**Urban Transportation Planning**
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**Module No. # 04**
**Lecture No. # 19**
**Modal Split Analysis Contd**

This is lecture 19 on Urban Transportation Planning. Today, we will continue our discussion on Modal Split Analysis and probably complete your discussion on this topic. Before we proceed further, let us quickly recapitulate what we did in the previous class, you may recall we mainly discussed about calibration of multinomial logic model by maximum likelihood method taking the data pertaining to the city of Tiruchirappalli as the database for understanding the calibration process. First we discussed about the reason as well as the process of data segmentation, for mode choice modeling.

We now understand very clearly, the reason for segmenting data for mode choice modeling and the procedure of segmenting the data. Then, we discussed in detail about the calibration procedure and the identification of variables that will be used for mode choice modeling. In that context, we made a comparison of mode choice in Tiruchirappalli city and in the city of Braunschweig in Germany, we found that the pictures were totally contrasting.

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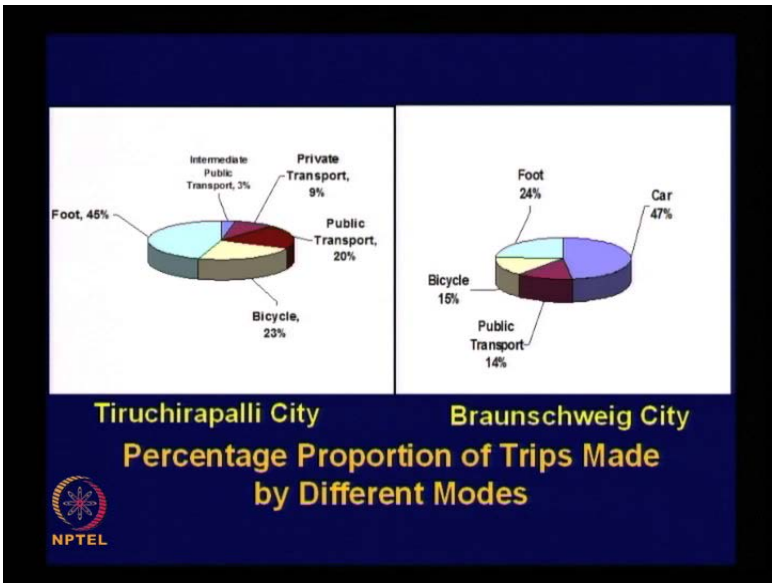

For example, we found in Tiruchirappalli city, private transport mode usage is just 9 percent and the corresponding figure in the case of Braunschweig city is 47 percent usage of car. So, this contrasting picture has to be kept in mind and I underlined the important point that, the developing countries are also tending towards the situation existing in developed countries, this fast changing scenario has to be kept in mind while we plan for transportation system.

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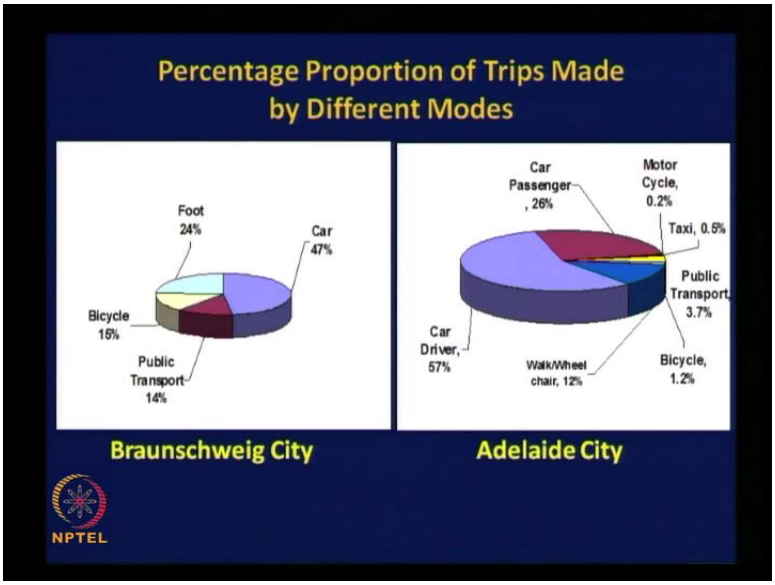


This is not with respect to only a city in Germany, it is a global phenomena, if you look at a similar statistic pertaining to the city of Adelaide in Australia, you can see that, car usage as driver constitute 57 percent and car usage as car passenger is 26 percent both together is about 83 percent of the trips are made using car, just compare this with the figures pertaining to Braunschweig city.

So, its worst than Braunschweig, situation is same almost in other parts of the world like USA, Canada and so on, how they are able to make so many trips using cars are they very rich, what is the income range in our country, monthly income range, shall we say that the minimum, average, monthly wage leaving out the extremes is about 2000 rupees and maximum 60000 rupees leaving out the extreme values small percentages. Now, under our condition, we find that the monthly maximum is about 30 times the monthly minimum, as far as income is concerned.

And if you look at this range, in most developed countries of Europe as well as USA and Canada, the average figure works out to as follows; the minimum and maximum are not very widely separated, the maximum is about ten times the minimum even considering a worst scenario, maximum is just 10 times the minimum this implies that there are lower middle class people living in developing countries also, in spite of that so much of car usage, how it is possible?

There are specific reasons, if you compare the price of a medium sized car in India, the prize can be equated to about 3 years salary of a middle level worker, let us say supervisor, earning a salary of about 10 to 12000 rupees per month. Assuming that the price of a medium size car today is about 3 lakh rupees it works out to approximately 3 years salary, the equivalent amount is about 36 years salary of a middle level worker in our country.

If you do the same comparison for a developed country, the price of a medium size car works out to be equivalent to approximately just 3 months salary of a middle level worker right. So, that is how the purchasing power of people living in developed countries it is much higher, compared to the purchasing power of the people in developing countries. So, you can imagine just even lower middle class people can afford to own a car, it is very cheap compared to the their monthly income; and if you do the same calculation in respect of the prize of the fuel, in our country today, in India today, the prize of one liter of petrol is equivalent to prize of how many cups of coffee taking that today's prizes roughly 70 rupees per liter, even though it might be slightly more the assuming that, the price of 1 cup of coffee in a medium or middle class hotel is about rupees 7, you can say that prize of one liter of petrol is equivalent to price of 10 cups of coffee.

Whereas in most developed countries, prize of one liter of petrol is equivalent to prize of half a cup of coffee right, the prize that you pay for 1 cup of coffee can fetch you 2 liters of petrol, if you pay the same money for getting your fuel. You can just imagine the affordability in filling fuel for the cars in developed countries, how do you compare the cost, relative cost of fuel in developed countries and developing countries, we have a clear comparison, I said in our country prize of 1 liter petrol is equal to price of 10 cups of coffee, whereas there price of 1 liter of petrol is equivalent to prize of half a cup of

coffee; that means petrol hear is 20 times expensive higher compared to what is prevailing in developed countries.

That is why, people are able to make use of car very easily right, this has to be understand very clearly and you may wonder whether such a situation is going to prevail in future in our country may not, but in spite of the adverse conditions for people to buy cars, buy personal motorized vehicles and purchase fuel paying higher prize, the vehicle ownership is increasing at an exponential rate, in terms of absolute numbers.

The reason is even if 5 percent of Indians are rich, the total number works out to a very high value, so that is how, we must understand the increase in personal vehicle ownership in our country, the numbers are too many; so this is the reason why private vehicle or personal vehicle ownership and usage is very high in develop countries.

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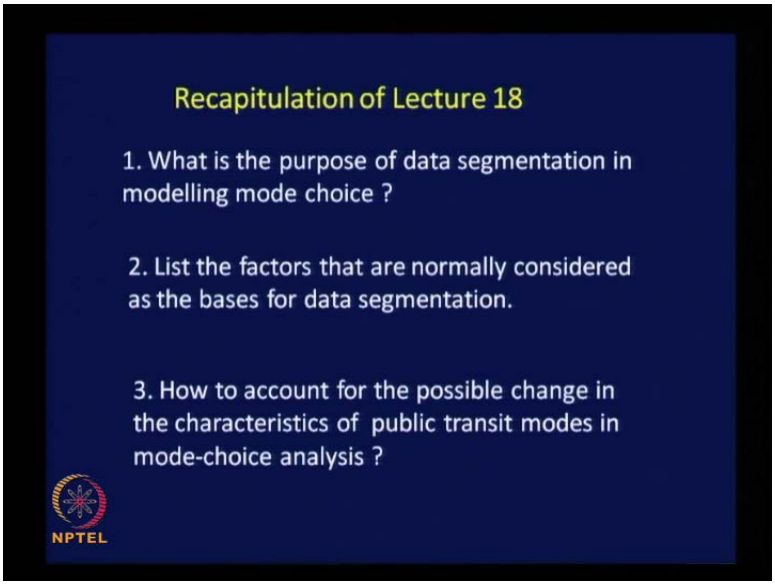


Then, with this understanding, let us try to check whether we have really captured the essence of the previous lecture by asking ourselves a set of questions. Recapitulation of lecture 18, the first question is this, what is the purpose of data segmentation in modeling mode choice? The purpose of data segmentation, purpose of data segmentation why should we segment data, why not just collect the whole of the mode choice information and put the data into a mode choice model, I hope all of you are clear what we really meant by data segmentation right, dividing the data set based on certain factors, that is what we mean by data segmentation.

Why should we do that, because the data set has to be homogenous for your model to be accurate to the extent of replicating the reality, unless your data set is homogenous you will not be able to develop a good model. So, just to reduce the heterogeneity of data base and enhance the homogeneity of your data set, we are doing data segmentation right.

The next question, list the factors that are normally considered as the basis for data segmentation, what are the factors that are used to segment your data, please recollect data segmentation flow chart that we saw in the previous class in respect of Tiruchirappalli city. The first factor is related to trip characteristics, it could be based on trip purpose or trip length, and most of the times we segment data based on trip purpose, because that influenced mode choice to a significant extent that is one factor. Then based on, you please recollect the 3 baskets that we discussed quite frequently and all these factors must emanate from these baskets, we have already exhausted one basket, we discussed about segregation based on trip purpose, other baskets consists of socioeconomic characteristics, so obviously we need to segregate or segment data based on socioeconomic characteristics of travelers.

And

(())

yes

Any other basis on which you can, I said that that number of available choices for a set of travelers should be same, you cannot combine travelers with different alternatives being available for them to make their trips; if you just have 1000 observations in a sample, all the 1000 individuals must have the same number of alternatives for travel. If some of them say have 500 have only 2 alternatives, another 500, 3 alternatives if you put them together and develop a model, your model will not be replicating the reality.

The available choice set for the travelers should be same, so you have to segregate data based on the choice set available for the travelers clear. So, these are the 3 important factors which are used as guidelines to segment data, for mode choice model is not it, then how to account for the possible change in the characteristics of public transit modes in mode-choice analysis? We, discussed about this points in the previous class, change in

the characteristics in terms of frequency of service for example, change in system characteristics might happen over space particular in respect of public transit service.

How do we account for this change in mode choice model, again we do yes please

Those people who are living in the outer areas they will prefer public transport and sorry they will prefer there won personal transport and those who are living within the city they will prefer the public transport system.

Right then how do we segment the data there

We will divide it into choice and captive users

Ya

Based on the vehicle ownership of

Not exactly, we have to segment the data based on residential location of the travelers, when they are living in an area where the frequency of public transport service this is very less, the relative attractiveness of the public transit is going to be less; if they are living in an area where very high frequency of public transport service it is going to be attractive, alternative. So, we have to segment the data based on the residential location of the travelers that is how we tackle this particular situation where there is variation of the characteristics of public transit mode over space right, a two emphasize the point of segregating or segmenting data based on trip characteristics.

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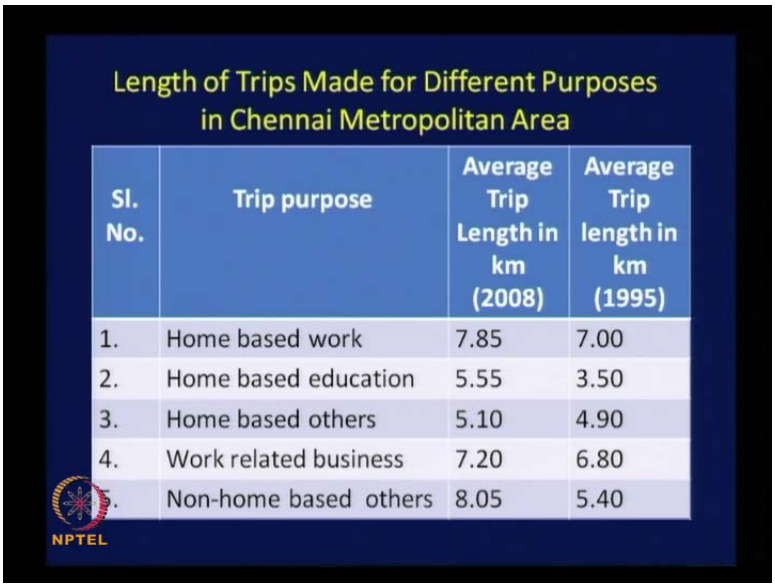


Let us look at this information pertaining to Chennai city, this table provides you information on length of trips made for different purposes in Chennai metropolitan area in 2008, as well as in 1995. If you compare the values in the last column and the last but, one column you can see, the numbers in the last column are less than the numbers in the other column pertaining to the year 2008, why? Why the numbers are larger pertaining to the year 2008 compared to the corresponding numbers, pertaining to the year 1995 in this particular case.

Over a period of time the expansion, due to the expansion of the city, the distance between the two places is also increase

That right, it is the after effect of the fast expansion of cities over space, the metropolitan effect is realized the trip length is bound to increase right, and interestingly you can see you look at the values pertaining to the recent period 2008, the trip lengths are different for different purposes right, home based work 7.85, home based education 5.55, home based education in 1995 was just 3.5, now it is 5.55 a drastic change compared to all other cases.

You have high percentage of increase its partly due to the the phenomena of expansion over space, and partly due to the attitude of the people looking for very good schools to put their (()), irrespective of the distance of the school form home, when everybody is trying to do that exercise this results in increase trip length for the purpose of education.

This factor plus the special expansion together has the result in a very high increase as far as educational trips are concerned, home based others 5.01 work related business 7.02, non-home based others 8.05 non-home based trips from somewhere to some other place and so on.

So, this is the average trip length of Chennai city, a similar values you can preserve for most metropolitan cities in our country, for Chennai city I would say the average for all purposes together you can assume that to be about 7 kilometers is the average length of one trip made in this city. Which is highly intensive, ideally as transport system planners we must plan to reduce the trip length by integrating land dues and transport system planning, we must aim for reduction of trip length as well as reduction of even number of trips, so that ultimately the travel intensity gets reduced.

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Length of Trips Made by Different Modes in Chennai Metropolitan Area

| Sl. No. | Mode of Travel | Average Trip Length in km (2008) | Average Trip Length in km (1995) |
|---|---|---|---|
| 1. | Walk | 1.50 | 1.10 |
| 2. | Bicycle | 4.68 | 2.80 |
| 3. | IPT (auto-rickshaw, Taxi, Cab) | 7.80 | 12.20 |
| 4. | Motorised two-wheeler | 10.38 | 6.30 |
| 5. | Car/van/Jeep | 14.10 | 8.00 |
| 6. | Private Bus | 12.00 | 18.50 |
| 7. | Public Bus | 9.99 | 14.40 |
| 8. | Train | 12.41 | 11.10 |

Let us look at a similar information based on modes used in Chennai city length of trips made by different modes in Chennai metropolitan area, mode wise trip length walk in 2008 average trip length is 1.50 kilometers, bicycle 4.68, intermediate public transport like auto-rickshaw, taxi, cabs and so on 7.80 kilometers, motorized two-wheeler 10.38, car, van, jeep 14.10, private bus like collage buses, software company buses and so on 12 kilometers, and public buses 9.99, train 12.41 right.

So, these are average person trip lengths using different modes that is how you must understand these numbers of course, if you look at the corresponding values for the year

1995 in most cases it is less, in certain cases it is more also in case of IPT it is 12.20, now it is come down to 7.8 partly, because of increased personal vehicle ownership and also because of availability of services in large numbers with different fare structure share auto, independent auto-rickshaws and things like that, that is how trip length has come down by IPT and private buses as well as public buses trip length has come down; could be mainly again, because of the increased private vehicle ownership and other related factors may be increased a service of bus to reach out to places form origin to destination.

Earlier, they might have been taking cycle route, because bus service might not be available along a longer shot route and so on, all these factors might be resulted in a longer trip length earlier, now it is come down. So, these 2 tables underline the need for data segmentation for mode choice modeling based on either trip purpose or mode used, so there is reason segmenting data based on trip characteristics that is the point to be understood very clearly right.

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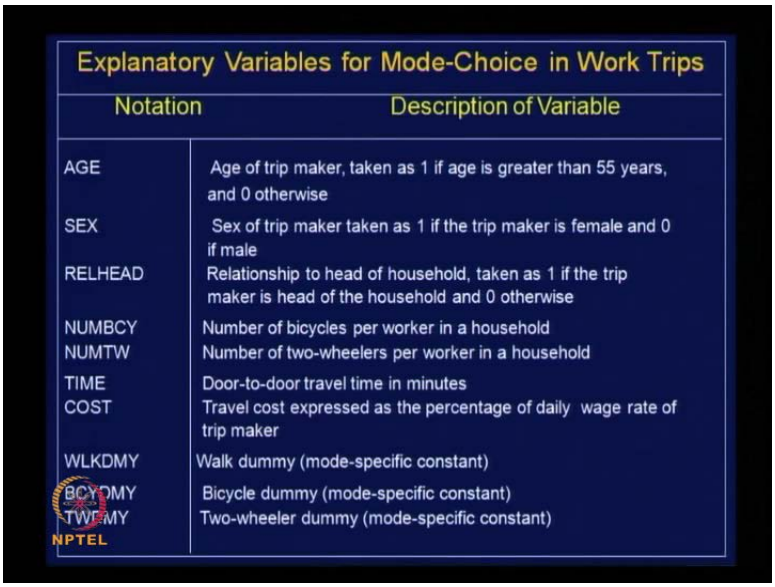


Now, let us continue from the point where we left in the previous class, this is where we closed in the previous class after identification of the set of variables for mode choice modeling. I would like you to remember, the binary values for the dummy variables considered here, age variable will take a value of 1, if the persons age is more than 55 years, elderly people means 1 for others 0, 6, 1 for female 0 for male, relationship to

head of the household 1, if the person is head of the household and 0 otherwise right, these are the things to be remembered for subsequent to appreciate the subsequent discussion.

As you would appreciate, we should have considered the factors related to trip characteristics, socioeconomic characteristics and transport system characteristics in the mode choice modeling process. Have we taken all these characteristics here in this, lists look at the table and let us check whether we have identified variables from all the 3 baskets, which is the variable pertaining to the baskets of trip characteristics, trip characteristics look at the title of the table explanatory variables for mode choice in work trips. So, we have already categorized trips based on trip purpose, so we have already picked one aspect from the basket pertaining to trip characteristics, how about the variables pertaining to socioeconomic characteristics of travelers, age shall we say it pertains to socioeconomic characteristics, social characteristics is not it, age, sex, relationship to head of household, number of bicycle per worker right, it is economic characteristic is not it vehicle ownership and then number of motorized two wheeler per worker all these five variables pertaining to socioeconomic characteristics or travelers.

They reflect the individual characteristics of travelers not, the combined characteristics of household that is very important, because we deal with disaggregate model right, each of these variables reflect the characteristics of individuals, age, sex, relationship to head of household, number of bicycles per workers, number of bi motorized two wheelers per worker, all these things pertained to individuals making trips, there may be members of household but, you can associate these variables with individual traveler right.

And what are the variables related to the transport system characteristics, how about travel time different modes may provide you different travel times, obviously travel time is one of the important characteristics of transport system. Travel cost different modes imply different cost of travel is not it, so travel time and travel costs are the variables related to transport system characteristics.

And the dummy variables are again related to a special aspect of the choice it being different within a socioeconomic group, if a person is within a choice set, but unable to use a particular mode we introduce to explain that situation we introduce, the dummy

variable you cannot associate this with any of the 3 groups, we can call this as a special set of variables to take care of this particular situation right.

So, we have stratified the data based on trip purpose and we have identified five variables related to socioeconomic characteristics of travelers and 2 variables related to transport system characteristics right.

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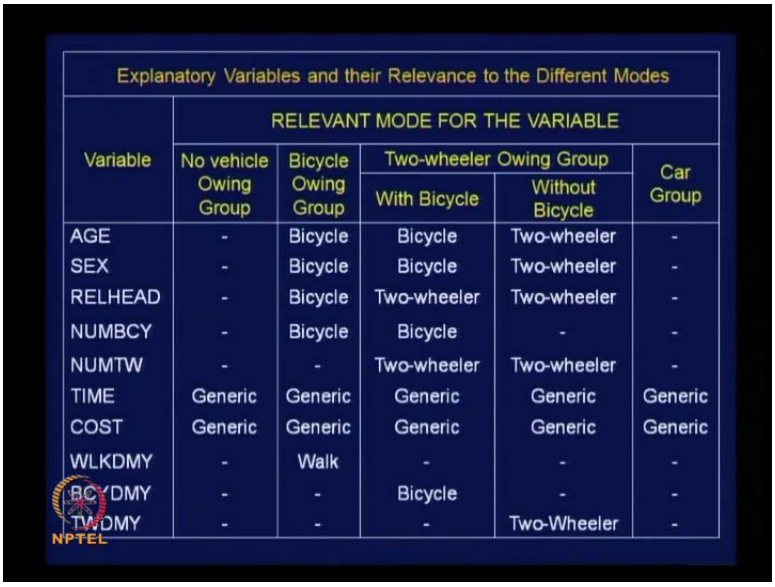


Next let us see, how each one of these variables will influence choice of different available modes, the grouping as we have see earlier has been done as shown in the column titles of this table, we have grouped the travelers as no vehicle owning group, bicycle owning group, two wheeler owning group, again within that with bicycle and without bicycle and car owning group right. And let us just fix one variable and see or identify the relevant modes, age age of an individual will influence right the probability of choice of these modes, bicycle right in that particular group, if that person if in that group bicycle choice will be influenced by age is not it, and similarly in the other group again bicycle will be an influensive mode, then if the person is in other group two wheeler or in general you can say age will have significant influence on the choice of bicycle and motorized two-wheeler.

If a person is elderly person, we are going to have the value of the dummy variable as one, is not it? Right, so please remember the binary values for the dummy variables then sex, sex of individuals will have influence on these modes bicycle again motorized two-

wheeler, relationship to head of the household will have significant influence in the choice of bicycle, two-wheeler and two-wheeler. As they have indicated here, for here groups in the first two cases the effect will be positive or negative, effect of age and sex in the choice of bicycle or two wheeler as mode of transportation, assume that age has got a value of one, elderly people would they prefer to use bicycle and motorcycle no, it will have a decreasing effect, negative value is not it, sex for that city as I said sex was found to be a very significant factor, will ladies and girls used bicycle and motorcycle in large numbers, obviously there will be a decreasing effect. If you put number one for sex, if the individual considered is lady or girl the relative the quantum of choice will have a decreeing effect on these modes, whereas is the person is head of the household with number one for this variable, then choice of bicycle in two wheeler will have positive effect right, so that is how we need to understand to have a feel of the variables in your model.

Number of bicycles per worker obviously, it will positive effect more the number of bicycles per worker, more will the choice of the particular mode number of motorized two wheeler per worker will influence two-wheeler choice travel time is taken as the generic variable common for all modes right. The time is more obviously the choice of mode is going to be less, time will have a decreasing effect on choice of any mode, cost generic variable for all modes common, for more the cost less will be the choice of your particular mode it is a relative figure, we have to see how it works.

Work dummy as we discussed earlier, pertaining to a particular group, bicycle dummy and then two-wheeler dummy, these are the set of different variables that we are going to consider for calibration of logic model where maximum light will measure.

Work dummy should not it be for the no vehicle owning group

No vehicle owning group, what will be the

Work dummy, so

Could you be louder?

Work dummy you have assigned work for the bicycle owning group

Ya

Should not it be for the no vehicle owning group

I would say that, this is dummy fixed for different groups of travelers is based on the available data set also, let us say there is not much of individuals for home walk is not available as a mode of transportation, in that particular group there is no need to introduce work dummy for that group, what is the purpose of introducing work dummy variable, that mode is not available for certain number of people in that particular group; in this particular case, we can say for no vehicle owning group right, there were negligible or no individual in that particular sample for whom walk was not an alternative. It was both the alternatives were available for all the travelers in that sample under this particular group let us understand.

If there is case obviously you have to introduce work dummy for that group also, that is how we need to understand all these things we introduced based on the data set, otherwise if there is no problem there is no no need to introduce these dummy variables. So, that is how I would like to understand, the introduction of dummy variables for for different groups.

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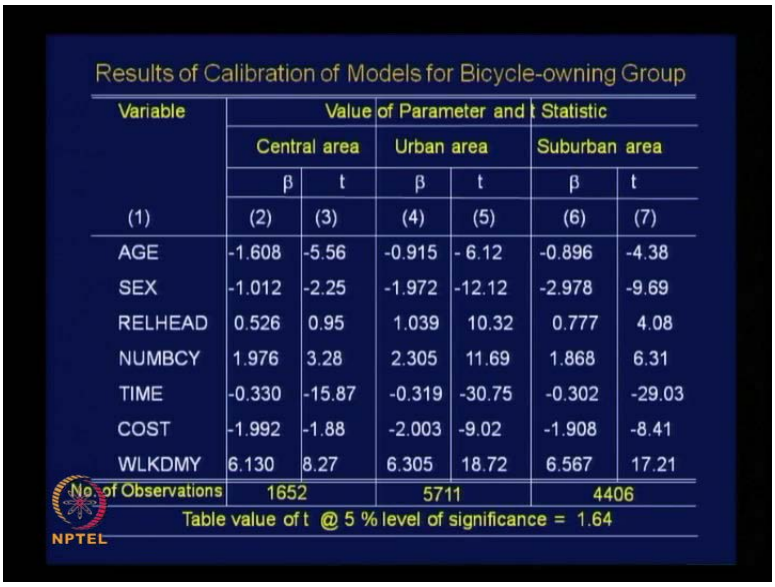


Right now let me show you the result of the calibration directly pertaining to these variables, as we discussed earlier we are developing attribute specific utility functions, not mode specific utility functions. This means that a particular attribute will have only one coefficient value, irrespective of the mode in which that attribute is used or

irrespective of the utility function in which that attribute is used to get value of utility, that is the specialty of attributes specific utility function, you can use the same attribute the same co efficient across modes, if that attribute is relevant for that particular mode right.

So, then it is advantageous for us to calibrate the whole of the model and get the co efficiencies for all the variables, and pick the relevant variables and develop your utility function. So, this is the calibrated result of the mode choice model, the coefficients pertaining to the attribute age is given here and sex values are here, relationship to head of household has got these co efficient.

Number of bicycles per worker, has got these values, travel time door to door travel time has got these values and cost of travel will have this thing and work dummy will have these co efficient, please note that this is the result of calibration for only one group of travelers, bicycle owning group alone right. Not for all the groups I am showing you the calibration result of only one group of travelers namely bicycle owning group of travelers, and that is why all the variables that we have listed earlier are not finding place here some of them are not here is not it, for example, number of motorized two-wheelers per worker is not here, because that is not relevant in this particular case, because the group considered here is bicycle owning group. Interestingly we can find that, we have 3 coefficients for the same variable pertaining to the 3 different areas, central area urban area and suburban area.

We can also find out whether, such a division had been really meaningful or not, based on the assumption that there is going to be a significant effect, because of the changes in transits the system characteristics, we have divided the dataset based on the residential location of travelers. Let us now check, whether such a segregation had been meaningful in this particular case, look at the value of the coefficient age for central area, it is minus 1.608 urban area minus 0.915, and for suburban are minus 0.896.

Let us say, that the person is aged person, then the value will be 1 of the variable will be one, so for an aged person the decreasing effect on the choice of bicycle, we have already identified bicycle as a relevant mode for this variable age, decrease in effect on choice of bicycle is minus 1.608, in central area. And in urban area the decreasing effect

is relatively less, in suburban area still less, you think of aged people still going for some work, because it is about work trip, people more than 55 years still doing some work.

And if they are living in a central area the traffic will be too much right, normally aged people may not prefer to use bicycle in such traffic condition, when you go little outside the traffic condition may not be that bad right, they might be finding a job around that area, around their home, it may be easier for them to use bicycle as a mode of transport. If they are living in peripheral area they are not going to commute to visit the city center everyday for work and go their elderly people, they will be working around that area, in that case the decreasing effect on use of bicycle is still less, is it not reflecting the reality, that is how we need to understand the correctness of division or segmentation of data based on residential location. Otherwise, you would have got same coefficient for all the locations, if the division is irrelevant there may not be such a variation, so there should be logical explanation for your coefficients, you must really have a feel of each and every coefficient that you get after the calibration process.

Look at the coefficients for sex, sex is a relevant mode again for use of bicycle in this group, this is bicycle owning group we have listed earlier bicycle to be a relevant mode for this particular variable sex. For female it is going to be one, it will have a reducing effect on use of bicycles you look at the reducing effect, it is a very interesting to note here it is minus 1.012 in central area, minus 1.972 it is increasing, the suburban area minus 2.978 in peripheral areas, suburban area and urban are it is minus 1.972, why it is so, female working normally they will prefer work places as close to home as possible, as well as they will like to choose a relatively safe mode.

In cities and towns security is also a concern for mobility of girls and ladies, even today it is true in our country right, if we take central area may be it might be safer and trip length are lightly to be shorter, because you will have several activities close by they might be working in some places which is very nearby right. So, the decreasing effect in choice of bicycle is relatively less when you go to urban area, the trip length may be slight more and the level of security may be slightly less and if we got to suburban are still adverse condition on these two aspects trip length might be still more and level of security may be still much less.

There may not be any traffic at all along a long stretch of road one may have to travel alone, all these aspects are there its situational location specific right. So, unless you understand each of these coefficients based on reality in the field, you will not be successful as a modeler, it is not just simple sitting doing something analytically and getting some numbers.

Your numbers must give a feel of the field condition, and then only you can be confident about the correctness of the model both logical as well as statistical basis clear. So, like that it is possible to explain all the coefficients and look at the sample size for these 3 groups of travelers there were 1652 observations for this particular group, bicycle owning group living in central area, large number sample size is very big and 5711 observations, so many individuals right, pertaining to urban area and 4406 observations pertaining to suburban area right.

And look at the t values t values are given for these coefficients, may be if you are interested to check whether these variables are significant, I have given you the t value and for 5 percent level of significance which is quiet normal practice, in practical conditions. The values 1.64, we can find that almost all the variables, except relationship to head of household pertaining to central area right or statistically significant, all the chosen variables are significant in explaining the variation of the dependent variables, namely probability of choice of a particular mode.

And in this case, because of this deficiency this variable was not eliminated because, in the case of other groups it was significant right; it was kept in the utility function, so that there is uniformity in utility function. It is found to be little in significant, does not matter it will not going to contribute much, but it is convenient to have same set of variables for all groups right, and utility functions were developed as follows.

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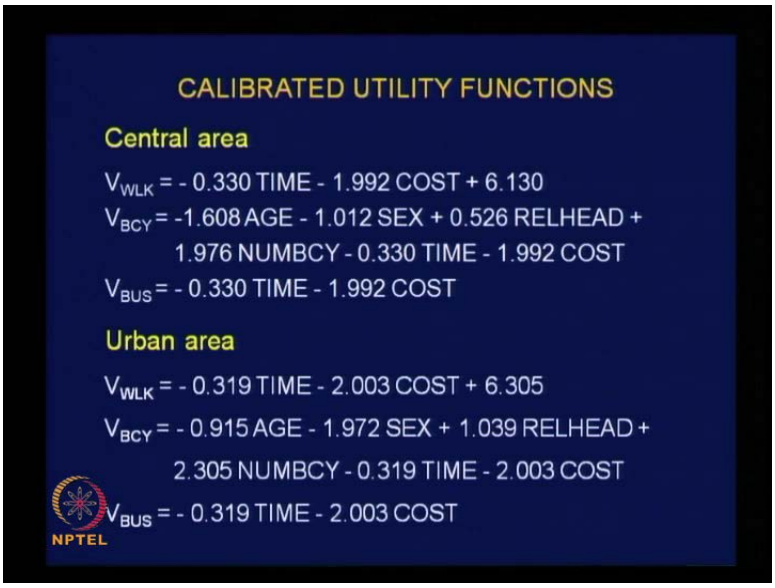


This is utility function, for the central area for walk these are the relevant variables time, cost and work dummy as far as this particular group of travelers concerned where, from we have got this numbers, we have picked up from the table directly the coefficients are picked directly from the table and written here right.

And utility value for bicycle is written here, pick the coefficient values from the table and write the name on the variable corresponding to the co efficient right, V bus only time and cost were there to define the variables, we have put them; and please note that the co efficient value for a particular attribute is that is same, for time irrespective of its location, whether it is V walk of V bicycle or V bus it is going to be 0. minus 0.330, that is the advantage of attribute specific utility function. For your information I would tell you that, the cost of travel for a walk was take as 0 obviously, there is no need to consider nay cost.

And even for bicycle, even though there may be some cost element involved if you take into account the maintenance of the vehicle, in the long run and divide it, divide the cost on daily basis you may end up with a small amount of money the cost was take as 0 should be realistic. And you can assign values for other variables, that should be taken care of and similarly, for urban areas you can get the set of utility functions as shown here right, any questions, are you clear about what we are discussing and how do we get

the utility function from the calibration result, just picking the values and formulating equation.

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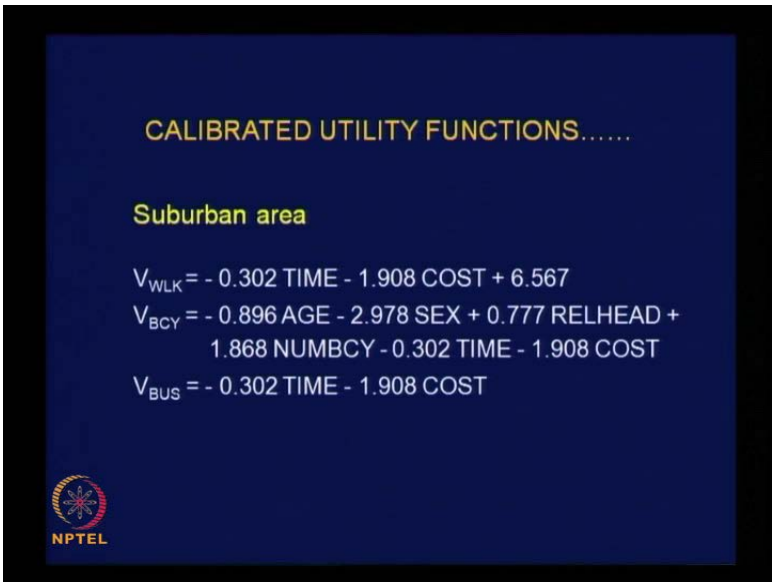


Then suburban area, so we have utility function for all the 3 areas for this particular group, for all the 3 alternative modes, this is not the end of the story we have to finally find out the probability of choice of a particular mode. What is the probability of choice of walk, as more for work trip by a particular group of travelers, that is the question to be answered, so that needs to be done using the logic model is nit it.

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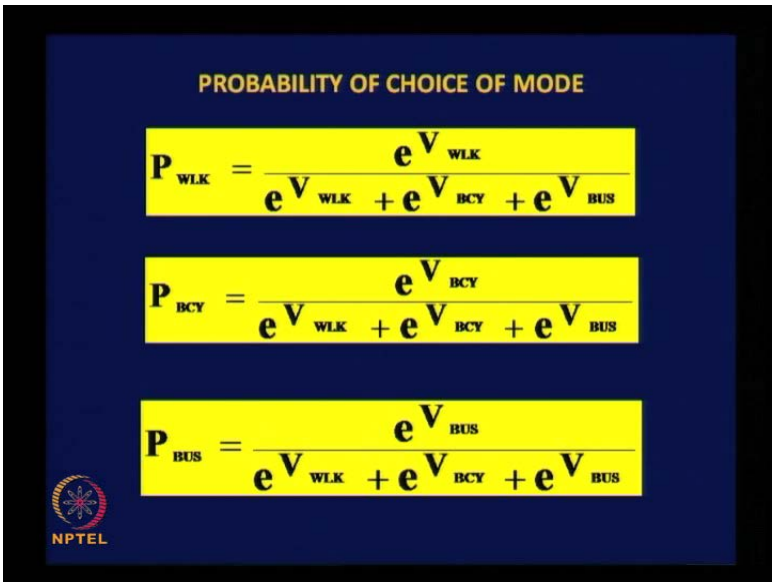

You can write Probability of choice of walk as e power V walk divided by e power V walk plus e power V bicycle plus e power V bus, we have 3 alternative modes for this group now we have the values of V walk V bicycle and V bus is known to us simply substitute the values and get the probability choice of this particular mode. Similarly, probability of choice of bicycle as mode of travel e power V bicycle divided by e power V walk plus e power V bicycle plus e power V bus same denominator, because we have same set.

And probability of choice of bus as a mode of travel for a trip e power V bus divided by the same denominator e power V walk plus e power V bicycle plus e power v bus clear. This completes our discussion on mode choice modeling or modal split modeling to summarize what we did in this class; we started off with recollecting the identification of the set of variables for this particular case study.

We found that we have considered trip characteristics by considering only one trip purpose in this particular case namely work trip, then we have chosen five variables pertaining to socioeconomic characteristics starting from age sex relationship to head of household, number of bicycles per worker, and number of motorized two-wheeler per worker, and the cost and time (()) the 2 transport system variables considered in this modeling process.

In addition to take care of the variation the choice set within a group, we introduced dummy variables pertaining to walk bicycle and two-wheeler and we looked at the calibration results pertaining to one group of travelers namely bicycle owning group travelers. We checked for the logical aspects or logical correctness of the calibration and found that there is perfect logical correctness with respect of all the variables spread over the 3 distinct regions, the variation of the coefficient values were logical.

Then we found or we tried to understand how to formulate the utility functions from the calibration result and finally, we just discussed about estimation of the probability of choice of a particular mode using utility functions. So, we will stop here, we will continue with another topic namely trip distribution analysis in the next class.