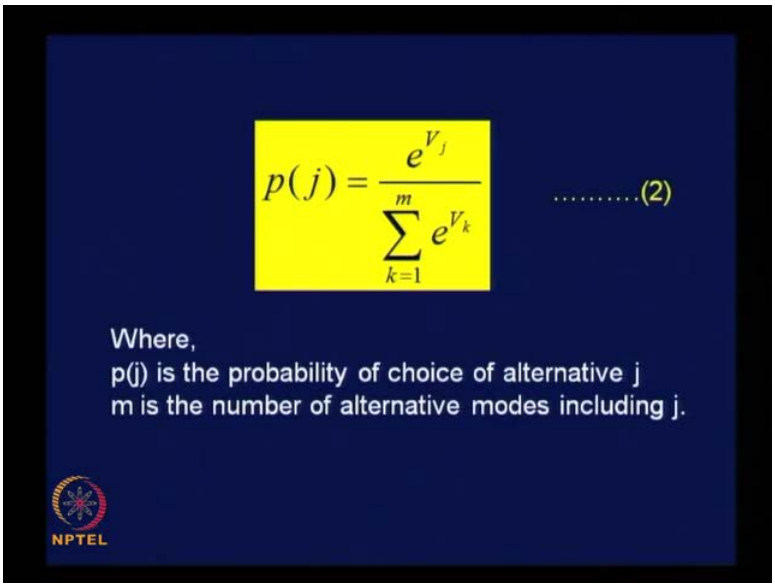
Urban Transportation Planning
Prof. Dr. V. Thamizh Arasan
Department of Civil Engineering
Indian Institute of Technology Madras

Lecture. No. #17
Modal Split Analysis Contd.

This is lecture seventeen on urban transportation planning. We will continue our discussion on modal split analysis in this lecture. To take a brief recall of what we did in the previous lecture, you may recall that we essentially discussed about two numerical examples, involving the application of logit model of mode choice. The first example, two modes or two alternative modes were considered, the modes considered were motorized two wheelers and bus, and the utility functions used were attribute specific utility function. The second example was the extension of the first example with the additional information that a new mode namely rapid transit is proposed to be introduced along with the existing two modes of motorized two wheelers and bus.

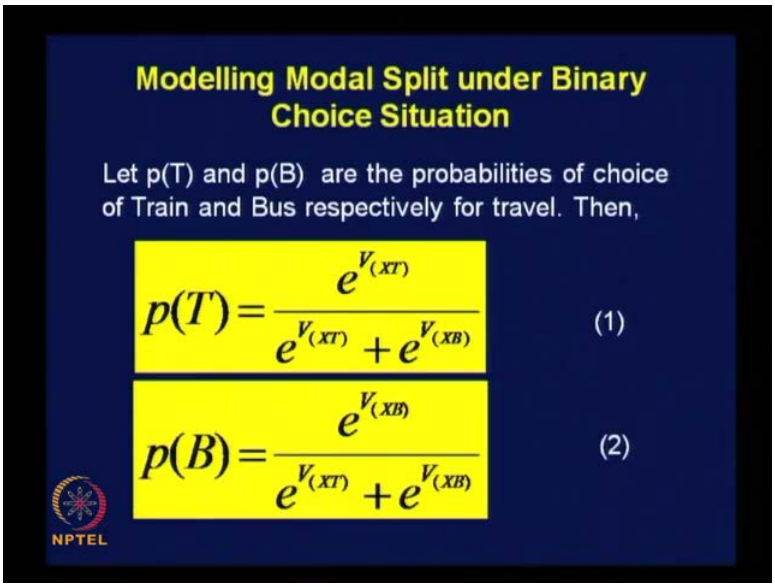
Since the utility functions were attribute specific, it was possible for us to consider the case of introduction of new mode also, and we analyze the mode choice among the 3 alternatives, and understood clearly the application of logit model for a mode choice situation involved in 3 modes. Now in this class, we will discuss a specific case of analyzing mode choice for a binary choice situation, where only two modes are involved, and we will also see that the application of logit modal of mode choice can be transformed into a simple linear regression equation, which will be easy to handle as far as analysis is concerned.

(Refer Slide Time: 02:48)



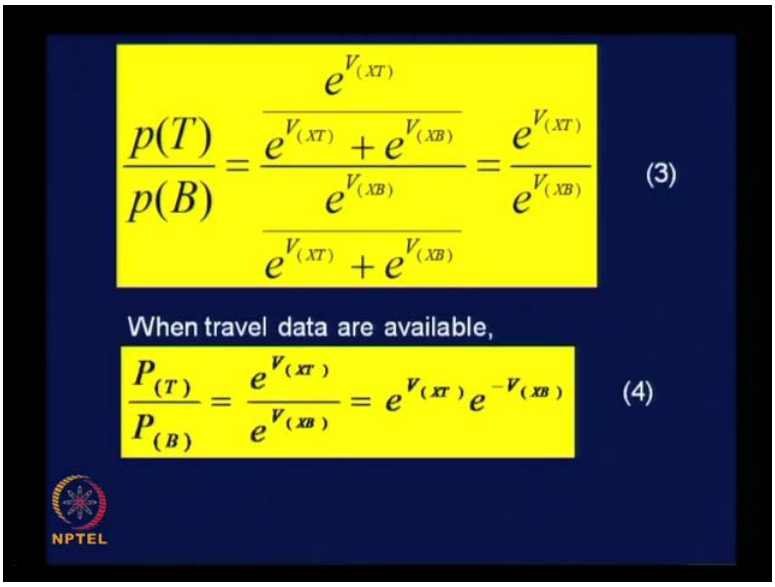
We know this is the general form of the logit model of mode choice probability of choice of mode. J is given as e power v j divided by sigma k is equal to 1 to m e power v k, and p j is the probability of choice of alternative j, and m is the number of alternative modes including j. If there are only two modes available for travel, then we can write p1 to be equal to e power v 1 divided by e power v 1 plus e power v 2; is it not? Or p of 2 probability of choice of 2 will be e power v 2 divided by the same denominator. E power v 1 plus e power v 2, let us consider a similar situation involving two modes namely bus, and rail and see how the application of logit modal can transform into a simple linear regression model.

(Refer Slide Time: 03:47)



Let P of T and P of B are the probabilities of choice of train, and bus respectively for travel in a particular context. We can write probability of choice of train to be equal to e power V XT. T - stands for train, X - indicates the independent variables involved in the utility function that is significance of this subscript for V XT divided by e power V XT plus e power V XB and, similarly we can write probability of choice of bus b to be equal to e power V XB divided by e power V XT plus e power V XB it. Now, let us do a small manipulation to get the final intended result of a simple linear regression equation.

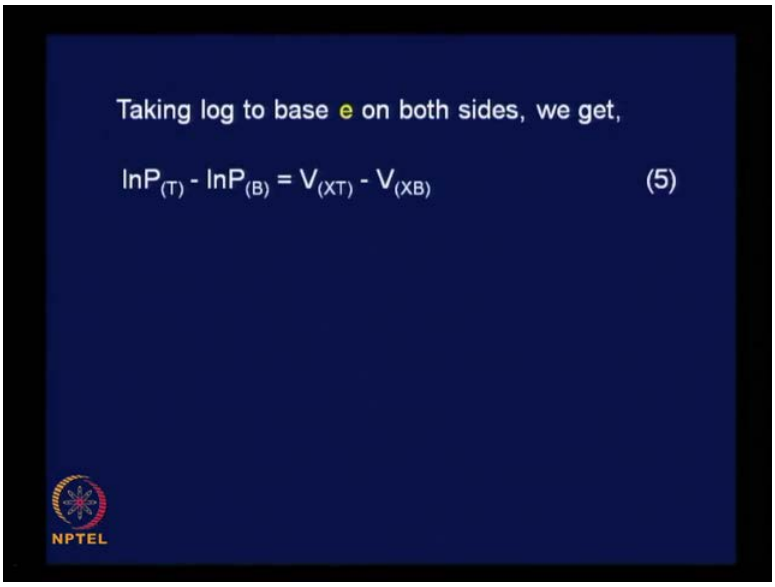
(Refer Slide Time: 05:10)



You just divide the probability of choice of train by probability of choice of bus. P T by p B, can be written as shown here; we can write that as simply e power V XT divided by e power v XT plus e power V XB whole divided by e power V XB divided by e power V XT plus e power V XB, denominator is same for the terms on top and bottom. So, we get simply p of T by p of B to be equal to e power V XT divided by e power V XB. And for a situation, where we have information about the travel data or when travel data are available. The condition when travel data is available means what? The values of p T and p B are known. Let us say about 45 percent of travelers are using bus, 55 percent of travelers are using train.

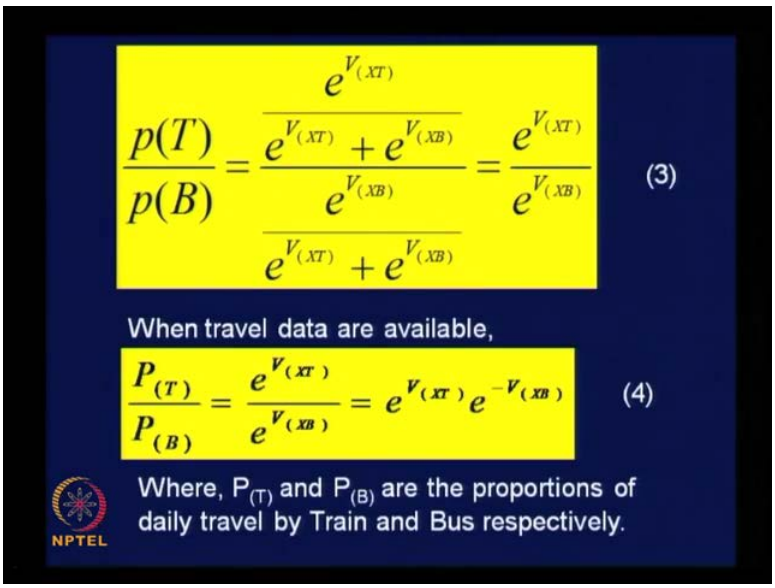
Since the data is known, we can take probability of choice of bus to be 0.45 and probability of choice of train to be 0.55. Because the information is known to us even through it is the real choice, but for this equation purpose nothing wrong in taking the known percentage of share by the two modes as simply probability of choice that is how the modal has to be calibrated in practice, and we can write as given here capital P of T capital P is to differentiate from probability. It is real share divided by P of B is equal to e power V XT divided by e power V XB. That is nothing but e power V XT into e power minus of V XB we can write that way also. Now, let us do one more manipulation at this stage. Let us take logarithm to the base e on both sides, so that value does not change for the involve variables.

(Refer Slide Time: 08:04)



Taking log to base e on both sides, we get simply ln of P T minus ln of P B to be equal to V XT minus V XB.

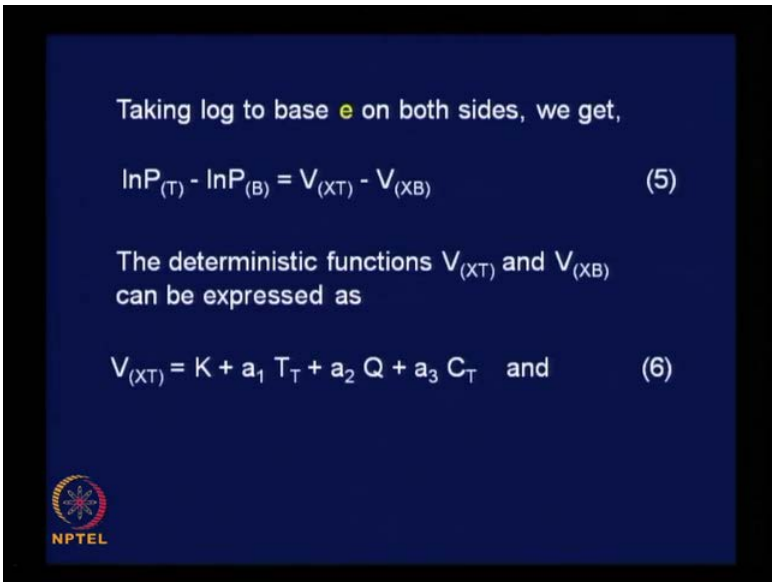
(Refer Slide Time: 08:51)



How do we get this result? P (T) was in numerator. So, we write ln of p (T) and p B was denominator with negative sign. So, we minus ln of p (B). On the right hand side we had e power V XT minus e power V XB you may recall that is the equation we had just look at this is what we do we take log to base e for this equation on both sides,. So, simply

when you take log to base C of this term it, becomes a V of XT multiplied by log e base e, and log e base e is 1. So, we simply get V XT.

(Refer Slide Time: 09:36)



So, that is how we get on the right hand side V XT minus V XB. The deterministic functions V XT and V XB can be expressed as follows. In fact, they are deterministic utility functions. Pertaining to train and bus. Now, we need to get some functional form for these two utility functions. For that we need to know what are the variables or factors that we are going to put into the utility function for a very simple case the travel time, and travel cost could be two important variables or factors, which can go into utility function, travel time, and travel cost. So, that is what has been done in this particular case to demonstrate the conversion of logit modal into a simple linear regression equation. cost and time have been taken to formulate the utility function for both train as well as bus.

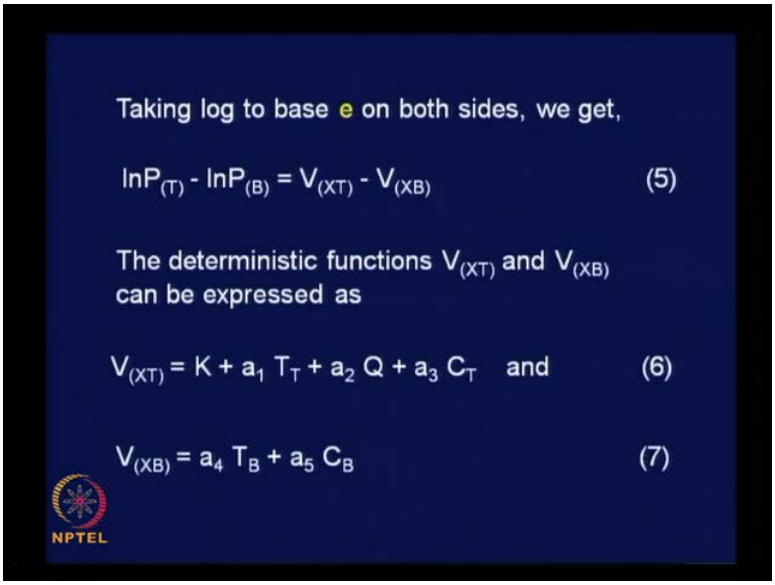
So, we can write V XT to be equal to a constant term K plus a one times T T. It is nothing, but travel time by train plus a 2 times q plus a 3 times C T. C T- stands for cost of travel by train interestingly. We find a term Q this became necessary, because of the fact that when the travel distance involved is more, whether it is metropolitan area or intercity travel, when the distance involved is more people prefer train rare than bus. I think all of you appreciate this point when the distance involved in travel is more even in metropolitan areas if the commuting distance is 20 kilometers and more traveling in bus.

If there is an alternative like train service available people choose train why the space available per passenger in square meters by virtue of the design of the two systems is more in train compared to bus.

In addition you have other facilities like toilet extra, inside the compartment coach itself in train, which is not available in case of bus. So, these are all additional advantages with train. So, when the distance involved is more people choose train or have a preference towards train compared to bus and how to bring in this fact into a modeling process. This can be done by segregating a data set based on travel distance you have some dividing line if the distance is more than that dividing line you give some value for the variable Q which is a binary variable here or dummy variable.

And if the distance is less than the dividing line you can say the value of Q is 0. As we discussed earlier. So, Q is nothing but a dummy variable to take into account the preference of travelers towards train when the travel distance is relatively more. This has to be brought into the modeling process otherwise we will not be able to explain the actual modes situation, which exist in practice.

(Refer Slide Time: 13:42)

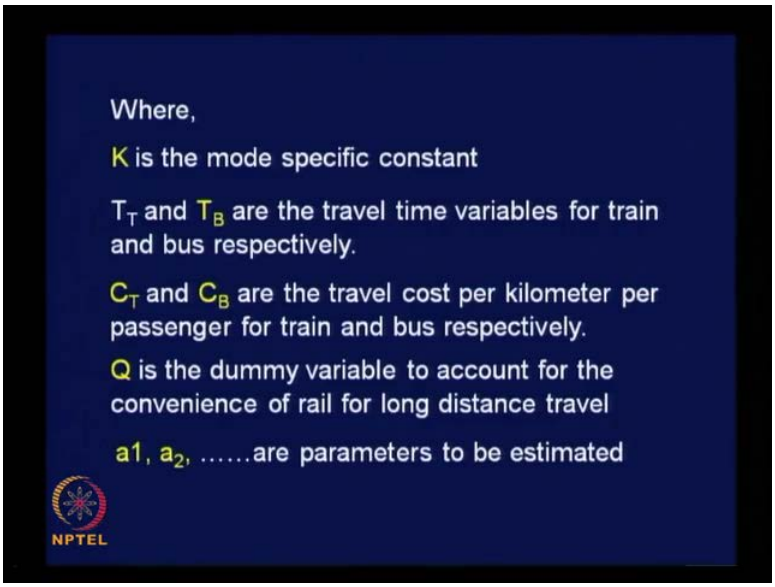


That is the reason we have introduces Q here particularly for V XT utility function for train utility function for bus looks like this we have simply taken travel time, and travel cost V XB is given as a 4 times T B plus a 5 times C B. Q is not included in this utility function also the constant term is missing in this utility function there is no K or K 1 or K

2 ; obviously, when we introduce a dummy variable for one mode there is no need to introduce the other one, because dummy variable becomes necessary in comparison with the 2 modes.

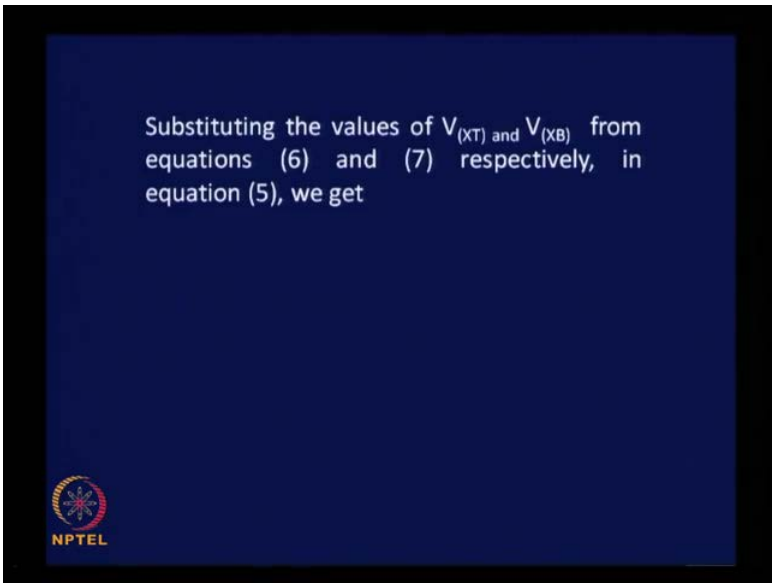
We compare bus and train and then we realize that train is preferred when the travel distance is more to account for this fact we are introducing dummy variable in respect of train. So, that takes care of this particular aspect, there is no need to introduce another dummy variable for the other alternative, because Q takes care of the travel time of both the modes and why we have not introduced the constant term here as we have done in the cases of train. Any suggestion you may recall we discussed about base mode in mode choice analysis, what you understand by base mode. Base mode is the one where we consider the unexplained part of the utility function to be 0. So, in this case bus is taken as base mode.

(Refer Slide Time: 15:56)



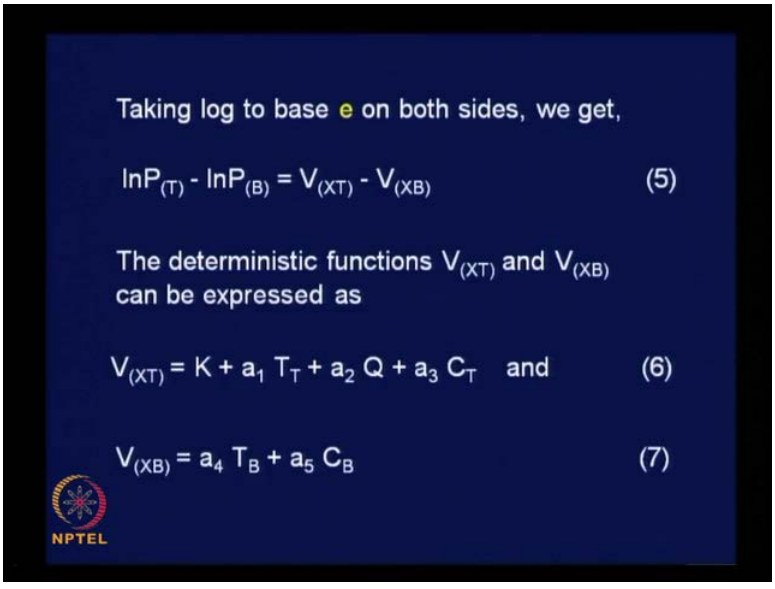
So, that is how K is not included in the case of utility function for bus of course the explanation for all the notation have given K is the mode specific constant and T T and T B are the travel time variables for train and bus respectively C T and C B are the travel cost per kilometer per passenger for train and bus respectively Q is the dummy variable to account for the convenience of rail for long distance travel. A 1, a 2, etcetra, are parameters to be estimated.

(Refer Slide Time: 16:41)



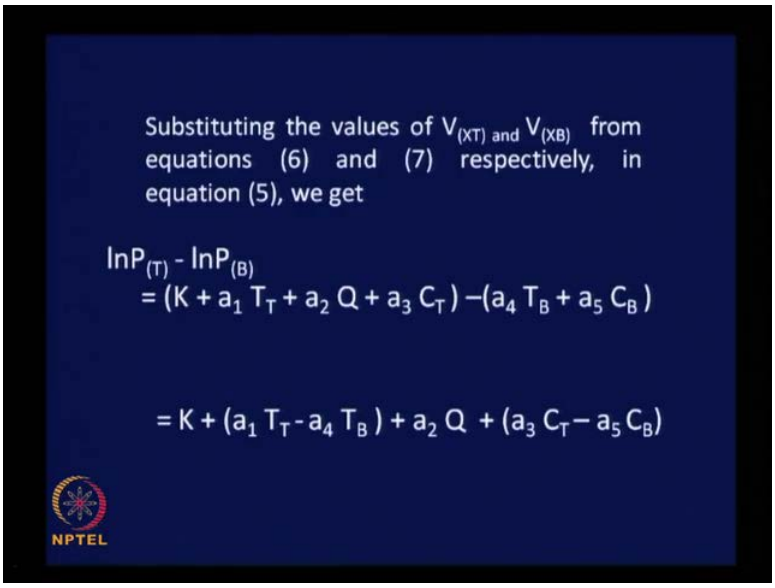
Let us substitute the values of V XT and V XB from equations 6 and 7 respectively in equation 5. We are substituting the values of V XT and V XB as given in equation 7 in equation 5.

(Refer Slide Time: 17:11)



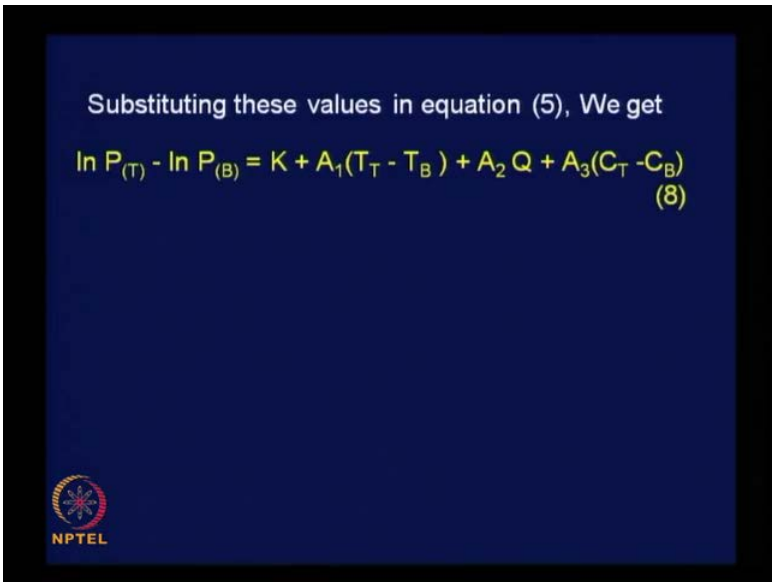
Let us quickly try to recollect equations 5, 6, and 7 this is equation 5 equation 6 equation 7 equation. So, we substitute the valves of V XT, and V XB in equation 5, instead of V XT. We are going to write the quantity of V XT and instead of V XB. We will right these 2 terms here that is what we are going to do by this substitution process.

(Refer Slide Time: 17:45)



We get ln of P T minus ln of P B to be equal to the first utility part for train. K plus a 1 T T plus a 2 Q plus a 3 C T minus a 4 T B plus a 5 C B. Let us do some simplification are rearrangement of the terms like this. This can be written as K plus a 1 T T minus a 4 T B am bringing the similar variables together a 1 T T minus a 4 T B plus a 2 Q plus a 3 C T minus a 5 C B.

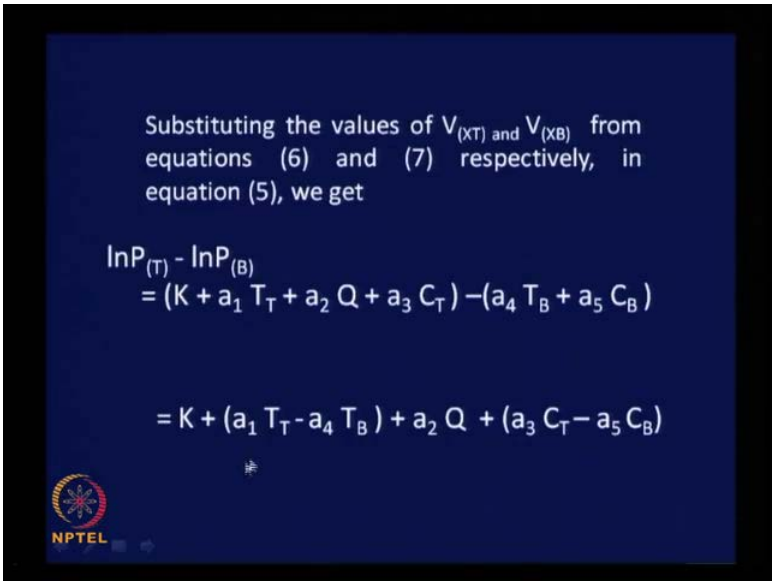
(Refer Slide Time: 18:50)



And substituting these values in equation 5 again we get this simplified form of this same equation it is nothing, but the same equation. I made some variations in the notations.

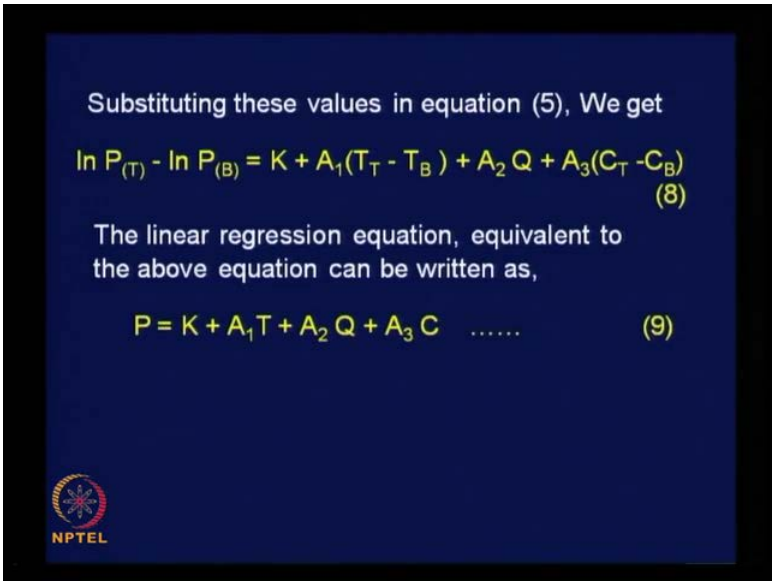
There were two values multipying T T and T B in the previous equation instead I have put T T and T B within parenthesis and taken one constant term. It is just representative constant term it can be done.

(Refer Slide Time: 19:32)



Able to follow see what you do in the previous case is a 1 T T minus a 4 T B. Travel time by train is multiplied by a constant some coefficient and then travel time by B is multiplied by a 4 off course we are yet to decide about the values of this coefficient.

(Refer Slide Time: 20:21)

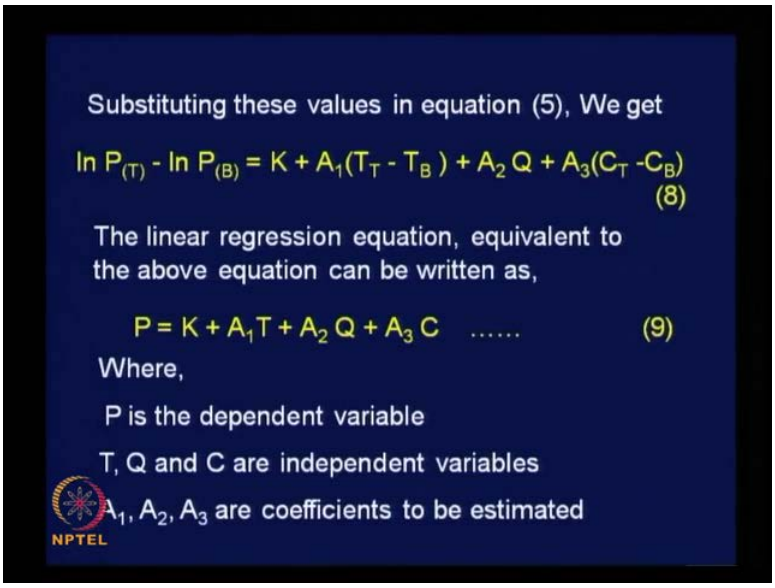


In any case the travel time difference will be multiplied by some factor. So, instead of writing like this I can write simply as a one times T T minus T B , because we are yet to evaluate one coefficient. So, nothing wrong in writing as and when here and plus a 2 times Q plus a 3 times C T minus C B. Let us further try to reduce these notational aspects and the linear regression equation equivalent to the above equation can be written as follows. We can write P to be equal to K plus a 1 T plus a 2 Q plus a 3 C. A very simple linear regression equation. You have a dependent variable with a notation P you have 3 independent variable T Q and C and a constant term K.

You can offered to write this way, because you know what is P. P means ln of P T minus P N of T T. T is nothing, but T T minus T B travel time difference for any travel from an origin to a destination between train and bus. Q you know what value to be substituted depending upon the distance involved and then C is nothing, but C T minus C P travel time cost difference between train and bus. In practice if you know the actual share of travel by train, and bus. Time difference in cost difference you can simply calibrate this regression modal. You will be able to find the values of K a 1, a 2 and a 3 once you calibrate a modal. Modal is ready for application for any given situation.

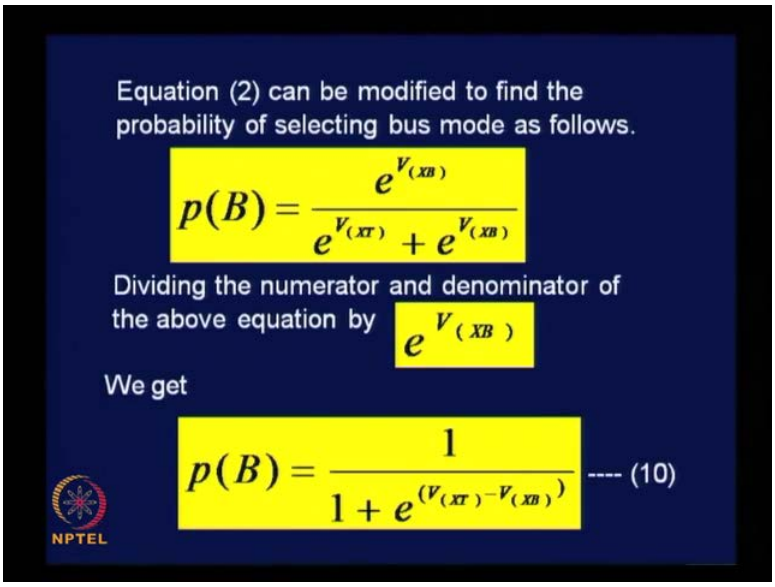
Let us say you are able to calibrate the modal and you want to find out the value of P for a given situation you just find out the value of travel time difference travel cost difference and check the value of Q depending upon the distance of travel involved and constant term is known to us we can get the value of P and from that it will be possible for us to find out the probability of choice of a particular mode.

(Refer Slide Time: 23:03)



We will just proceed and see how this can be done of course if here p is the dependent variable as I mentioned to you T Q and C are independent variables and A1, A2, A3 etc, the co efficient to be estimated. Are you able to appreciate the method of manipulating the logit modal of mode choice to get a simple linear regression equation we are doing any magic it is just systematic mathematical procedure. So, for a binary choice situation you can use simple linear regression equation still analyze mode choice you can find out the probability of choice of a particular mode.

(Refer Slide Time: 23:50)

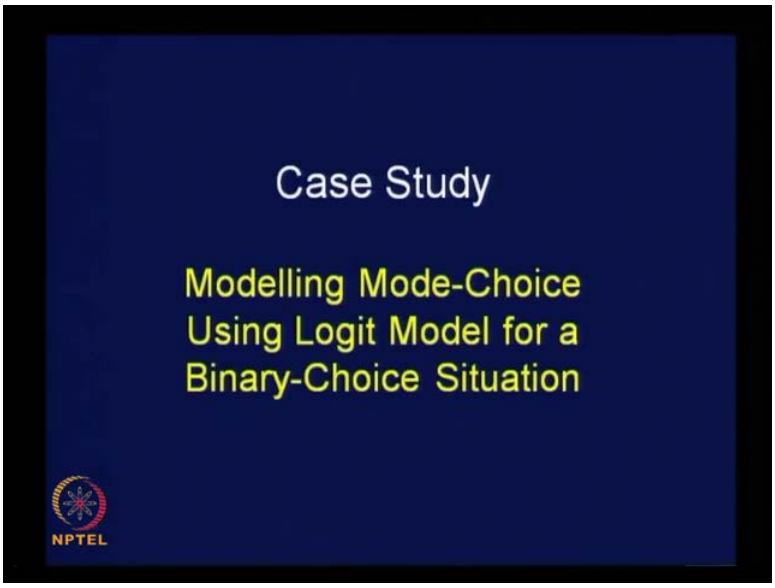


Now, the equation two can be modified to find the probability of selecting bus mode as follows. I will give the equation two again here this is equation 2, which we saw initially probability of choice of bus can be written as e power V XB divided by e power V XT plus e power V XB. Now, let us divide the numerator and denominator of the above equation. By e power V XB we are dividing the numerator, denominator. So, that the value does not change and if you do. So, you will get this result. P of B will be equal to one divided by 1 plus e power V XT minus V XB.

What is P of B probability of choice of bus. We get this probability using this very simple equation it is nothing, but 1 by 1 plus e power V XT minus V XB do we have the value of V XT minus V XB with us at this stage. See go back and see this is nothing, but V XT minus V XB right hand side is nothing, but V XT minus V XB. So, for any given situation it is possible for us to get this values. Once you know the travel time difference, travel cost difference. Value of Q and the already calculated value of K you can find out the value of V XT minus V XB and simply substitute that value here. So, this term can be evaluated using linear regression equation and substitute that value in this equation 10 to get P of B. Once you get P of B. 1 minus P of B is P of T.

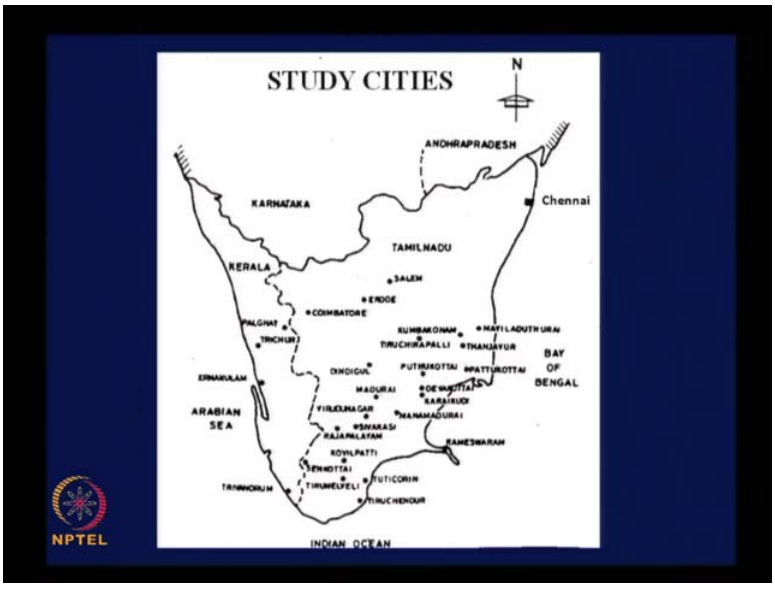
So, that is how we can transform logit modal into a simple linear regression equation for a binary choice situation and for a given situation. We will be able to estimate the probability choice of any mode. Once you know the travel time difference, travel cost difference. The distance implication as per this modal it should be possible for us to find out the probability of choice even for any given future situation. Now, with this understanding, let us take case study where we have actually collected data and use this modal for a binary choice situation and calibrated the regression modal. So, that the modal can be used to predict the mode choice situation in the horizon year.

(Refer Slide Time: 27:25)



The example pertains to the intercity travel does not matter whether it is intra city or intercity mode choice is always mode choice. The factors influencing mode choice are not going to change its again going to be related to travel time, travel cost, comfort, and so on.

(Refer Slide Time: 28:08)



So, we are going to discuss an example; involving intercity travel, but the principles involved are same. The cities considered for this particular case study where spread over space covering 2 States Tamilnadu and Kerala states and you can see there are 4 cities

involved in the State of Kerala; Trivandrum, Tirchur, Palakad, and Ernakulum and 22 cities apart from Chennai are in Tamilnadu State. In total travel from Chennai to 26 other cities spread in 2 States were considered for calibrating a binary choice modal, split modal as a simple linear regression equation. When I think of mode choice analysis for this kind of a situation.

You must very carefully study the system characteristics. If you take train service normally train service the schedule on weekly basis. Some trains may operate only few days per week may not be on daily basis some trains may be operated on daily basis, where as bus services will be operated on daily basis this is one difference which has to be accounted for if you take train you have differential pricing you have First AC, Second AC, Three tire AC, then Sleeper Class and so, where as in buses mostly normal buses or sometimes Air Condition buses not much of variation as per as price is concerned. Now, how do we collect the data required for the analysis, let us look at a weekly and daily basis travel. Since scheduling of train service is based on week, we have to necessarily collect weekly travel data. To get the value of P T and P B.

To collect the weekly data and then get the daily average. Similarly collect the data pertaining to bus travel for same week and then work out the daily average to have daily travel data still. It is better to collect data for one week and then get the daily travel data. So, these travel data value of P T and P B are going to be daily average travel by train and bus. Then travel by which particular class in the case of train and we compared all the classes together the train compared with bus travel. We should know it we should realize that social economic characteristics of travelers also influence mode choice.

A person who normally travels by second AC. Will never choose bus as an alternative mode. So, economic status comes into the picture. So, when you try to compare mode choice between bus and train in the case intercity travel. It is more appropriate logical to consider only Sleeper Class traveling train and bus travel. So, this is affordable for a particular section of the society middle income group, they may either choose bus or simply Sleeper Class in train Second Class. So, when we collect data you should eliminate travel data by Upper Classes in the case of train like data pertaining to only Sleeper Class and compare with the bus travel data.

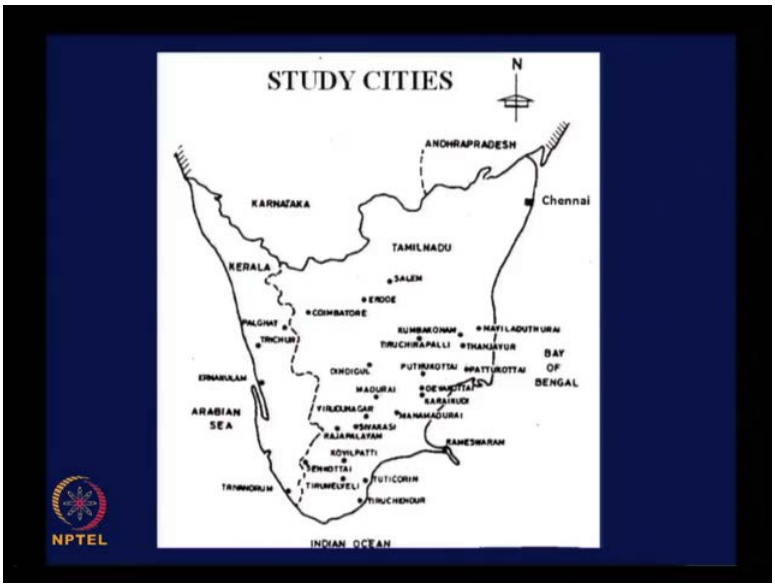
Your data base creation is very important another related question is in reality in most situations in our country. The demand for train travel is normally more and when tickets are not available in train people get pushed to bus, there will be a push back demand for bus service, because people do not get seats in train that is one situation. Another situation is that some people reserve ticket in advance and some travelers just come at the time of making the trip and get into the bus or get into the open compartment in train and travel. Without any planning prior planning.

So, when you collect travel data should we have to account for all this total travel information or is there any rational way of collecting the travel data. It would be appropriate, if we consider only data pertaining to reservation, reserved tickets both in train as well as bus. Bus system also has got its own reservation system. So, consider only data pertaining to reserved passengers in both modes because they think carefully decide the choice of mode and reserve ticket, they have considered all aspects and then reserve their tickets for travel.

So, that is how you must 0 on the data requirement for your analysis. So only reserved ticket based on weekly travel, but convert into daily average, unreserved travelers are eliminated and also, you must take into consideration denied travel, because of the inadequate system capacity sometimes both trains and buses. Will be full under such condition if you collect data the mode choice situation may not be reflecting the true scenario.

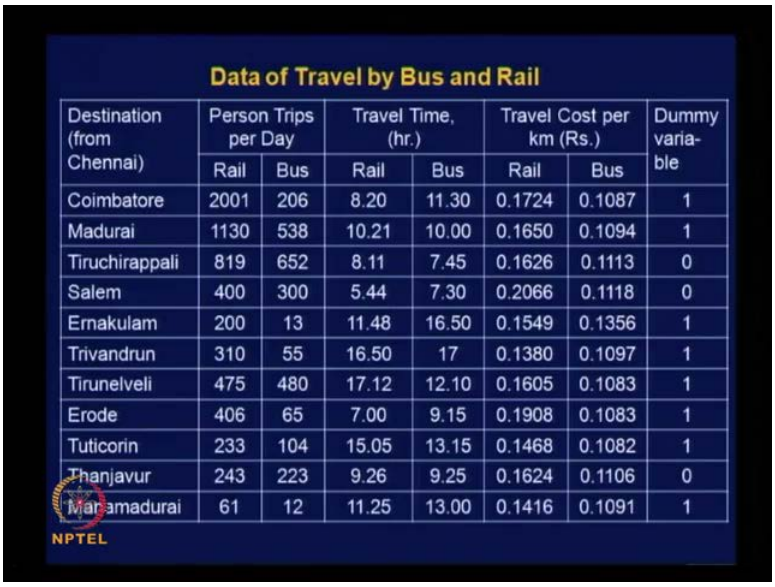
So, look for a time period where the demand is not very high. Demand is not exceeding the capacity and collect your data at that point of time. So, that everybody who desire to take the particular mode was able to get a Seat, a Birth, and then able to make the journey.

(Refer Slide Time: 35:23)



Normally under our condition in this condition pertaining to these two states September was found to be having quite normal demand not any peak demand condition. So, data pertaining to the month of September was collected. In fact, a monthly data was collected even though weekly is sufficient. A data pertaining to 4 weeks were collected and then daily average was worked out both in the case of bus as well as train. So, that data is it more constant and reflects the overall average travel matter. Now, let us look at the data base.

(Refer Slide Time: 36:04)



Destination (from Chennai)	Person Trips per Day		Travel Time, (hr.)		Travel Cost per km (Rs.)		Dummy variable
	Rail	Bus	Rail	Bus	Rail	Bus	
Coimbatore	2001	206	8.20	11.30	0.1724	0.1087	1
Madurai	1130	538	10.21	10.00	0.1650	0.1094	1
Tiruchirappali	819	652	8.11	7.45	0.1626	0.1113	0
Salem	400	300	5.44	7.30	0.2066	0.1118	0
Ernakulam	200	13	11.48	16.50	0.1549	0.1356	1
Trivandrun	310	55	16.50	17	0.1380	0.1097	1
Tirunelveli	475	480	17.12	12.10	0.1605	0.1083	1
Erode	406	65	7.00	9.15	0.1908	0.1083	1
Tuticorin	233	104	15.05	13.15	0.1468	0.1082	1
Thanjavur	243	223	9.26	9.25	0.1624	0.1106	0
Mar amadurai	61	12	11.25	13.00	0.1416	0.1091	1

This is the information collected remember when we say person trips per day. It is daily average of 1 month travel for both the modes, but it is daily travel data. And the travel time in hours actual travel time as per their time table and travel cost per kilometer was worked out considering the minimum of the travel time involved in a particular city path considering the two modes. If you work out travel time per kilometer taking different travel distances for these two modes that will not reflect the real influence of a time. Consider both the modes look at the travel time take the minimum of the 2 and then total cost travel cost is known to us by train as well as bus.

Work out those costs by the same travel distance. So, that the relative merit or demerit of each of the modes for that particular city pair is reflected. You understand for a particular city pair the train route may be little circuits, bus route may be little shorter. In that case what will happen more people may choose bus compare to train. So, this has to be brought in to your modeling process. That is why for each city Pair take the shortest distance then divide the total fair by train as well as bus by their distance to get per kilometer pair that is what was done the number of you see here are worked out based on this particular worksheet.

And you can see interestingly in all the cases train fair is higher that bus fair. In spite of the manipulations done in getting it is true at the time of doing the calculation most situation train fair is more than bus fair per kilometer rate. And the travel time off course various and you can see the influenced travel time on modal share.

You take this case travel from Chennai to Salem the travel time implication is just 5 hours 5.44 by train and 7.30 hours by bus the share is almost same 300, 400. When the travel time is more than 10 hours say for example, let's say Madurai 10.21 travel time. You can see shared by busses decreasing considerably and train share is increasing within the state. And if you take interstate travel, because interstate bus service is limited. The availability of seats in the busses becomes much less. So, that is also one of the factors. Are the system itself is like that, because of that you see for Ernakulum for example, the travel time is 11.48. 200 in train and only 30 in by bus it does not mean that only 30 passengers travel by bus, because there are no seats available in bus.

There is no demand for bus service for very long distance. Services are operate based on demand. So, that is how you must understand this numbers. Very interesting numbers

very widely spread the range is very wide. And look at the dummy variables can you guess the range of travel distance that might have been considered to give value of 1 and 0 for Q from this table.

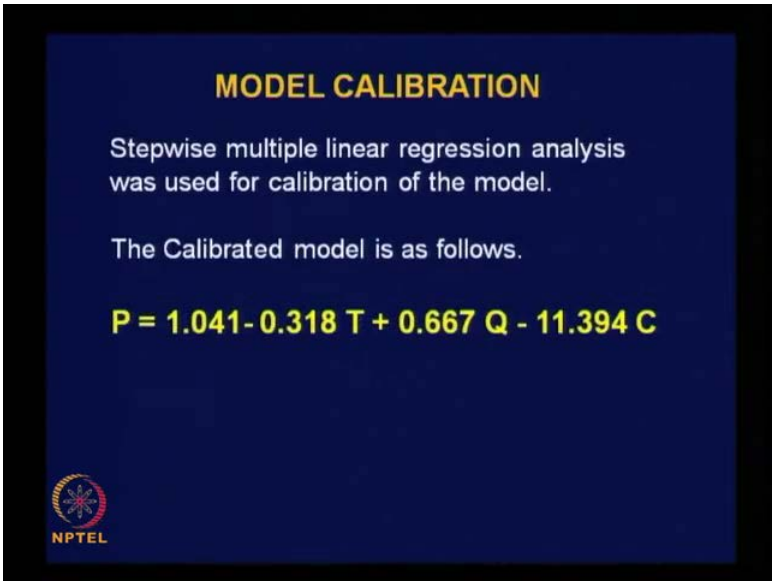
The travel time difference between the rail and bus when it was just less than two they preferred bus and as you said intercity they preferred train interstate they preferred train. That is fine my question is related to fixing a limiting value for travel distance, travel time can be fixed as limiting value, but travel time depends upon the route length also. So, that is how travel distance was found to be convenient to be a criteria. A limiting value to assign value is for Q and 400 kilometers. 400 kilometers was the limiting value fixed to assign value for Q. If the travel distance is less than 400 kilometers the value was 0 and if it is more than 400 kilometers Q will take the value 1.

400 kilometers means approximately, how many hours of travel what is the average earning speed by bus or train under our condition. About 50 kilometers per hour maximum. 50 kilometer per hour journey speed maximum the higher side. 50 kilometers per hour means to travel 400 kilometers how many hours 8 hours; obviously, when the travel time is more than 8 hours we prefer more train than a bus. So, that is how. In fact, passenger interview survey was conducted for this purpose to hit this 400 at the railway station. And based on the response given by train travelers 400 kilometer was taken as the limiting distance to assign value for the W D V.

(Refer Slide Time: 42:49)

And similarly for other city bus, there are totally 26 city bus involved in Chennai and all other cities, and you can see the very small values like 11, its only per day in the case of Trichur and so on. And you can see in general that the value of q is most case is 1, and in very few cases it is 0, because it is comparison between train and bus for intercity travel. It is better to avoid very short distance travel like Chennai to Changalpet involving less than 100 kilometers, there will be so many other services available. Even van services may be run. So, it may not really reflect the two motor situation unless we take all our possible modes into the account. Keeping that in mind the minimum distance involve also considered as a criteria while choosing the city bus.

(Refer Slide Time: 44:03)

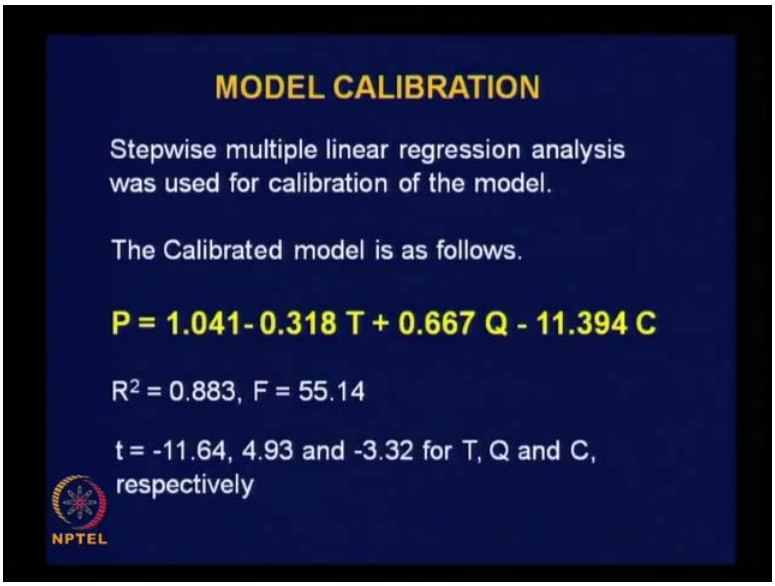


Now, modal calibration was done using this information. What is the information available to us the actual travel by train and bus is known. Capital P T and capital P B is known to us. So, we know the value of P. ln of P T minus ln of P B will give you the value of p. So the information is known to us on the right hand side. We know the value of Q for every city pair. We know the value of T. T T minus T B is known to us, we know the value of C. C T minus C B is also known to us. Substitute all the known values and get the values of the coefficient.

So, this is how the regression equation was calibrated and this is the result of calibration. Even though it is a simple regression equation you must accept this as your mode choice modal for a binary choice situation, when there are 2 modes involved this is the modal.

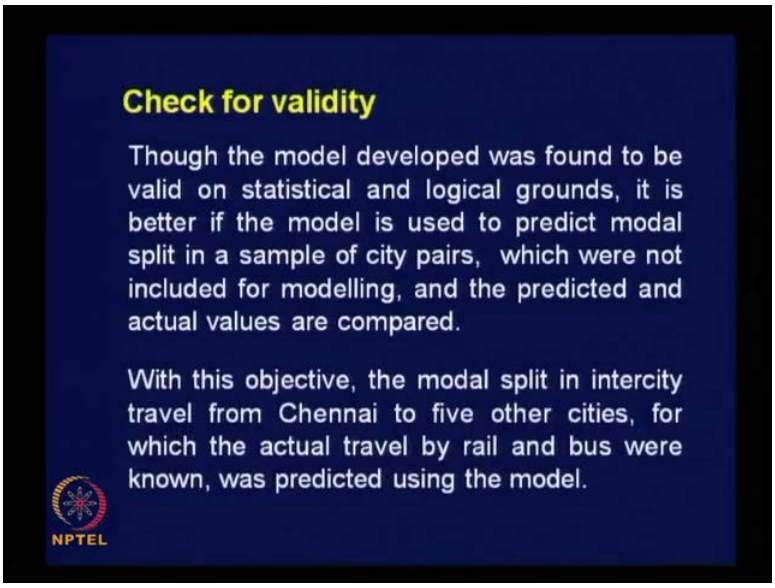
You can directly get the mode choice. Probability of choice of any one of the alternatives.

(Refer Slide Time: 45:19)



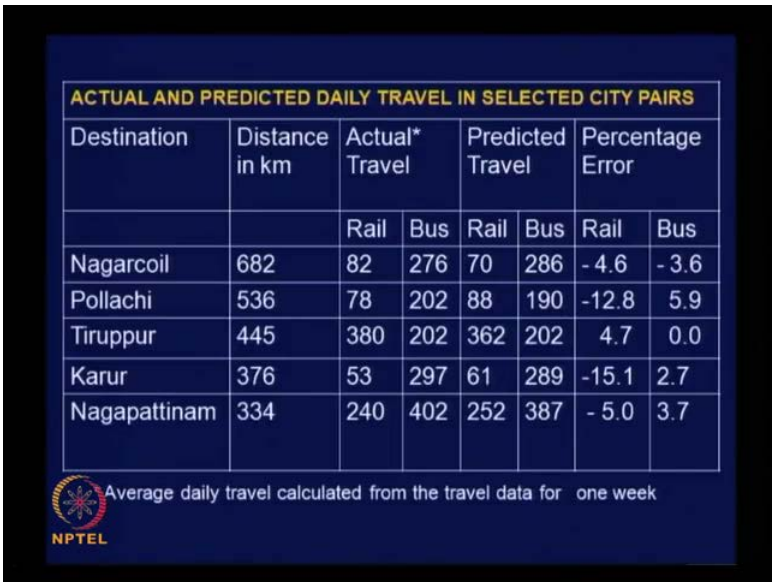
And R square value was quite high 0.883 and F statistics you are not familiar with F statistics this will come to know late when you take probability statistics course. This is also an indicator of overall goodness of the regression modal. And t values were also calculated and were found to be much higher. Much higher than the table value of t. So, the modal was found to be statistically significant what is your comment upon the logical correctness of the modal. You have some plus and minus sign. More the travel time less will be the demand for particular mode. See travel time will have a decreasing effect on the dependent variable. Travel cost also will have a decreasing effect on the dependent variable. Since we have a dummy variable taking values of 0 and 1. It should naturally have a positive sign. So, we can say this modal is both logically as well as statistically sound.

(Refer Slide Time: 46:34)



And it is better to check for the validity of the modal in practice it is better to apply this modal for another situation, where you actually know the modal share. Use the modal and get theoretically in the modal share and compare the actually observed and modal estimated modal share and check whether both are reasonably same. That is what was done in this particular case for this purpose the modal split in intercity travel from Chennai to five other cities for, which the actual travel by rail and bus were known was predicted using the model.

(Refer Slide Time: 47:27)

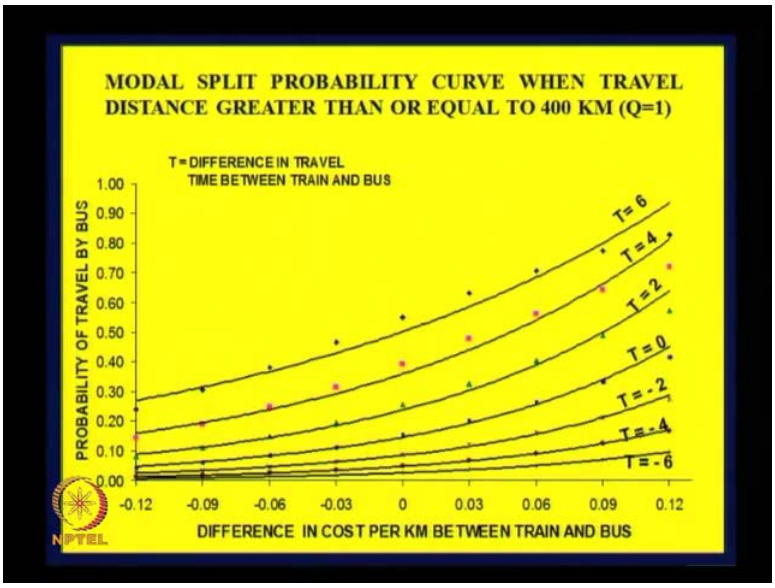


And the actual known value was compared with modal predicted. This is the comparison the city pairs considered were Chennai - Nagarcoil, Chennai - Pollachi, Chennai - Thirupur, Chennai - Karur, and Chennai - Nagapattinam 5 city branch. You can see the distances for information given here and in this particular case you have Q value to be 0 for 2 city bus in the other city bus and other city bus will have Q to be one. Actual travel by rail and bus are given here and predicted values using the modal are given here and percentage error is also shown. It varies in one case for Karur, we will get minus 15.1.

And for Pollachi we get 12 minus 12.8 percent and there are special reasons for getting little higher value if you look into the actual route followed by the two modes right and other alternative available over part of the stretch exedra. You will be able to reason out for the higher error, but overall this kind of error up to 12 percent even 15 percent. When you take things at a micro macro level it is possible to get such error, but you should not get carried away by a result one city pair. If you want to make sure apply the modal again for another set of data and check for the correctness. One particular case the error may be due to some specific reason, nothing wrong in getting a results only thing is you should be able to reason out as to why a you are getting result if your able to then you’re a successful modeler.

Generally we can say that this modal is acceptable and good enough to analyze mode choice for a binary choice situation. This is fine, but for decision makers. If you want to really present your analysis for the purpose of making policy decisions. How to present your modal is the question ideally we must present the results of any analysis in a pictorial form. Graphical presentation is more impressive and easy to understand by managers and decision makers.

(Refer Slide Time: 50:06)



For that purpose this kind of plots are made its nothing difficult what we have done is we have taken the difference in cost per kilometer between train and bus. T T minus T B is taken in X axis. Probability of travel by bus is taken on Y axis. And we have made different plots for different travel time differences considering one case where Q is equal to 1.

We have considered city pairs with travel distance more than 400 kilometers is that is the situation this is the result of your mode choice analysis. Let us say currently T T minus T B is 0.03 and the system manager of the train. System manager is interested to know what will happen off course travel time, let us say it has no difference at all. Then the share by bus for this given situation is about 20 percent probability of choice of bus is going to be 20 percent if the T value is 0.03 and T value is 0 the probability of choice of bus is going to be 0.2.

Let us say the railways is interested increase of fair in such a way that the cost difference T T minus T B becomes 0.06. And for the same situation where there is no travel time difference at all. What will happen, what will be the implication you find that you share by bus is going to be at least 25 percent, there is going to be a shift of travelers from train to bus. So, that the share of bus increases by 5 percent very simple presentation of the results.

This is what the system managers look for if I do this what will be the scenario what will happen to my operating system whether I will be losing if extent. So, this is how we can present the modeling result. So, that it is really the useful tool for decision making process. A similar presentation can be made for case where Q is equal to 0, when travel distance between city pairs is less than 400 kilometers. So, with this, we will conclude our discussion for today. To summarize we started our discussion about application of logit model for a binary choice situation, and then we found that it is possible to manipulate the same logit modal to get transformed into a simple linear regression equation, which can be used to analyze mode choice situation, when only 2 modes are involved.

Then we also seen a case study involved in intercity travel between the involving the choice of train and bus. And we discussed this example with specific reference to the complexities involved in data collection process. We have to be very, very careful in creating the database; once your database is perfect then modeling process can be very smooth, giving you very useful results. We will continue the discussion in next class.