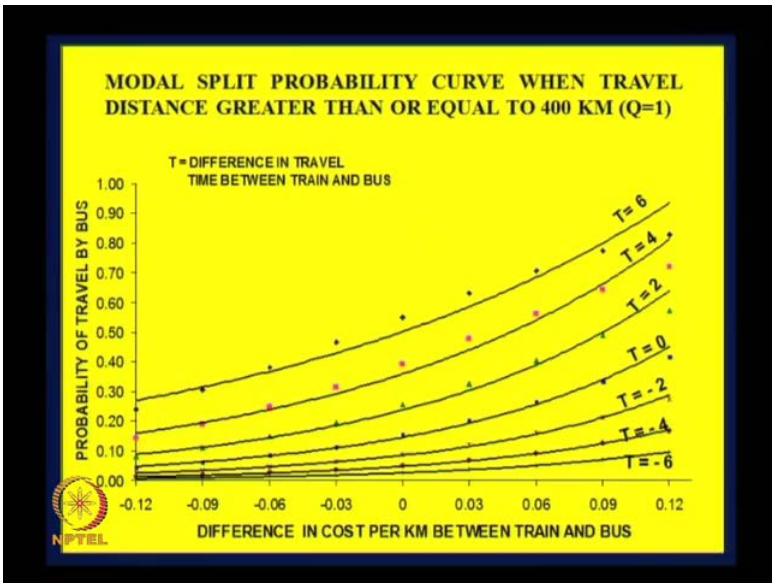
Urban Transportation Planning
Prof. Dr. V. Thamizh Arasan
Department of Civil Engineering
Indian Institute of Technology, Madras

Lecture No. # 18
Modal Split Analysis Contd.

This is a lecture eighteenth on urban transportation planning. In this lecture we will continue our discussion on model split analysis. Before we proceed further with the discussion, let us try to quickly recapitulate what we did in the previous class. We started our discussion in the previous class with mode choice analysis under binary choice condition, and we found that the application of logit model of mode choice can be transformed into a simple linear regression equation, still the regression equation can be used as mode choice model, and it is possible to calibrate regression equation for practical application. Then we just discussed about a case study involving choice between bus and rail a binary choice situation, and discussed in detail about the data requirement for development of mode choice model using regression analysis.

We found that by simple data set involving the actual travel by the two modes, travel time implications with respect to the two modes, and travel cost implication it is possible to analyse the mode choice to a satisfactory extent. In fact, if we can calculate the travel time difference, travel cost difference and some distinction when the distance involved in travel is more than certain limit it is possible to calibrate a mode choice model for binary choice situation. And then we also discussed about the methodology of presenting the result in such a way that the decision makers can appreciate the results of your analysis, and this can be really used as a tool for decision making.

(Refer Slide Time: 02:35)



In that context only, we discussed about model split probability curve; first when the travel distance is greater than 400 kilometres with dummy variable value to be 1. We have made this curve by relating the travel cost difference, and probability of travel by bus and the variation of travel time difference is taken into account by making a set of plots for different travel time differences, and we have taken care of the value of q by assigning only one value for this particular plot, q is equal to 1.

We also discussed about the usefulness of this kind of plot. I gave an example of railways desiring to increase the fair in such a way that the fair difference or the cost difference becomes 0.06 from the earlier value of 0.03. When the time difference is 0 as we saw earlier the share by bus will be around 20 percent, and when the railways increase the cost of travel in such a way that C t minus C b becomes 0.6, then you will find that there is an increase in the share of bus to an extent of 5 percent. So, railways will be losing some traffic to bus service.

Let say railways is interested to introduce a high speed train in such a way that the travel time between the train, and the bus is really the time difference is really significant; let us say the time difference becomes minus four in a particular case T t minus T b becomes minus 4; that means, train is faster than bus train travel time is less; that is why we get a negative number. Compared to initially value where there is no time difference at all, and if you look at the significance of this kind of decision or policy in respect of travel speed

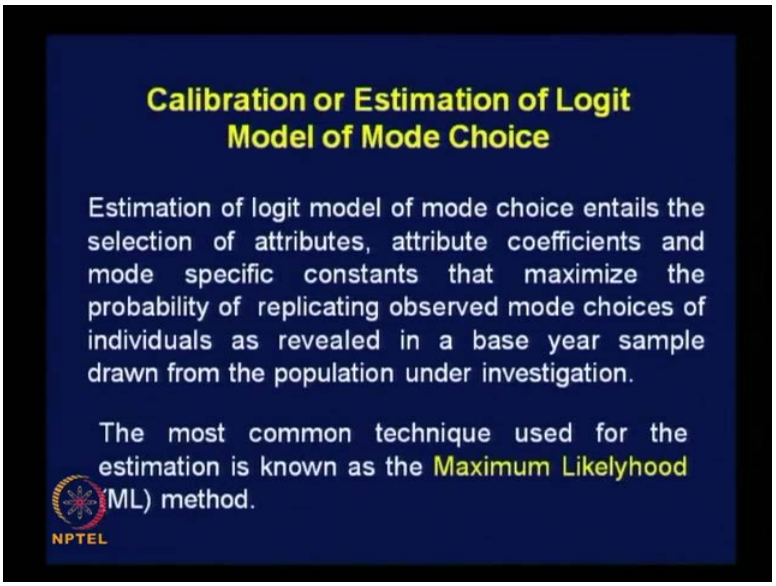
for this particular cost difference for example, when there is no time difference the share by bus is going to be 25 percent, when you make your train faster to have a t value of minus four you will find that there is a significant fall in the share by bus it is going to be about 7 percent.

So, train will be able to attract a significant proportion of bus travellers to train. So, this is how we can really make use of this kind of plots for taking policy decisions, you can visualize the future scenarios by thinking or just applying different policy options that is the usefulness of this kind of plots. So, this implies that the logit model that we study is not just a theoretical exercise it has got every important practical application. So, the only difference is the way you make the model to work, the way you present your results that is very important. On the same lines you can make plots for this situation where q is equal to 0, the curves are going to be slightly different otherwise that is not much of difference as for us the principle of application is concerned.

Earlier we saw when the travel cost difference is 0.03, when the travel time difference is 0 the share by bus in the previous case was around 20 percent whereas here we find it is nearly 30 percent are you able to recollect for the same situation we found in the previous plot it was just 20 percent, now we find here for the same situation the share by bus is more why distance is less. So, the preference of train gets reduced compared to the earlier case. So, bus takes an additional share. So, that is reflected in the presentation that is very important.

Now, with this understanding, let us try to understand in general what we mean by calibration of logit model of mode choice for any situation could be a binary choice or a multiple case with more than two choices involved.

(Refer Slide Time: 08:01)



In general we can explain calibration of logit model is nothing but estimation of logit model of mode choice estimating the coefficients; that is what we do through calibration can be stated as follows estimation of logit model of mode choice entails the selection of attributes; that is the first step you have to select the attributes to formulate your utility functions. Attribute coefficients through the calibration process and mode specific constants if any that maximize the probability of replicating observed mode choices very important replicating observed mode choices of individuals as revealed in a base year sample, because we collect the data for base year condition both related to actual mode choice and other attributes of the other alternative modes the information is collected for base year condition.

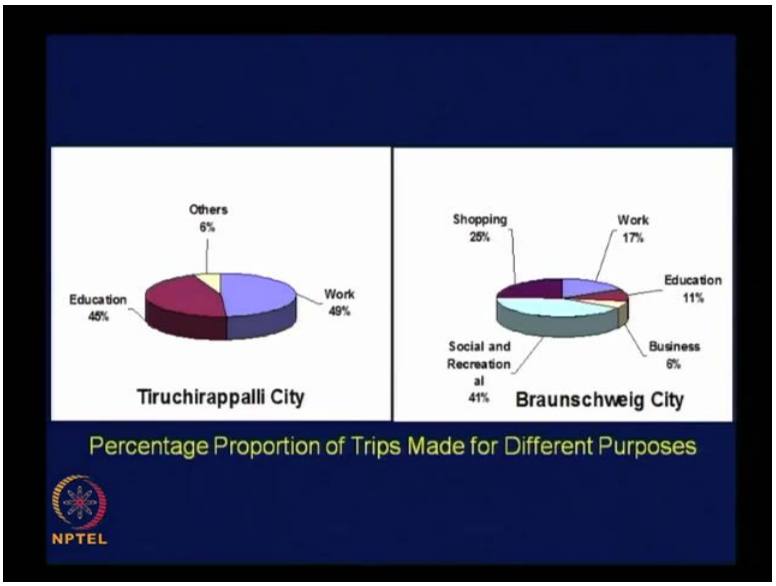
Base year sample drawn from the population under investigation this implies you can develop model through sampling exercise also, only thing is you should see that the sample really represents the population once you are convinced you can use the sample data to develop mode choice models. The most common technique used for the estimation of the parameter values is known as the maximum likelihood method maximum likelihood method, we are not going to discuss about maximum likely hood method as it is beyond the scope of this particular course involves again detailed knowledge on probability and statistics.

Once you gain that level of knowledge you will be able to understand this in any case we will not be covering this part, since it is beyond the scope of this particular course. You should know that there is a method available for calibration of logit model involving any number of alternatives multi nominal logit situation can be dealt with by maximum likelihood method of estimation parameters. Those who are interested may contact me later, I can give you some handouts related to this particular aspect, let us proceed further to see how this maximum likelihood method was applied for a particular case.

(Refer Slide Time: 11:04)

Calibration or estimation of logit model of mode choice in urban travel a case study, the city chosen for this study is Tiruchirappalli city about which I have told you briefly earlier in Tamilnadu state, India. The city is located almost at the geometric centre of Tamilnadu state the population of the study area, the planning area of the city at the time of study was around one million, and to give you some idea about the travel pattern in the city I will just give you two important statistics.

(Refer Slide Time: 11:53)



And we will also try to compare this with situation in developed countries. This pie diagram shows you the details of percentage proportion of trips made for different purposes you can see that for work about 49 percent of the total trips are made only for work education 45 percent of the total, and for all other purposes which includes shopping recreation personal business and so on all together only 6 percent. It is a very interesting extreme case Tiruchirappalli cities economy is agro based lot of agricultural operation around the city the periphery of the city is full of paddy fields agricultural land and two major rivers cross the city, Cauvery and Coleroon.

Latter on I will show you the map of the city when we discussed about other aspects on the transportation system planning in general. So, the economy is agro based. So, lot of agricultural operation is going on that is why most of the trips are related to low income group or middle income group of the travellers. You may wonder what happen to the shopping trips social recreational trips and soon because the number shown here is very small six percent most of the times people do their shopping in cities like Tiruchirappalli in the work place itself there will be shops around.

So, there may not be exclusively separate trips made for shopping purpose; they also cannot afford to make such trips for want of money to make trips as well as for want of time. So, in such a case this could be the scenario let us compare this with the

information pertaining to another city about which you also know the Braunschweig city in Germany.

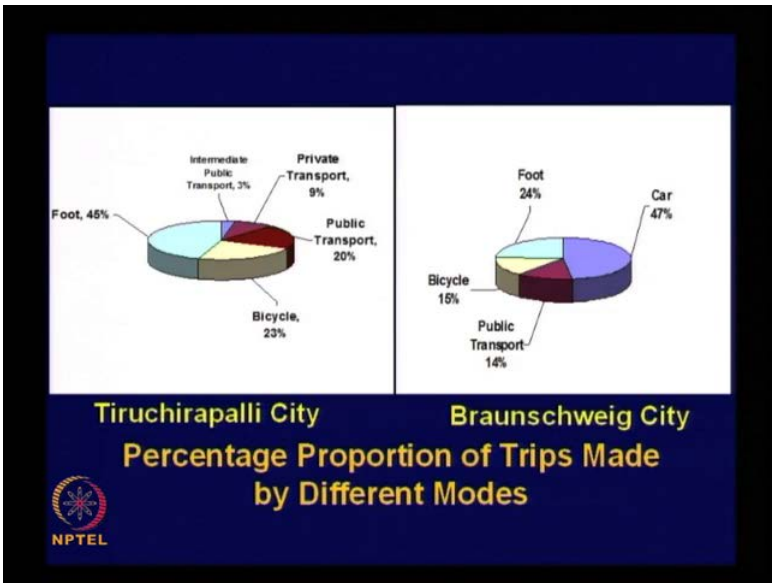
This is the scenario in the city of Braunschweig you can see the percentage of trips made for social and recreational purpose 41 percent, business 6 percent, education 11 percent, work 17 percent, shopping 25 percent. Compare the percentage of educational trips 11 percent in Braunschweig city and 45 percent in the city of Tiruchirappalli, does it mean that Germans are not educated that well compared to the people in Tiruchirappalli city. Look at the percentage of work trips, 17 percent in Braunschweig and 49 percent in Tiruchirappalli again we should not infer that Germans are not working that hard compared to people in Tiruchirappalli city.

Why then the percentages are less in the case of Braunschweig compared to Tiruchirappalli. The total trips made in the Braunschweig city must be much higher. So, the percentile distribution of work is only 17, yeah that is the point the total trips made or the mobility rate is very high that is how we get trips made for social and recreational purpose is to be 41 percent.

So, total number of trips made are large involving purpose other than work and education that is how when you work out the relative percentage the percentages become very small as just 11 percent and 17 percent where as in Tiruchirappalli city almost all the trips are made for only work and education; 94 percent of the total of the trips are made only for work and education; obviously, the percentages are bound to be very high that is the difference the point here is please understand the difference in the travel pattern in the city of developing country, and another city in an developed country also we need to realize that some time latter Tirchirappalli may transform into Braunschweig. Our country is developing it is going to be like this.

So, we need to be prepared to meet the future changed travel pattern while planning for transportation system; that is the point made, here it is not just for comparison and forgetting the important message is there we are developing, and the pattern is going to be just similar to what is existing in developed countries. We need to change our mind set and orient our planning policies to meet this kind of changed travel scenario in the future.

(Refer Slide Time: 17:51)



Let us look at another important information pertaining to Tiruchirappalli city, percentage proportion of trips made by different modes simply, modal split in Tiruchirappalli city, trips made by foot 45 percent; by private transport vehicles including motorized two wheelers cars and soon 9 percent; intermediate public transport auto rickshaw, cycle rickshaw, taxi all together 3 percent; bicycle 23 percent; public transport 20 percent.

For your information, in Tiruchirappalli city at the time of the study bus was the only public transport mode available the share of bus is 20 percent of the total trips. One important point to be noted here is trips made by foot constitutes a major junk of the total 45 percent this is an extreme case, normally trips made by foot in Indian cities would be around 30 percent, 25 to 35 percent, this is an extreme case mainly because of the fact that I mentioned earlier lot of agricultural workers, they just walk for any purpose there is no possibility of making use of other modes mostly they walk.

Another point is when you account for trips made by foot in this particular case trips of all lengths were put together by foot, we make trips for different purposes trip length might be varying from just 15 meters to several kilometres; all this trips are put together to get a higher value or if you consider trips of half a and more as trips and ignore trips of length less than half a kilometre for a study, then probably it may not be 45 percent. It would be much less. So, these are the two possible reasons for this higher percentage of

trips made by foot. Let us compare a similar information pertaining to Braunschweig city trips made by car 47 percent foot 24 percent very significant bicycle 15percent public transport still I would say significant 14 percent. So, an interesting point to note that most European cities have a good public transport system there is a reasonable pattern age for public transport.

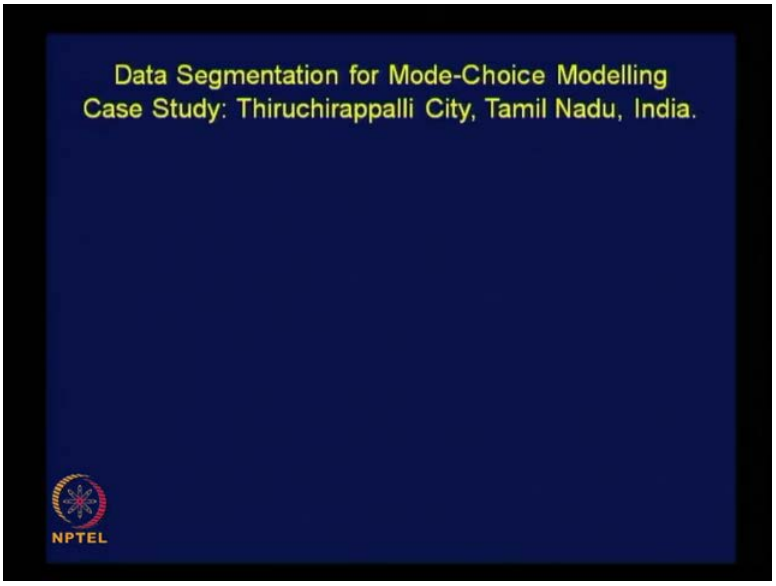
So, about 14 percent of the people in the city are using public transport, but the worry is 47 percent of the trips made by car, cars occupy almost entire road space and a makes lot of poisonous gas. So, that is there problem and look at the contrasting scenario between Tirchirappalli and Braunschweig city do you think that we are also tending towards the modal split scenario shown for Braunschweig. We are tending in my opinion we may not reach the exact figures shown for this city, but definitely trips made by personal vehicles like cars and motors two wheelers are going to increase a very significant extant this is the result of economic growth in any country which is unavoidable, but with a very good public transport system providing high level of service it is possible to contain a growth of trips made by personal ways one standing.

Example, of success of this kind of policy is Singapore has got a very good public transit system metro rail is connecting all the activity centres, when you have a good public transit system, and when there is some restriction of owning personal vehicles. Obviously, people tend to make use of public transport for more number of trips, and if that is going to happen here in our cities then probably we can anticipate some at least lesser rate of growth of travel all trips made by personal vehicles it is expected to happen in the perception of the ministry of urban development.

We have urban transport policy for government of India urban transport policy clearly indicates that in future transport policy should be towards patternizing - public transport patternizing; the use of non-motorized vehicles that is the essence of urban transport policy of government of India and in funding major transportation projects. Decision about giving loan for implementing transportation projects or checked or based on the policy decision of the government of India. If a statement government is asking for about few 100 crores of rupees to construct a flyover the money may not be provided if the government is asking for several crores of rupees for developing a bicycle track network in a town, you will get money immediately.

So, that is the policy of government of India as of now. So, they are trying to enforce to some extent the policy of sustainable transportation system development. So, if we succeed probably we may not come to this level there will be some containment. Let us proceed further to see how to calibrate the logit modal of mode choice when we come across several alternatives for choice for travel this is what we discussed just now, and when we do mode choice analysis it is necessary that the data is segmented. Why should we segment data for mode choice analysis?

(Refer Slide Time: 25:10)



See we collect information about the total number of trips made per day by the residence in the urban area and the modes they have used for making the trips, and other related information like time of start of the trip, like time of ending of the trip. And if there are more than one mode used for the travel are used for the all this such information can be collected, and we cannot put all the information together and develop one mode choice modal. It may not work reason is as follows.

Number one all the travellers may not have same number of alternatives available for travel, some may have only 2 alternatives, some may have 3 alternatives, some may have even four alternatives. So, when alternatives available for travel are different you cannot just group all the travellers with different alternatives being available for making the trips.

The modal will not work. So, there is a need to segregate the data based on the alternatives or the choice set available for the travel. That the important basis you must see that the data set that use for a particular modal as contains travellers, that only one set of travellers either three alternatives or two alternatives or whatever maybe the number of alternatives that is one condition, then as much as possible we must see that the data set pertain to a particular socio economic group of travellers, even when the choice it is same when the economic status changes the mode choice pattern changes.

Households owning say motor cycle car bicycle put as one category this category of household may have different levels of income within that group. So, it is likely that based on the economic status some households use more of cars some use lesser cars and more of two wheelers and so on. So, there is a need to segregate the data set based on economic characteristics of the travellers. Any other problem with regard to homogeneous the data set or in other words what I mean here is your data set should be homogeneous it should not be heterogeneous involving all categories of travellers.

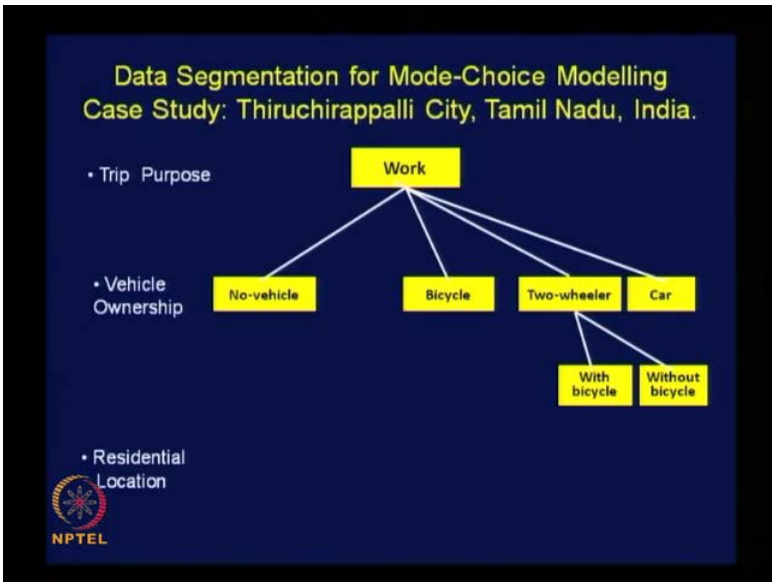
You may recall when we initially discussed about mode choice analysis, we identified three important baskets where from you can identify or pick the factors influencing mode choice one basket pertaining to the socio economic characteristics of the travellers another basket pertaining to the transport system characteristics third basket pertaining to the trip characteristics.

The two important trip characteristics that we identified were trip purpose and trip length; these were the two important characteristics of trips which may influence mode choice, I think all of you will agree with me that trip purpose will influence mode choice to a significant extent. Think of a person in a household going for work, and the mode choice process and think of few members a family going for a social purpose attending marriage or some other social event a mode choice is likely to be totally different from the choice of mode for work.

So, unless we bring in trip purpose into data segmentation process or mode choice modelling may not be accurate may not be able to replicate the reality. So, the moral of the story is that we need to have homogenous data set for mode choice modelling homogeneity can be achieved by segregating data based on trip purpose, based on socioeconomic, characteristics of travellers and based on the choice set number of

choices are available for travel. So, these were the approaches adopted for modelling mode choice in this particular case.

(Refer Slide Time: 30:36)



So, the a trip square segregated based on trip purpose, we first want to model mode choice of trips made for work alone, modelling work trips or modelling mode choice of work trips. And just showing you vehicle ownership as another factor this was introduced here as a proxy for economic status of the traveller, which is appropriate for our condition as I said earlier this is inappropriate for conditions prevailing developed countries.

When a household is owing only bicycle vehicle ownership reflects the overall economic status in owning only motorcycle reflects the economic status of the household owning car definitely reflects economic status. So, as of now it is possible to use vehicle ownership as a proxy for economic status of travellers and our conditions maybe after some time it may have to change. So, divide the travellers into four categories as shown here no vehicle owning category of travellers, bicycle owing group of travellers, vehicle ownership plus two wheeler owning group of travellers, and car owing group of travellers.

Now we have come to two levels of segmentation one based on trip purpose that is complete. Then we have divided based on economic characteristics of the travellers, we must look into the other aspect of the choice set being same for the different categories

of travellers. Two wheeler owning households may also own a bicycle or may not own a bicycle. So, when they own a bicycle then number of alternatives will be different, when they do not alternatives are going to be one less than the other case. So, that should be taken into account.

Another aspect namely residential location this was very special for this particular city. There could be situation in an urban area where the model characteristics change over space in respect of a particular mode in urban areas. We have city centre then the municipal areas, surrounding the city centres and then the peripheral areas; if you look at carefully the characteristics operating characteristics of public transit service bus service, in the city chore area you will find the bus frequency to be very good, and the bus stop spacing very reasonable, because is getting in and out a frequent in travels you will find that bus stop spacing is relatively closer in the C B D and surrounding areas.

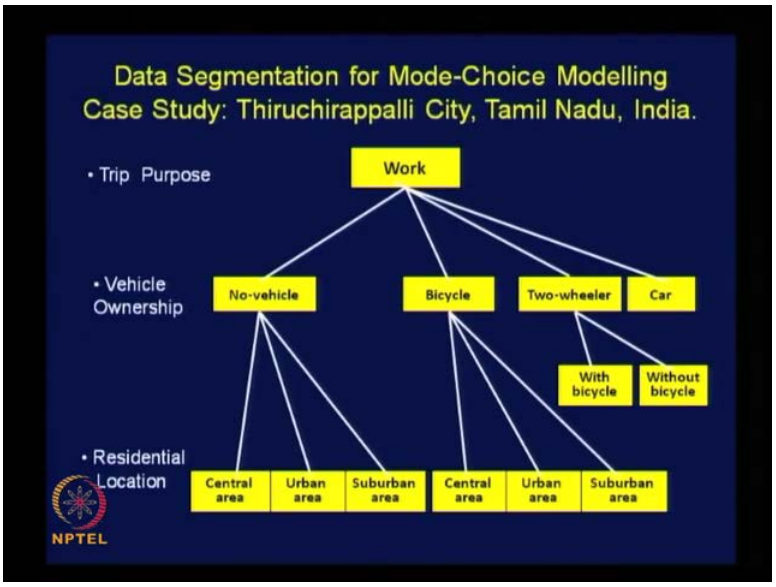
And farther apart when you go for the peripheral areas, and the frequency of bus service will be much better in the central portion compare to the frequency service in the far length in peripheral areas. And please remember people choose modes for travel based on the model characteristics or the characteristics of different alternative modes available. Obviously, you can easily guess in the central portion bus will be more attractive, because frequency is better and the working access distance of access time is going to be less, because you have good number of bus stops available at frequent intervals, where as in peripheral areas the attractiveness of a bus is likely to be less the transport system characteristics changes over space.

In certain urban areas if you feel that these change is not significant then it is fine there is no need to vary about this particular aspect, when there is a change you must do something about it otherwise you will treat bus to be have same characteristics same attractiveness over the whole of the urban area, and develop a model which may not replicate the reality. You can easily guess people living in peripheral areas will use more of bicycles more of motorcycles and lesser bus compare to people living in central part. So, this aspect as to be brought into your modelling process otherwise the model will not work. That is why we discussed about the standards, the objectives, at the beginning.

You may recall we fixed one of the standards as minimum frequency of bud service on any route to be at least three per hour and so on these standards may or may not be

possible to be implemented; if it is not implemented then this problem arises. Now how to take care of this variation of system characteristics or model characteristics over space, these variations are felt while those who are living in different areas those who are living in central area treat bus as a relatively better mode, those who are living in peripheral areas they treat bus as relatively inferior mode.

(Refer Slide Time: 37:15)



So, we have to categorize travellers based on their location of residence. So, that is what has been done here for no vehicle owning category of travellers, the data set was again sub divided based on residential location as central area, urban area and sub urban area central area is just C B D and surrounding areas urban area, is area beyond central area, but within municipal limit that is urban area, and the area beyond municipal limit is taken here. In this particular case as sub urban area, and similarly for the other category bicycle owning travellers. The same categorization was applied bicycle owning group, but living in central area, urban area, and sub urban area and this categorization was not extended to the other two categories of or other three categories of travellers.

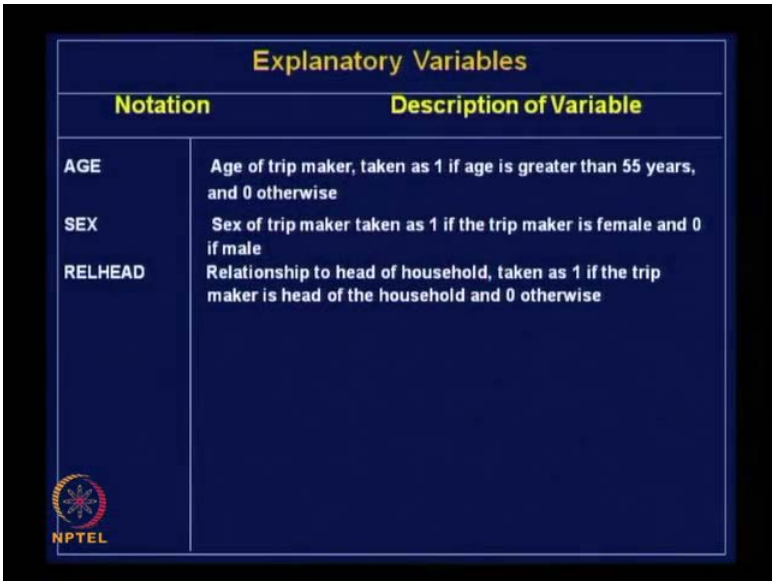
It was felt it is sufficient to categorize travellers based on residential location only for these two groups no vehicle owning group, and bicycle owning group please remember this categorization mainly, because of the reason that the characteristics of bus mode changes significantly over space. Who are the major users of bus service captive riders, no vehicle owning category, and then or in general you can say economical weaker and

lower middle class people will use bus service extensively, and we can identify these two groups based on vehicle ownership as no vehicle owning category and bicycle owning category.

Once I own motorized two wheeler some of them might use bus service the proportion is going to be much less, and the advantage that you will divide I mean derive based on this subdivision may not be significant if you apply these categorization to other categories of travellers we. In fact, tried applying these sub divisions for other categories, and found that the advantage was not significant; that is why it was stopped with these two categories for this particular case.

So, this picture shows you very clearly the approach for data segmentation for mode choice analysis there are three basis for segmenting data, there could be additional basis as we have come across here this is the forth. One based on residential location when there is a change, significant change in a modal characteristic, and this is how it was done. Let us see how the variables were identified for modelling mode choice for work trips we are confining our discussion to only work trips. So, let us put the information a tabular form notation used and description of.

(Refer Slide Time: 40:41)



The variable the first variable was age of trip maker was taken as 1 if age is greater than 55 years and 0. Otherwise, this was necessary to distinguish between people service, and retired employees of different organizations retirement age at the time was 55 years;

obviously, when we are concerned about work trips this categorization is very importation whether the person is retired person or still in service has to be known that is how age was brought in as the very important variable.

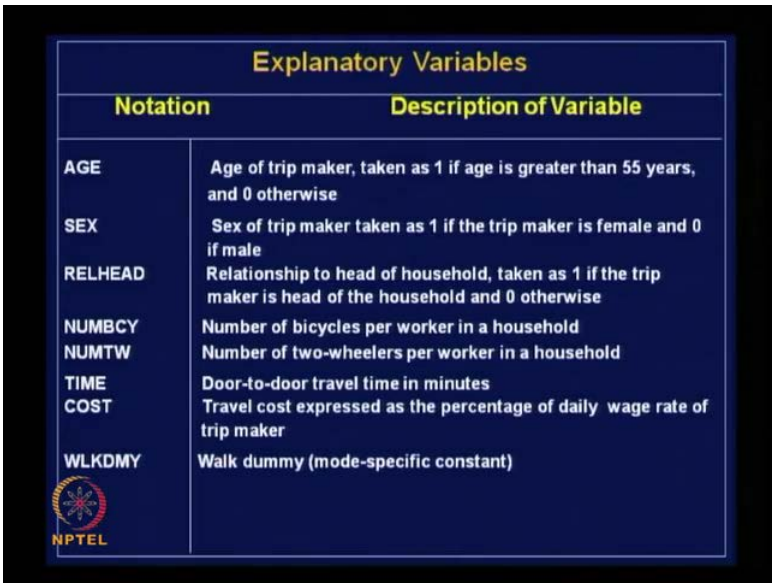
Sex particularly in developing countries sex is also a factor influencing mode choice think of the ladies, and gents using the bicycles in small towns and villages; obviously, proportion of girls and ladies using bicycle is much less compare to gentle men and boys right. So, as long as there is a significant factor we have to use such factors even though significant in developed countries.

And sex of trip maker taken as one if the trip maker is female and zero if male this is relationship to the head of the household abbreviated as RELHEAD relationship of that particular travel to the head of the household normally households will have one head if some house will have more than one head; that is a different story normally households will have only one head, and the head of the household on the Indian condition controls the mobility pattern of a household to a very significant extent.

Because head of the household is taking care of most of the activities like shopping and other activities are mainly taken care of by the head of the household; that means, there is a preference given to the head of the household when a household is owning a particular type of vehicle let us say a household is owning motorcycle, we will find that more frequently only head of the household is using motorcycle other members may very rarely make use of the motorized two wheeler.

So, how to bring in this into a modelling, which is real reflection of Indian condition, so you must first identify whether the traveller, that you considered is the head of the household or the other members of the family. So, that is how this variable has been brought into the picture relationship to head of household taken as one if the trip maker is head of the household and zero otherwise. There is a preference in provision of vehicle to the head of the household this as to be brought into the modelling.

(Refer Slide Time: 44:15)



Number of bicycles it is not simply vehicle ownership, please note here we have defined ownership differently it is defined as number of bicycles per worker in a household. Because we are concerned about modelling mode choice for work trips instead of taking like this if you take bicycle ownership as obsolete number. So, one bicycle per household, two bicycle per household.

Then a small household might own two bicycles and a large household might own only one bicycle then this obsolete number does not reflect the availability of the bicycle to the members of the family, if you hear the availability for work trip is reflected directly because you are modifying the vehicle ownership as number of bicycles per worker in a household if there are more bicycle less workers availability less more bicycle more worker you can easily have a feel of the vehicle availability for making work trips that is the idea.

Similarly, motorcycle ownership number of two wheelers motorized two wheelers. In fact per worker in a household again vehicle ownership per worker in a household, then travel time of course, it is a major factor time implication with regard to a mode influences mode choice.

Travel time is nothing but door to door travel time in minutes, if you are using public transport the working time to bus stop should be accounted for it is only door to door travel time in minutes cost travel cost expressed as the percentage of daily wage rate of

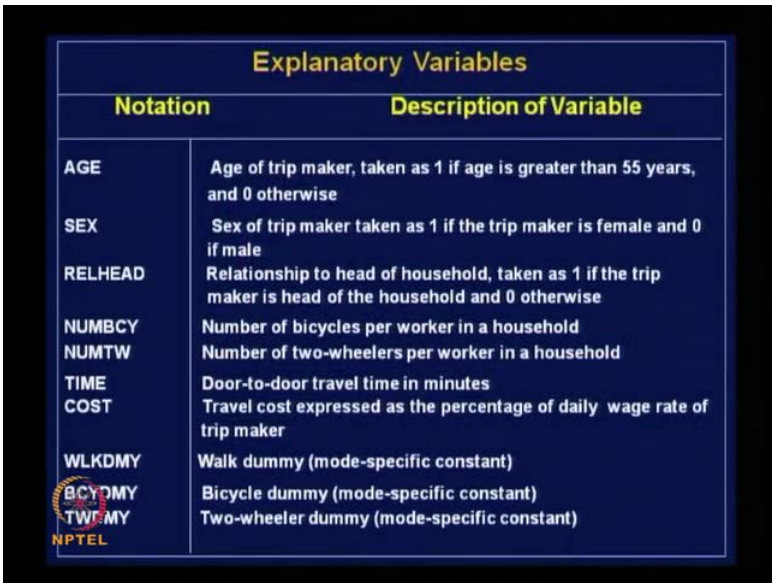
trip maker I think now you know why we are expressing travel cost as percentage of the trip makers wage rate or monthly income. What is the purpose? You cannot introduce travel cost in obsolete terms, because it will not reflect the mode choice effect unless the exact impact of the expenditure on the travel is reflected by some form you will not be able to make use of the travel cost as influencing mode choice. So, that is why it is expressed as a percentage of a wage rate or a monthly income of the traveller for a person who is earning a lot of money travel expenditure will be negligible small amount.

So, he may not he or she may not mind taking an expensive mode for a person earning less money the expenditure is more; obviously, such people will choose a cheaper mode. So, that as to be brought into our modelling process. Then walk dummy variable this is a mode specific constant. Why walk dummy variable see there could be a situation where there are two alternative modes available for travel walk and public transit for no vehicle owning category these are the two vehicles or modes available for travel walk and public transit if you take a household there may be people who will not be able to even make a trip by foot.

Because, your modal is going to be developed based on individuals traveller category I mean characteristics you consider each and every individual as separate entity. So, when an individual's characteristic is totally different in respect of available modes within a particular category how to bring in that situation into your modal.

When there are five people in a household there may be one elderly person you cannot even walk short distances still he or she might make trip using transit, and in that case we must bring in that situation by bringing in this kind of variable. You can say when a person is enable to make use of walk or foot as a mode of transport give the value for the variable or introduce that as a dummy variable give the value 0. Then all others are make use of this as an alternative mode give if the value as one. So, that this situation is also brought into the picture, and to a modelling process that is my introduce this kind of dummy variable for different modes.

(Refer Slide Time: 49:50)



Bicycle dummy similarly for some bicycle may not be an alternative a family may own a bicycle all other members expect one have three alternatives for travel, and one the members will have two alternatives for travel, because bicycling may not be possible for particular member that you get that data into a modelling process, because that person is travelling choosing modes there are ready to bringing in that information of the modelling process.

So, use zero for this variable bicycle dummy when a variable person is not able to use a bicycle even though it is available as an alternative mode. Similarly motorized two wheeler dummy if a household may own a motorcycle one person will never be using motorcycle, then why treating motorcycle as an alternative for that individual give zero for the variable motorcycle for that person and one for others.

So, this is how we need to identify the variables and assign values interestingly, you can find that lot of binary variables are been introduced to bring in various socioeconomic factors, age is treated as binary variable, sex again a binary variable, relationship the head of the household again binary variable, only number of bicycle number of motorized two wheeler, and travel time and cost are the variables for which we will actually collect information and then walk dummy, bicycle dummy, two wheeler dummy binary variables.

So we have. So, many binary variables in our modelling process this is the reality, we will have a lot of binary variable to distinguish between individuals, because we do modelling at a very high disaggregate level treating, each and every individual as separate entity that leads to this process of identification of variables.

To summarize what we did in this class even though brief we try to generally understand what is meant by calibration of logit modal of mode choice in general, and then we considered a case study to understand the application of logit modal of mode choice namely Tiruchirappalli city. And we compare two important travel pattern information of Tirchirappalli city with Braunschweig in respect of trips made for different purposes, and then the mode choice scenario in Tirchirappalli and Braunschweig city and realize that the scenarios are distinctly different from one another simultaneously understood that Tiruchirappalli is slowly tending towards Braunschweig, and we should be prepared to accommodate the likely changes on the future.

Then we actually considered data segmentation process for mode choice analysis starting from segmenting data based on trip purpose, and then segmenting data based on socioeconomic characteristics of travellers. And segmenting data based on alternatives available this was automatically done, when we categorized travellers base on vehicle ownership that is how the alternatives were ready fixed once we categorized travellers based on vehicle ownership based on number of alternatives becomes same.

And then we also discussed about a special situation where characteristics of a particular mode is changing over space, and learnt how to accommodate this variation in the modelling process. And finally, we discussed about identification of the set of variables for mode choice modelling with this we will conclude our discussion for today we will continue our discussion in the next class.