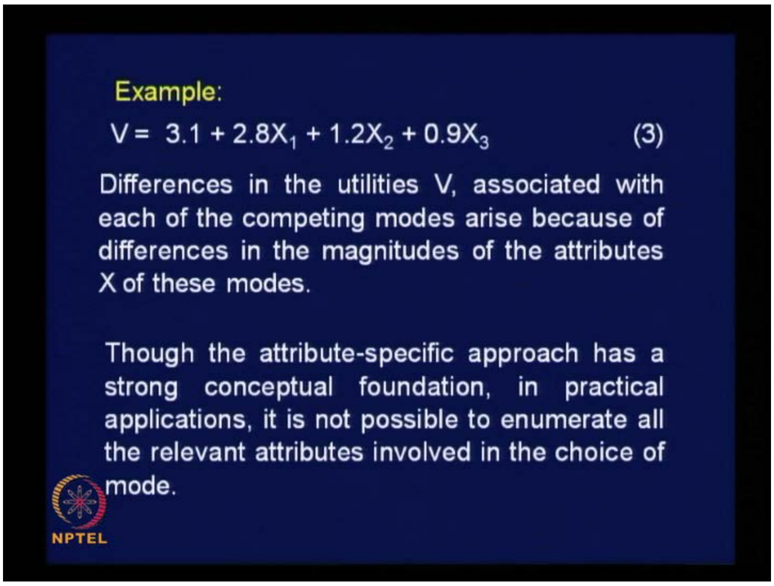

So, this will be utility function, even when you have three alternative for choice. You may wonder, when how do we get different utility values for the three alternatives, how the V value is going to be different for the three alternatives, it cannot be the exactly same is not it. In practice, there will be some difference, how do we get the difference obviously, we will collect information about the values of X 1, X 2 and X 3 for these alternatives. So, the values of these variables will make a difference in the value of V is not it. So, ultimately the V is nothing but, the cumulative effect of the three attributes namely X 1, X 2 and X 3, even though co efficient are same, the values of X 1, X 2, X 3 is going to make a difference.

So, differences in utilities namely V, associated with each of the competing modes arise because of differences in the magnitudes of the attributes X of these modes, that is how you are likely to get, different V values for different alternatives. This approach is not completely, though the attribute-specific approach has a strong conceptual foundation, in practical applications, it is not possible to enumerate all the relevant attributes involved in the choice of mode or it is not possible to take into account all the attributes, accounting for the total utility of a mode. We just consider two three attributes and quantify the utility, there could be unaccounted part of utility associated with each of the alternative modes and that unaccounted part, may make a significant difference, in the total utility utility of the alternatives is not it, based on which, we make normally choices.

In this equation, where is unaccounted part indicated, is there any indication about unaccounted part, the constant term 3.1 is the portion which is not accounted for by any of the variables or any of the attributes. So this is a single constant value given, for all the three alternative modes. The question is, is it right to assume that the unaccounted part is same for all the three alternatives, it is not right; it will be different, for different alternatives. The level of service provided by mode one may be explained by X 1, X 2 and X 3 to an extent of ninety five percent and the total level of service offered by mode two may be explained by these three variables X 1, X 2, X 3 to an extent of only eighty eight percent is not it. So, it is not right to assume that, the number indicated as a constant term is same for all the alternatives, so we must do something about it, how to do some a compensatory measure for this particular problem.

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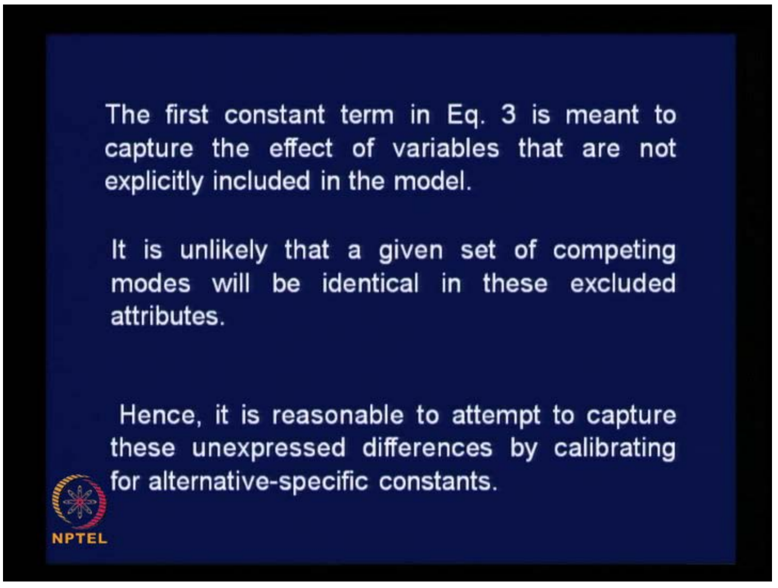

The first constant term in equation three is meant to capture the effect of variables as I said, that are not explicitly included in the model. It is unlikely that a given set of competing modes will be identical in these excluded attributes, that is what we discussed, need not be identical, there will be variation. Hence, it is reasonable to attempt to capture these unexpressed differences by calibrating for alternative specific-constants or in other words by some means, if it is possible for us to get different constants values for different alternative modes, it will be more appropriate and we will be able to get more accurate representative value of V, as total utility of various alternatives instead of having only one constant term.

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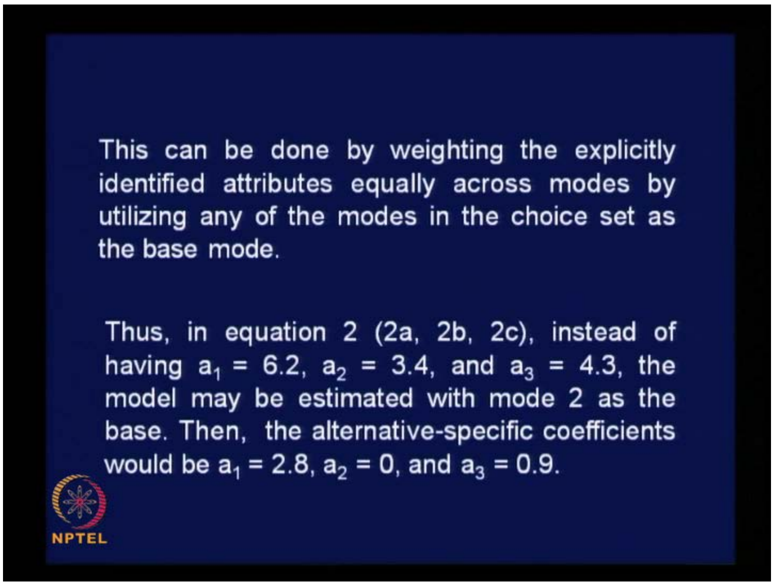

And, this can be done by taking one mode as the base mode, this can be done by weighting the explicitly identified attributes equally across modes by utilizing any of the modes in the choice set as the base mode. You consider one mode as the reference mode and look at the constant term for that mode and express the relative constant terms for other modes in relation to this constant term, so that, your comparison is more effective right. Thus, in equation 2, which we have seen in the last class, for the benefit of recollecting what we did, I will just show you the three equation.

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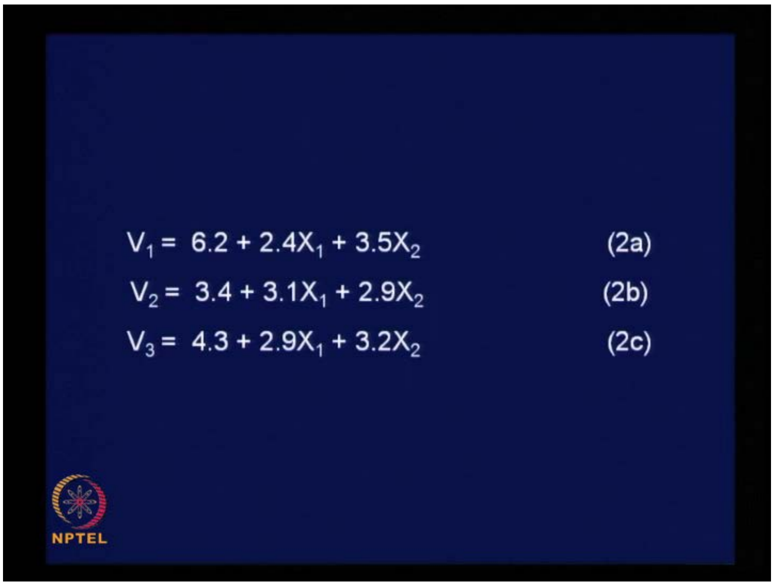

This is what we saw under mode specific case, three utility functions for three alternative modes right, look at the constant terms for V 1 it is 6.2; for V 2 3.4; for V 3 it is 4.3. Now the question is, can we just modify these constant terms, in relation to a base mode, let us say we take, mode two for which utility value is V 2 as base mode and subtract the value of the constant term pertaining to that mode from all the constant terms for example, then for V 2, the constant term will become

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No for V 2, we are subtracting the value, it will be 0 and for other modes for V 1 it will be 6.2 minus 3.4; for V 3 it will be 4.3 minus 3.4 right. So that, there is some relationship between the unexplained part, between the three alternatives, that is what we want, we do not, we are not interesting in the absolute value, but the difference is more important, that gives you a correct picture, to enable the travelers to choose a particular mode based on the bundle of the attributes, attribute values of the modes. So that is, what is indicated here, thus in equation two 2 a, 2 b and 2 c, instead of having a 1 to be equal to 6.2; a 2 being 3.4 and a 3 being 4.3, the model may be estimated with mode 2 as the base. Then, alternative-specific coefficients would be a 1 will be simply 2.8; a 2 0 and a 3 0.9 clear. So, this is how we can get over this particular problem of unexplained part of the utility of the various alternative modes, with the available attributes, that we make use of to develop utility function clear.

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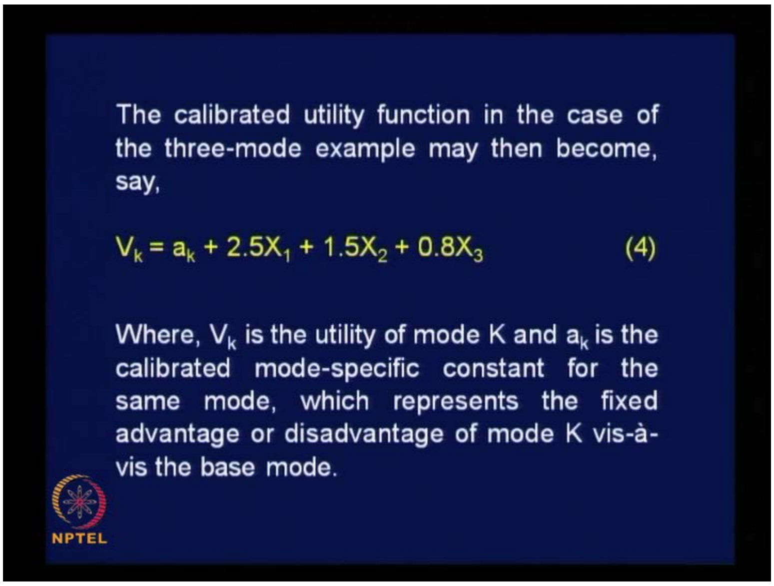

So this problem, can be sorted out to some extent, then you can write the general form of the utility function, like this the calibrated utility function in the case of the three-mode example may then become simply V k, we are not making it is specific to a particular mode, just mode k to be equal to a k, a k can take a value depending upon the mode under consideration, a k plus 2.5 X 1 plus 1.5 X 2 plus 0.8 X 3, these numbers are based on some calibration, let us not worry about these numbers, general formulation is important. We do not give specific numbers for the constant term, it is, it will attain or take a corresponding value based on the mode you consider to develop utility function right.

Where, V k is the utility of mode K and a k is the calibrated mode-specific constant for the same mode, which represents the fixed advantage or disadvantage of mode K vis-à-vis the base mode that is our interest. We consider one mode as a base mode, with respect to that, whether the other mode has got an advantage or disadvantage, can be easily accessed by this approach is that clear.

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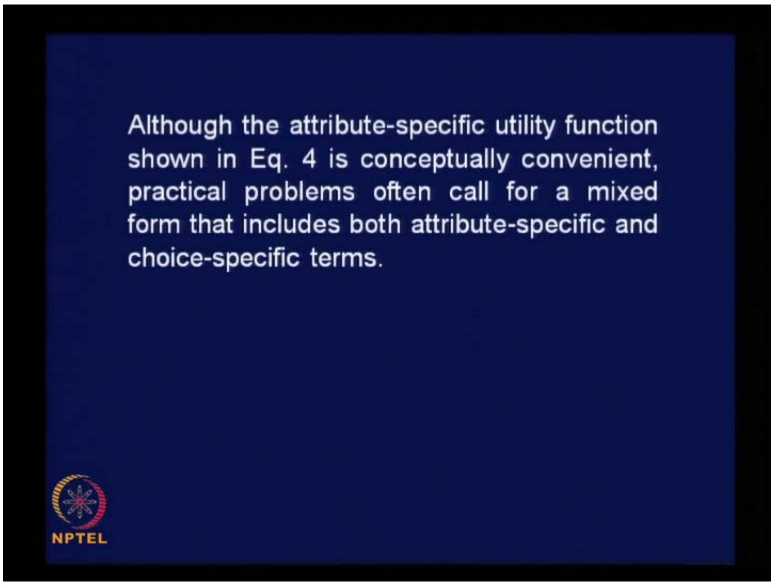

Now, it is not the end of the story, although the attribute-specific utility function shown in the previous equation is conceptually convenient, we have single equation, we managed to solve the problem of the constant term, but still there are some problems, when we use these utility functions, in practice. Practical problems, often call for a mixed form, that includes both attribute specific and choice specific terms. There may be certain situations where, you may have to necessarily bringing, some mode specific attributes. In addition to accounting for a set of common attributes for all the alternatives, in a specific case it may be necessary for us to, introduce another attribute specific to a particular mode.

The example is this, the need to capture the added utility of using transit for travel oriented for travel oriented toward the central business district is one example, why this is given as an example, how there is added utility for the transit, when the travel is towards CBD, CBD is city centre, where most of the activities are concentrated, so people travel to city center, the movement is going to be towards city centre in the morning peak and then away from city centre in the evening peak, that will be the normal travel pattern, but here it has mentioned, that utility of transit is going to be more more compare to the private transport vehicle, when the trip is oriented towards CBD, even though this statement may not be very accurate, for the conditions prevailing in developing countries.

In developed countries, there is a lot of restriction, with regard to parking facility, in central business district area, limited parking facilities and parking fee is very high, to discourage car users, to bring a car to the CBD area to reduce congestion. Then, obviously transit becomes a preferred mode; there is a specific advantage, so this is one situation. In another case, people might be travelling in the peripheral areas, from origin to a destination, there you will find that, both the modes might be equally competing or may be car has got an advantage over transit, possibly because of lesser frequency service in the peripheral areas with transit service right.

So, it is specific to a particular travel pattern, if the trips are considered, connecting the CBD and other activity centers then we need to introduce some other factor, to take care of the advantage, enjoyed by transit, when one trip end is connected to CBD, otherwise if you simple use the utility function commonly derived, taking and account the data, covering the whole of the urban area, it may not work for trips made towards and away from CBD. If one trip end is connected to CBD, then you would would have missed this particular aspect of transit enjoying better partonage compared to car.

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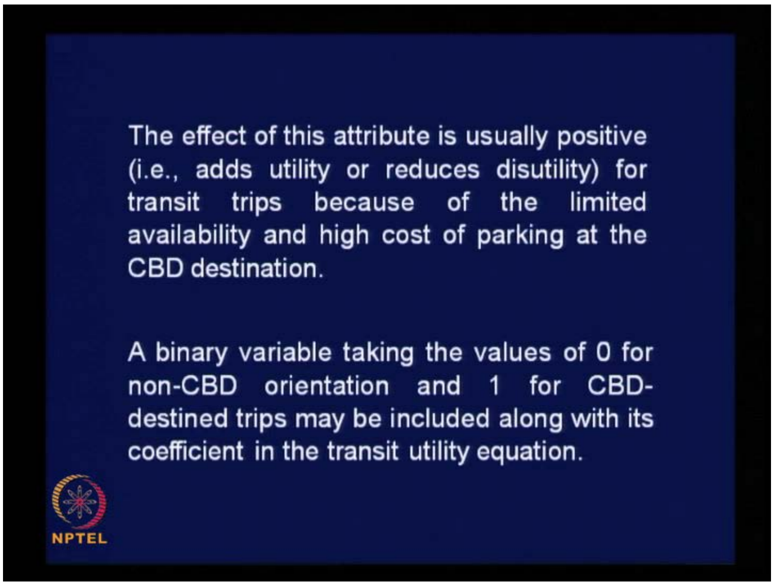

So, how to bring in this situation, in the modeling process, it is possible and we need to, do this by some methodology. The effect of this attribute is usually positive, obviously for the transit adds utility of reduces disutility for transit because of the limited availability and high cost of parking at the CBD destination for private vehicles. This is the solution; a binary variable taking the value of 0 for non-CBD orientation and 1 for CBD-destination trips may be included along with its coefficient in the transit utility equation. You introduce, a binary variable, which is also termed as a dummy variable by some author's right.

To distinguish between transit and other alternative modes, so this variable will take a value one, if the trip is towards CBD and 0, if it is non-CBD oriented trip, so whenever you deal with CBD oriented trip, there will be some weightage added to the utility of this particular mode and 0 weightage, if it is concerned with trips, not connected with CBD. So, this technique of modeling is also called as dummy variables technique, this variable will have just only two values, 0 either 0 or one, but still it will be introduced as a variable and there will be a parameter, co efficient for this variable also, when you develop equation by regression technique.

This is a situation, that arises quite often in modeling process; you take the case of mode choice by younger people and elderly people, aged people above seventy years and below seventy years. The physical constraint of elderly people, excludes some of the alternatives form their choice set is not it, they will not be able to drive on their own right or some public transit modes may not be easily accessible to them, right the flow level of some of the buses are too high for them to climb up. So, their constraints with regard to mode choice is going to be totally different, from the mode choice process by others, but when we do mode choice modeling.

We include all kinds of travelers, including elders right then how do we explain choice of mode by elderly people, you must first distinguish the travelers based on age, whether they are seventy plus or less than seventy right, if they are seventy plus give the binary number value one, less than seventy 0 right use dummy variable technique, in such cases still bringing these variations, in your modeling process right. So, these are all the techniques quite commonly used in any choice process, not only in mode choice, you have to differentiate situations based on the field conditions.

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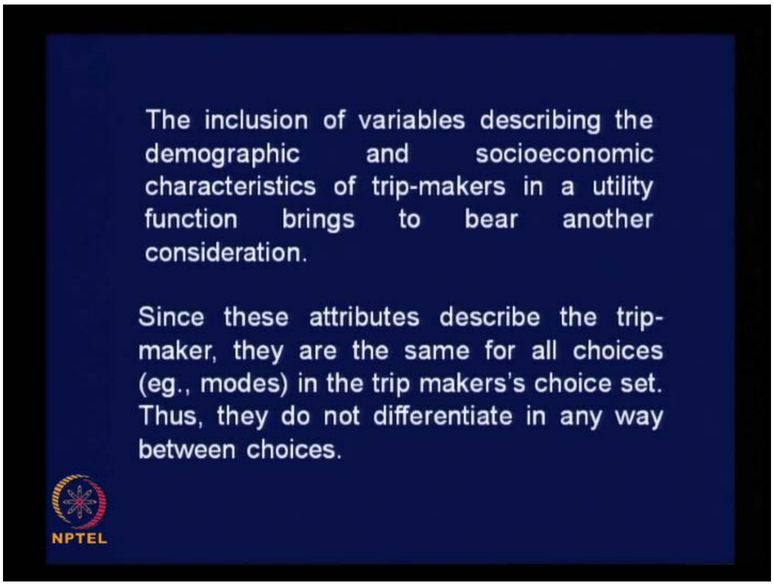

Inclusion of variables describing the demographic and socioeconomic characteristics of trip-makers in utility function brings to bear another consideration. So far, we have been discussing based on the assumption that, there is no distinction between individuals, we have not considered, socioeconomic characteristics of people in our discussion so far, in the mode choice modeling or in the development of utility function. We consider only modal attributes X 1, X 2, X 3 whatever we considered, were modal attributes, so it is appropriate to bring in the socioeconomic characteristics of travelers into your choice process, so that, your model really reflects, the actual choice process.

Now the question is, how do you bring in socioeconomic characteristics of travelers in the mode choice process, anyway, one important characteristic, which needs to be brought in, is the economic status of the traveler. A rich person, a very rich person may never choose transit, they might be using their personal vehicle, a very poor person may always use only transit is not it. It cannot treat all the travelers to be same, for mode choice modeling purpose; somehow we need to bring in the economic status in the development of utility function, any suggestion?

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It should be based on the extent of pinch of purse they feel, while spending money for making trips right. A middle class person may spend a lot of money in his perception, for travel. A rich person may be spending a small proportion of the total income in transportation is not it. It depends on the pinch, the purse realizes for different individuals in making trips, the cost is not same for all individuals, even though absolute value is same, it is not going to be same for individuals. It depends on a economic status, somehow you should be able to relate the actual transportation cost, with the economic status of the travelers, how do we do that, shall we express the cost of travel, as a percentage of the monthly income.

If there is some connectivity between the income of the traveler and the actual cost of transportation, then we will be able to bring in this particular aspect into a modeling process, express the transportation cost as a percentage of income of the travelers. You can broadly classify the travelers into high income, middle income and low income like that and get some ratio, so that the economic status is automatically reflected, when you develop utility function. Since these attributes describe trip-maker, they are the same for all choices or modes the trip makers choice set. Thus, they do not differentiate in any way between choices.

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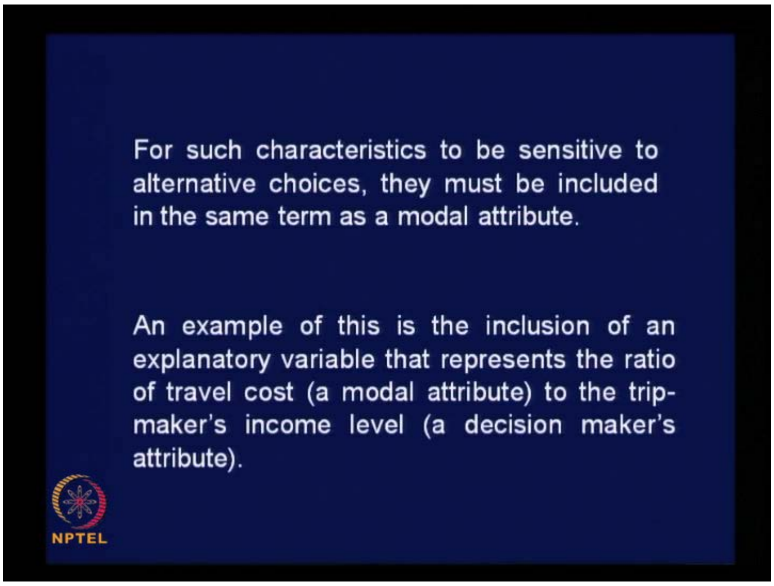

This has to be changed in fact and for such characteristics to be sensitive to alternative choices, they must be included in the same term as modal attribute. An example of this is the inclusion of an explanatory variable, that represents the ratio of travel cost, travel cost is in modal attribute, is not it, ratio of travel cost to the trip-makers income level. It is not absolute value of income income level; you can broadly classify the income level into broader categories and incorporate that into your modeling process, a decision maker's attribute.

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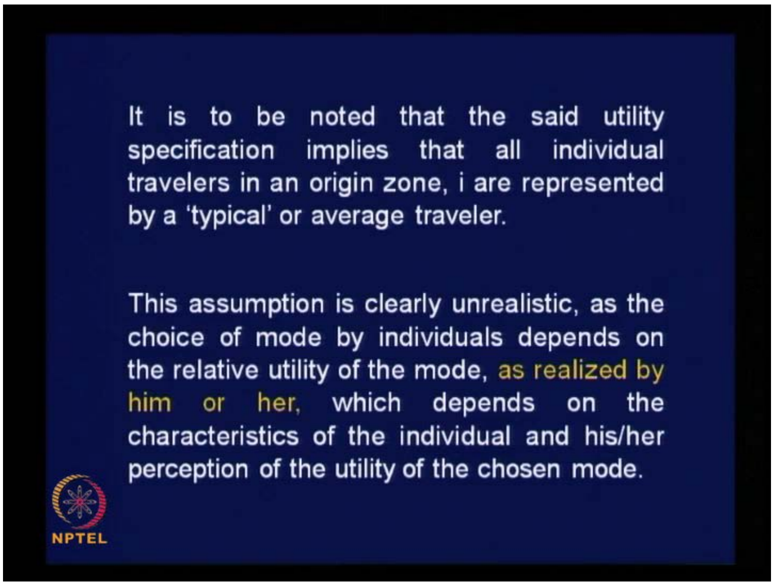

It is to be noted that the said utility specification implies that all individual travelers in an origin zone, i are represented by a typical or average traveler. This another issue to be kept in mind, even though we bring in the economic status of the traveler in modeling, still we assume that, if the traveler belongs to a particular income group, lives in a particular zone, then there is no difference in the mode choice process, by any of the travelers within that zone, within a particular income group, that is assumption we are making so far in developing utility function, will it be so in practice. You take a middle income group, living in a particular area and they assess utility of different modes based on modal attributes, as well as their income level.

They perceive the utility of different modes, so far based on the discussion, we can say that all we imply that all the travelers of a particular income group, living in a particular zone, will have same pattern of mode choice is not it. That is what we have been assuming so far, in developing utility function, but in practice, it need not necessarily be zoom, there will be difference, in the perception of utility by different individuals, even though they might belong to same socioeconomic groups, same age, same income right same vehicle ownership right same social status, still two individuals may not behave the same way, in choice of mode. And we need to somehow bringing this variation also, into our modeling process. Otherwise we are not completely representing mode choice process right.

Let us see how to go about doing this, this assumption is clearly unrealistic, as I said, as the choice of mode by individuals depends on the relative utility of the mode, as realized by him or her as realized by him or her, it is very important, which depends on the characteristics of the individual and his or her perception of the utility of the chosen mode. Perception of utility; one may say bus is fine for me; other one would say bus is not that good, I prefer train; third person might say bus, both bus and train are not good for me, I will just choose motorized two wheeler. All the three people may be may belong to same age group, same income level, same social status, but still perception vary and this has to be brought into a modeling process.

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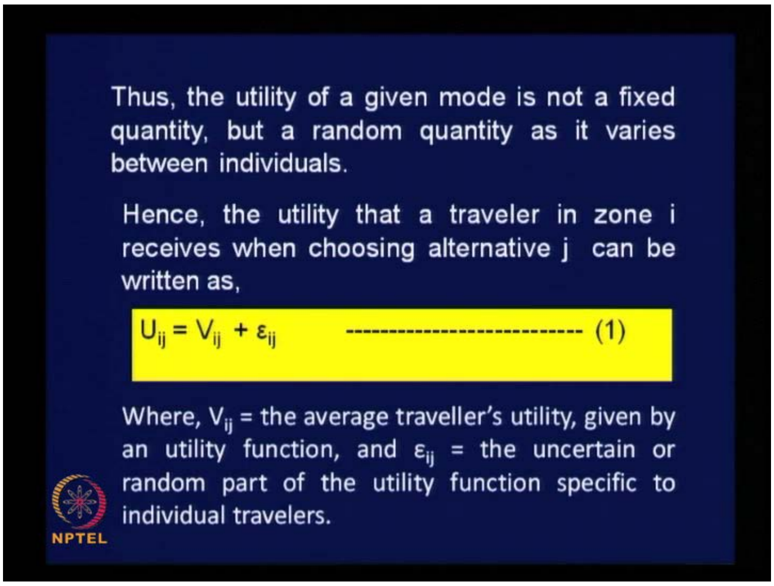

Thus, the moral of the story is this, the utility of a given mode is not a fixed quantity, you cannot just calculate the value of V and say this is the utility of a particular alternative mode, it is not a fixed quantity, but a random quantity as it varies between individuals. We need to treat V to be a random quantity, not a fixed quantity, utility of a mode has to be treated as a random quantity. So bring in the theory of randomness into the mode choice process. Hence, the utility that a traveler in zone i, receives when choosing alternative j can be written as, traveler lives in zone i and he or she is choosing alternative j, alternative mode j.

This situation can be explained like this, U i j utility of mode j for a traveler living in zone i, U i j is equal to V i j plus epsilon i j, V i j is known to us, V i j is nothing but, the utility function about which we talked right, for some time is not it. We know, what we meant by V i j, V i j value is obtained by calibrating, utility function involving the attributes of the alternating modes right and we are trying to introduce, one more term epsilon i j. And, where V i j is the average traveler's utility that is very important, V i j represents just the average traveler's utility, it is not bringing in the variation, given by an utility function and epsilon i j is equal to the uncertain or random part of the utility function specific to individual travelers.

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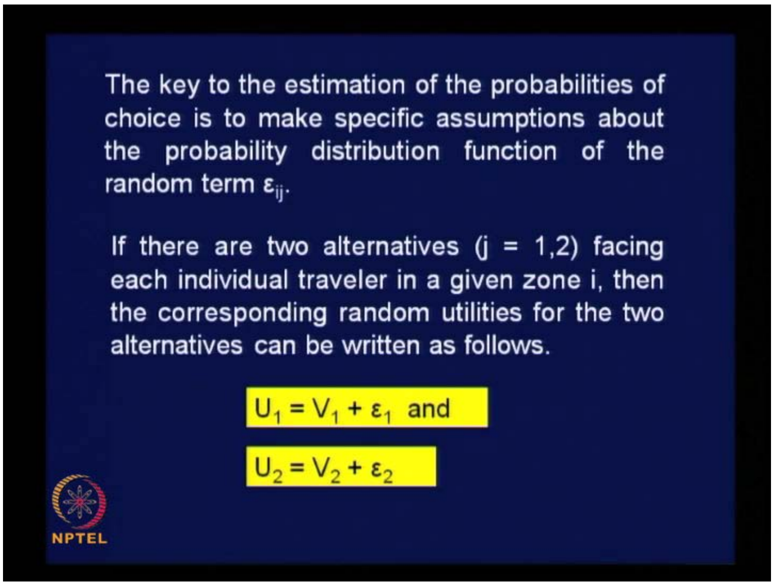

Now the question is how to quantify epsilon i j and get the value of U i j right. The key to the estimation of the probabilities of choice is to make specific assumptions about the probability distribution function of the random term epsilon i j. Our worry is, to see how epsilon i j will vary, will get distributed are is there a way to find out or formulate a probability distribution function for epsilon i j. I think you are familiar with different types of probability distribution functions is not it, think about it, try to recollect those who are unable to connect yourself with the discussion, just go back and refer the books and get connected to our discussion yes, could be either continuous or discrete right.

So, the key to the estimation of the probabilities of choice is to make specific assumption about the probability distribution function of the random term epsilon i j. There are suggestions available, if there are two alternatives, just to simplify the case j to be equal to one comma two facing each individual traveler in a given zone i, then the corresponding random utilities for the two alternatives can be written as follows.

It is very simple based on our earlier understanding, we can write, utility of mode one is nothing but, V 1 plus epsilon 1, we are talking about travelers in a particular zone, so i etcetera is not brought in here because we talk about a specific case. So, you can write U 1 to be V 1 plus epsilon 1 for alternative one. And U 2 could be V 2 plus epsilon 2 right and if U 1 is simply equal to V 1 and U 2 is simply equal to V 2, then difference in utility is between the two modes can be easily calculated, just difference between V 2 and V 1, will give the difference in the utility of the two alternatives, but we have included random term. So, unless the magnitude of epsilon 1 and epsilon 2 are known, we will not be able to really check whether, mode one or mode two is going to be more useful to the travelers in a particular zone.

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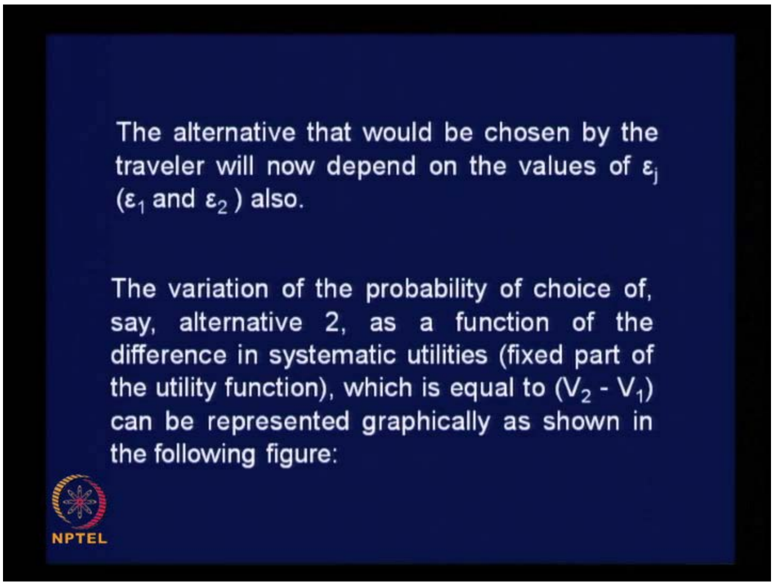

The alternative that would be chosen by the traveler will now depend on the values of epsilon j, in this case epsilon 1 and epsilon 2 also. In addition to V 1 and V 2, the values of epsilon 1 and epsilon 2 will influence the choice of mode, that is how, we need to understand the randomness in the choice process right. The variation of the probability of choice of say, alternative 2, let us say, we are interested to know the probability of choice of alternative 2, as a function of the difference in systematic utilities as a function of the difference in systematic or the constant or the average utility indicated by V, fixed part of utility function, which is equal to V 2 minus V 1, our interest is to find out the probability of choice of mode two, that is why we have put V 2 minus V 1 here, right, can be represented graphically as shown in the following figure, let us try to represent the probability of choice of V 2 for the given situation.

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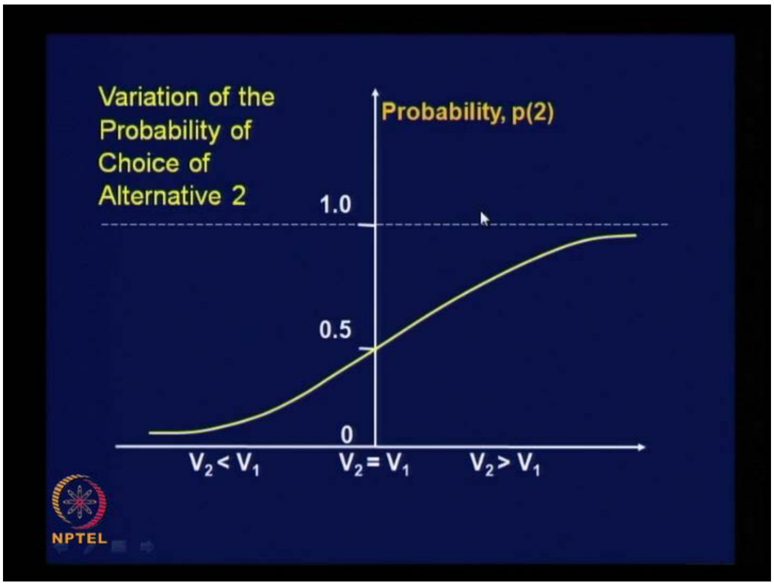

This is how, we can represent the probability of choice of V 2, study this plot very carefully, probability of choice is indicated along this vertical axis and difference in utility of the two modes is shown along the X axis, at this point both the modes have same utility V 2 is equal to V 1, known systematic utility or known constant value of or average utility is same in this particular case, whereas on the right side V 2 is more than V 1, on the left hand side V 2 is less than V 1. If the mode choice is going to be based only on values of V, V 1 and V 2; obviously, when V 2 is equal to V 1, it is likely that the division is fifty percent each, may be half might choose V 2 are mode two and half might choose mode one, that is agreeable, that the point to be noted is, when V 2 is more than V 1, when mode two is more useful than mode one.

As per the logic based on your constant utility, everybody should choose only mode two is not it, but what is happening here, when V 2 is more than V 1, still there is increase in choice of V 2, but not to the expected extent of everybody choosing V 2 right. Even at this level of difference, you see only about seventy to eighty percent of the people choose V 2 in spite of, utility of mode two being very high and still about thirty percent of the people are using mode one, for reasons known to them based on a perception. And similarly, when V 2 is less than V 1; obviously nobody should use, V 2 based on the value of V and everyone should use only V 1, but it is not happening, still some people are using V 2 is not it. Probability of choice of V 2 is still there and this explains the actual choice process.

It is not strictly based on the systematic or the quantifiable part of utility of the alternative modes. It is also dependent on the actual random part, which belongs to are, which can be explained only based on the the nature of perception of the individuals right. And, this implies what, we can say that this is how, the random term epsilon j varies, this is effect of epsilon j is not it, that is what is plotted here, effect of epsilon j is shown here, right this has to be accounted for. Now, the question is, what is the shape of this curve and is it possible to standardize or at least associate this curve with, known standard curves is the question.

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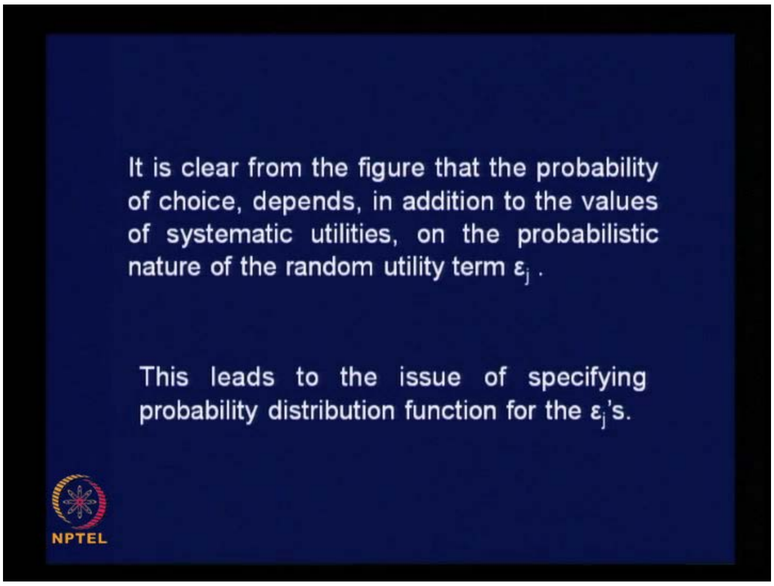

And it was not that easy, a lot of research work has been done. It is clear from the figure that the probability of choice depends, in addition to the values of systematic utilities V 1, V 2 on the probabilistic nature of the random utility term epsilon j, that is what I told you. This leads the issue of specifying probability distribution function for epsilon j, we need to specify a functional form for epsilon j right.

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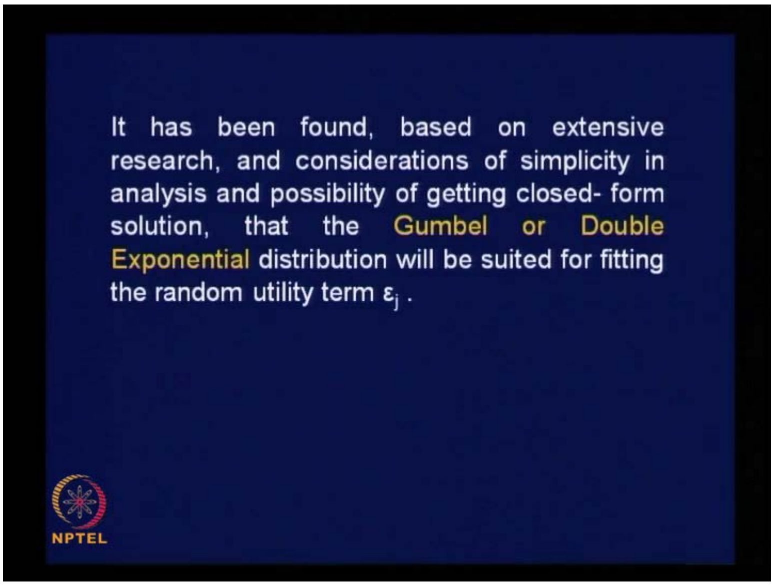

It has been found, based on extensive research, and considerations of simplicity extensive research leads to lot of complex conclusions also. So, while you recommend something for adaptation for implementation practice, you need think of simplicity, in use of a concept or theory, considerations of simplicity in analysis and possibility of getting closed-form solution, that the Gumble or Double Exponential distribution will be suited for fitting the random utility term epsilon j, that was finding. So our subsequent discussions are going to be, on the assumptions that, epsilon j will follow double exponential or gumble distribution right. So, with this let us, recollect what we discussed in this class, we started our discussion on disaggregate mode choice modeling with the understanding of development of utility function, specific to different alternative modes, but we realized later, that mode specific utility functions, will not be helpful.

And, we need to going for attribute specific utility functions, because of the reason, that mode specific functions will not be able account for new modes that might be introduced in the future. So, we realized attribute specific functions are much better than mode specific functions. In the attribute specific function one aspect that we encountered was the constant term, so there was a need to take different constant terms for different alternatives, to account for a variation in the utility of the alternative modes more accurately. And we know now that, this can be archived by taking one of the alternative modes as the base mode and vary the value of the constant terms, even though this solves a problem and the attribute specific utility function could be a better tool for assessing the utility of alternative modes.

There is a need to consider, mode specific aspects on certain situations like trips connected to CBD, where transit will have a specific advantage over personal vehicles, in that context there is a need to introduce binary variable technique or dummy variable technique to take care of, the CBD oriented and non CBD oriented trips. Then, we found that, it is also better to take socioeconomic characteristics of travelers, in the modeling process, to reflect real choice process. We found, that is possible to take into account, the economic status of travelers, by expressing the cost of transportation as a percentage of the money income of the travelers, with this assumption or with this approach we found that, this possible to satisfactorily develop utility function.

To assess the utility of different alternative modes, but still one question which was not answered at that point of time was, the variation in the perception of the travelers regarding choice of modes. This was not really brought into the picture at that point of time, so to bring in the individual variations, in the choice of mode the utility is treated as a random term. And instead of V i j, we call it as U i j to be equal to V i j plus epsilon i j, where epsilon i j is a random part of the utility function, which need to be explained with reference to some random theory. Now finally, we found based on literature, that e epsilon i j is distributed following gumbel or double exponential distribution. So, based on this assumption, we will continue our discussion in the next class to formulate more appropriate mode choice model to explain the choice process.