Urban Land use and Transportation Planning
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Lecture-31
Travel demand forecasting and Trip generation

In lecture 31 is on travel demand forecasting and trip generation.

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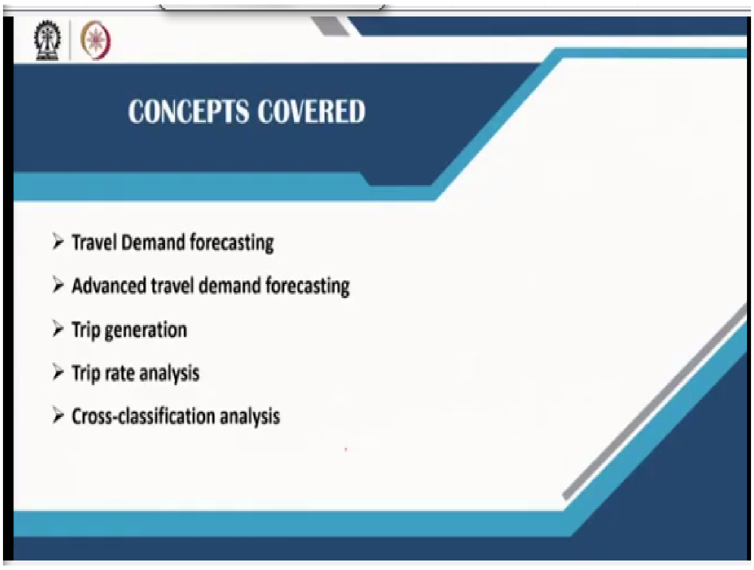

The different concepts that would be covered in this lecture are on travel demand forecasting, trip generation, trip rate analysis and cross-classification analysis.

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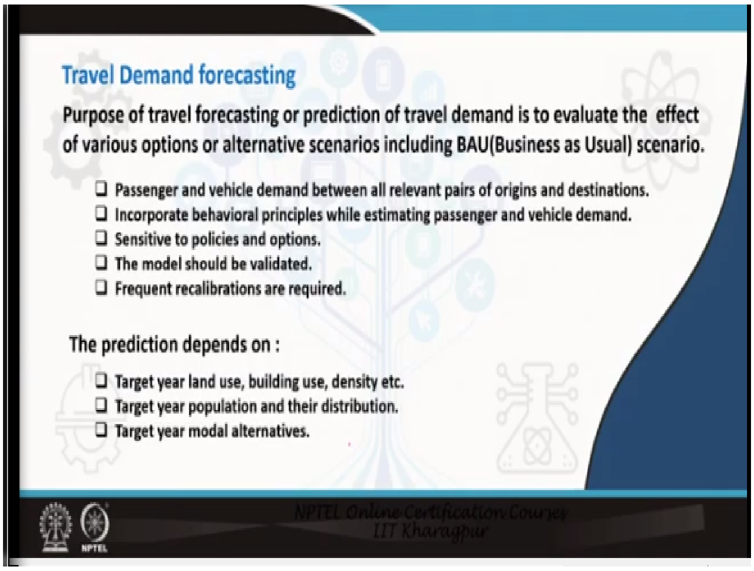

Travel Demand Forecasting

The purpose of travel demand forecasting or prediction of travel demand is to evaluate the effect of various options or alternative scenarios including the business as usual scenario. The aim is to understand that how people might travel or take their travel decisions given some changes in the social and physical aspects of the area. The focus remains on the aspects like, what mode they may choose, when they might travel, where they might travel and to determine the possible outcomes of these scenario(s). Apart from the scenario with certain changes, the outcome of the BAU (Business as Usual) scenario is also determined i.e., the kind of travel demand that might be resulting after any given years down the line when everything remain same. The reason behind assessing multiple scenarios is to compare outcome with respect to parameters like total vehicle kilometers, total emission, etc. The salient features of this kind of study are;

- Estimation of passenger and vehicle demand between all relevant pairs of origins and destinations.
- **Incorporation of behavioral principles:** The different ways people change their choices as per different characteristics, perceptions, etc. are included in the estimation process.
- **Sensitivity of policies and options:** The sensitivity of policies and options under consideration for implementation are determined. For example, what might be the effect of 'Odd-Even' policy on a particular city; How introduction of a new mode might affect the city; How a new commercial area might impact the city.

- **Validation of model:** Any model that is developed within the travel demand forecasting framework, needs to be validated using field data.
- **Recalibrations:** These models also need to be recalibrated at certain intervals to keep the models relevant with respect to the current time period. Even though the basic characteristics that influence the decision of people might remain same, their relative effects may change. That is the reason why frequent recalibrations are required i.e., at the end of every 5 years or 10 years.

Predictions depend on target year land use, building use and density, target year population and their distribution and the target year modal alternatives. We estimate our models based on existing situation, existing datasets, existing characteristics and then we use these models to predict for target year land use, building use, population, their distribution etc. while considering modal alternatives which would be available in future.

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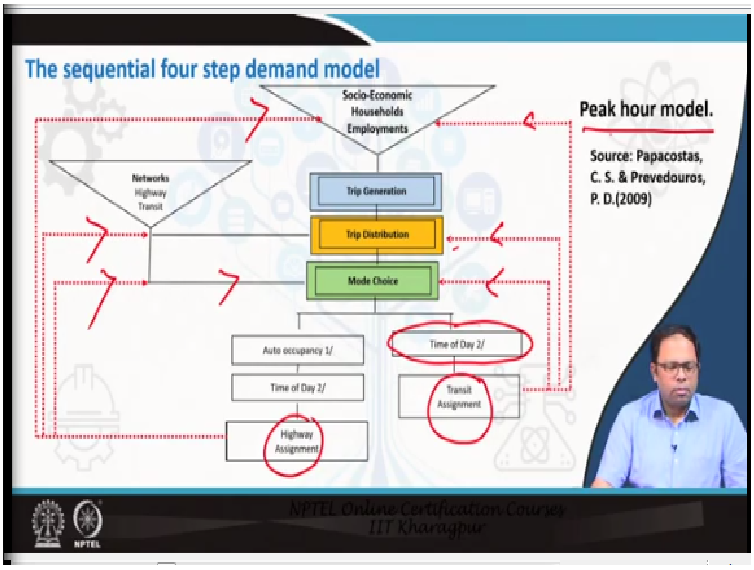

Sequential four step travel demand model:

The diagram shown here has been taken from Papacostas & Prevedouros (2009). The sequential four step travel demand model starts with socio-economic and household characteristics, number of households, and the number of employments in different zones. This data is used to determine the number of trips which are generated which essentially has two components, number of trips produced and number of trips attracted in different zones. Trips can be classified based on purpose, time of day etc. Based on trip purpose, trips can be classified into work trips, education trips, shopping trips, recreation trips, and other trips. Work and education trips are called mandatory trips while other trips can be called as discretionary trips. All of these are normally home based trips and constitute around 80-85% of the total number of trips. The small percentage of non-home based trips are treated separately in models. Also, trips can be classified into peak-hour and off-peak hour trips, based on time of day; and can be classified based on the socio-economic group the trip maker belongs to as well. Once we have done trip generation, we develop our trip distribution model, which actually helps us to understand how many trips are undertaken from one area to another area or from one zone to another zone. This could be happening in both ways like we can start with one zone and go to another zone. And again in the evening we will return from that other zone to the first zone. So, the origins and destinations actually interchange during the different trips. For each zone, we have a certain number of trip produced by it, and certain number of trips attracted by to it. While doing trip distribution, we also require data from the networks like the highway network or the transit network or the road network. The data that we require are the travel time along each link in the network So, in the development of the trip distribution model, the distance between different zones plays a major role, along with the total number of trips that are generated and attracted at those zones and this is used to predict the total number of trips that would be distributed among different zones.

After trip distribution, the next choice is to determine the mode choice. Mode choice can be a bit tricky in the sense, it may depend on certain things like, time of the day, or destination of a trip. Mode choice is determined for each i^{th} to j^{th} zone, so the dependency on destination is automatically taken into consideration. Further, time of day, as in peak-hour and non-peak hour can be also taken into consideration by developing models for each and every hour. Next, we can consider people using cars or two wheelers or public transit separately. Public transit can be of different types like be rail or bus and so on. Thus, alternatives in a mode choice model can be of 2 broad categories, one which utilizes the transit network and the other the highway or the road network. When the highway network is under consideration, input from the highway network like, travel time taken by different modes, which is actually a highly influential factor in case of mode choice is required**.** Similarly, the travel time taken by different transit modes influence the mode choice of transit alternatives. Travel time taken by transit also influences the trip distribution by transit as well. So, a feedback loop exists which connects to the initial models which implies that estimation is done after a certain number of iterations.

Car can have a single occupancy, or multiple occupancy and several people can also join to go in a single car i.e. carpooling. Thus, we can develop mode choice models for single occupancy car i.e., drive alone, shared ride with one passenger, shared drive with 2 passenger, etc. Likewise the car choices can be expanded and corresponding travel time inputs can be taken from the highway travel times.

Next, we need to assign these trips to a highway segment. We assign these trips, based on different times of the day, to a particular highway segment or a particular route which is further comprised of many links. This is done for every movement between one zone to another. The sum of all the trips for each and every link is called trip assignment. The assignment process for transit and highway is different. When more number of cars are assigned to a particular route or a particular link, the travel times will be affected. As shown in the figure, this actually leads to change in the trip generation, trip distribution and mode choice. These are the feedback loops in the model. So iteration is undertaken several times and when the changes are more or less stabilized, we stop iterating the model any further and we report the travel demand for that particular city. In most cases, people only develop a peak hour model. After trip distribution and more choice, peak hour time period is selected and then the number of vehicles moving during the peak hour is determined. Capacities of highways or transit are determined based on that peak hour model. It is done so because we understand that during the peak hour, the network is the at its highest stress. Capacities based on peak hour also ensure the adequacy for any other time periods of the day.

However, assessment of the capacity of the highway or the transit network is not the only motive. We also need to understand the distribution of travel demand during the entire day because there are several modes which depend on that. Certain choices of modes and destinations are dependent on time of the day and that is why a full day model is required. We can divide the entire day into some homogeneous time periods or for every hour and accordingly prediction for trip distribution, mode choice and then highway and transit assignment can be undertaken. So, this is the sequential four step travel demand model.

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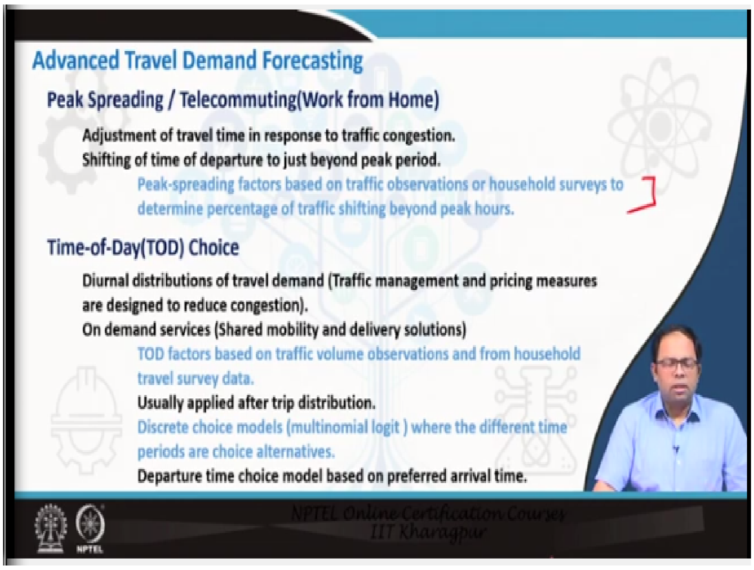

Advanced Travel Demand Forecasting:

Peak Spreading/ Telecommuting:

Contrary to the basic travel demand models, in advance travel demand models we have to look beyond the peak hour. We need to be thinking about the travel demand all throughout the day. The reason is, there are certain policies like 'peak-spreading', that means dissolving the peak load into the adjacent time segments, so that the overall network dependencies, capacity requirement and amount of congestion reduces. This further results in lesser pollution and travel time. Policies like telecommuting or work from home, staggering trips, etc. can also be tested as these have become pretty common these days. People might choose to go to office on particular days of week and 'work-from-home' for the rest of the days of week. Trips can even be staggered by people to avoid the peak hour, and eventually people might inculcate this habit of traveling during off-peak hours. These kind of strategies/ policies requires understanding the response of people to traffic congestion as these may obviously lead to other type of mode choices and travel demand estimates.

We also need to understand that how travel time, congestion and link travel times influences the shifting of the time of departure, i.e., is it going to be shifted to the adjacent to peak period(s), or is it going to be spread across multiple periods. Peak spreading factors also needs to be determined, which is done based on surveys. Traffic observations, household surveys help to understand the percentage of daily trip shifting beyond the peak hours. Stated preference surveys can be used in these kind of studies where people are subjected to hypothetical scenarios with the interventions like congestion pricing or toll for a particular area to understand their response to congestion.

Time of Day (ToD) choice:

Time-of-day (ToD) choice is choosing a particular time of day during which the decision maker wants to travel. From the diurnal distributions of travel demand, we need to understand the travel behaviour with respect to ToD, which can help to device traffic management measures and pricing measures with the aim at reducing congestion for the given travel demand by spreading the demand across multiple periods. On demand traffic services like shared mobility and delivery solutions depend upon the overall daily demand and this demand varies from time to time throughout the day. Based on the demand variation, adequate number of vehicles and delivery agents needs to be supplied to ensure a profitable business. Hence, the demand variation throughout the day helps in determining the impending vehicular load on the network or system. So, overall daily demand needs to be broken down into demand in different time periods. A taxi company like Uber would probably like to know what is the spread of the demand all throughout the day, and accordingly it will make sure that it ensures its driving partners or drivers who will be supplying vehicles during that time periods, are present in the network.

ToD factors are determined based on traffic volume observations and from household travel survey data. Usually ToD of the trip is determined after the trip distribution. So, once we know that a person will go from zone A to zone B, then only we determine at which time of the day he or she will go. According to the ToD we also determine the departure location, departure choice as well as the mode choice.

Usually discrete choice models like multinomial logit models are used where different time periods are there in the choice set. Through the discrete choice model, we try to infer which time period a person is likely to choose. Also, a person might as well decide his/ her departure time based on his/ her intention to arrive at the destination at a particular time. Hence, departure time choice model is also based on preferred arrival time.

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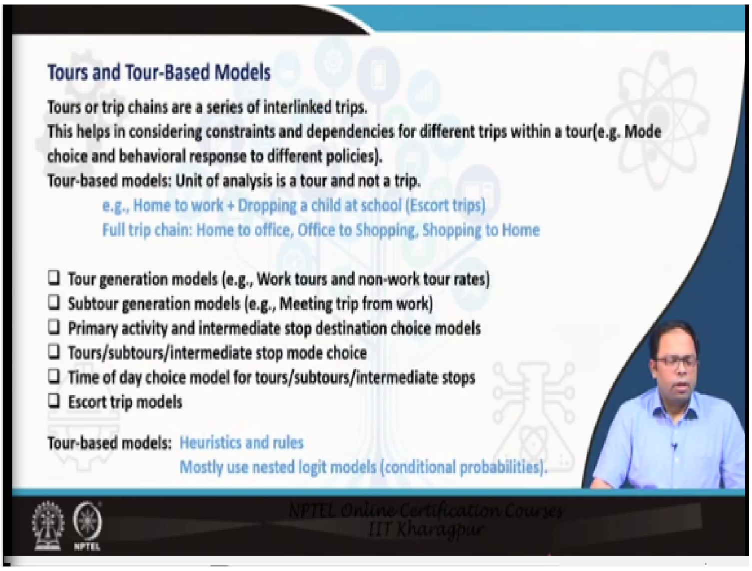

Tours and Tour-Based Models:

On one hand where classical 4-stage models consider trips as the unit of analysis, there are other kind of models that consider tours as unit of analysis. Let us consider a woman starting in the morning to go to office. In the evening she goes for shopping from the office and then returns back to home after shopping. In trip based model, we are required to find mode choice for each of the individual trips i.e. home-to-office, office-to-market, and market-to-home. All these three linked trips comprise a single tour. Let us consider that the woman uses her car to go to office, and one fine day she took a detour to market while coming back home. The trip based mode choice model might show car as the selected mode for going to office and coming back to home, but it may show transit as the mode to come from market to home, which is counterintuitive. This is an inconsistency that we may encounter with trip based models, and the very motivation behind developing tour based models. Tours or trip chains are a series of interlinked trips. Modelling based on tours help in considering constraints and dependencies for different trips within a tour which further affects the modal choice and behavioral response to different policies. For example, A change in the congestion only during morning peak hour (due to a congestion pricing policy) will affect the mode choice which will affect all the other trip choices within that particular tour such that a person's home to office and back to home tour would be affected because of congestion pricing policy in the morning itself. So, that is why this constraints and dependencies help us to determine mode choices or travel demand in a much better way and this makes tour based models more robust.

There can be many application of tour-based modelling. Few are enlisted below:

- Tour generation models, which can be again divided into work tours and non-work tours can be developed. We can also determine tour rates, i.e. how many of tours happen per day in particular type of household, hence enabling us to estimate the total number of tours that are generated for different kinds of household.
- There can also be sub-tour generation models within tour. For example, a meeting trip from work and back to office could be a sub tour within a bigger tour like home to office to home.
- We can also develop primary activity and intermediate stop destination choice models. For example, determining which is the primary activity, which is the intermediate choice, in a tour. For example, work is a primary activity and going to shopping is the intermediate stop destination.
- Mode choice models can be also developed for each of these tours or sub tours or intermediate stop choices.
- A time of the day choice model can be developed for tours, sub-tours, and intermediate stops.
- Escort trip models can be developed for determining which segment of the tour would be an escort trip.

Usually tour base models are more complicated than trip based models, where the prediction of distribution, time of day, mode choice is pretty simple. In tour based model, we have to be aware of the entire trip chain, and we need to understand what is allowed and what are not which results in the introduction of several constraints and rules. Each tour is each segment of the tour is not determined independently. It is a conditional decision which means a decision to use a car in one or multiple trips, depends not only on those trips under consideration, but also on all the different trips that are already existing. So, that is why we use a lot of heuristics and rules for developing this kind of models and we sometimes use nested logit model where we use conditional probabilities. Nested logit model is covered in the mode choice model section, where it is shown how to develop conditional probability models i.e., where we can link several decisions which are linked with one another; and together we can estimate the choices made during each of these decisions.

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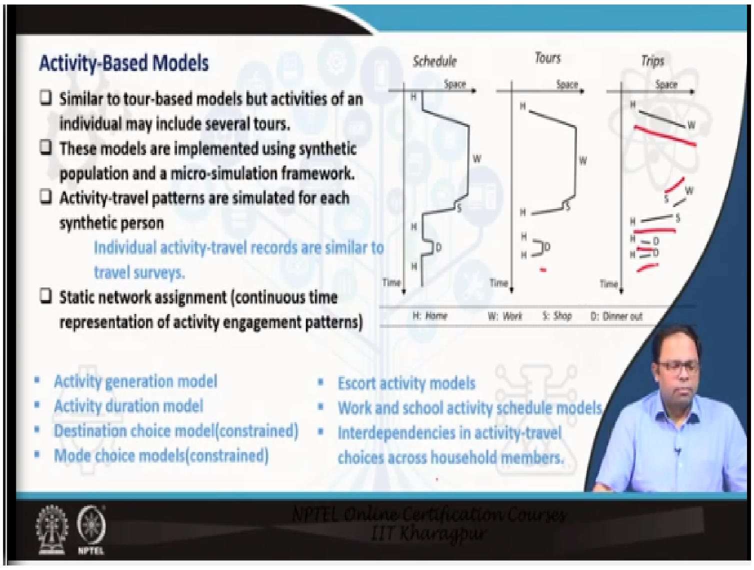

Activity-Based Models:

In trip based models, we have multiple trips like *home-to-work*, *work-to-shopping*, *shopping-to-home*, *home-to-dining*, *dining-to-home*. So, in this case, we need to develop models for each of the different types of trips. In other words, determination of trip rates, determination of the distribution, determination of the mode choice for all the trips mentioned. Whereas, in a tour based model, we see *home-to-work*, *work-to-shopping*, and *shopping-to-home* as entirely one tour. So, all these decisions are joint decisions or linked decisions. Which means, decision to choose a mode from *home-to-work* is dependent on *work-to-shop* and then from *shop-to-home* and so on. Similarly, we have *home-to-dining* and then back to home as another tour. So, instead of so many trips we need to model for two separate tours in a particular day. Whereas in an activity based model, we need to understand that the entire schedule for the day or the activity pattern for the day like *home-to-office-shopping-home-dining–home* is a pattern in entirety and is dependent on several constraints. A person’s decisions are also connected with family's decisions which makes the choice process very complicated and is said to be a joint decision process. This entire schedule could also be modelled using several rules and heuristics. Alternatively, we can also have nested logit models for the same. So, this kind of decision making is called activity based modelling.

Activity based models are based on the entire day's activities but, activities of an individual may include several tours. These models are implemented using a synthetic population and a micro simulation framework. So, for each individual we need to understand that what kind of family structure he/she belongs to. Then we need to determine the schedule for the entire day based on observed values from travel diaries of these kind of individuals in terms of socio-economic background, family structure, etc. This is done to understand the kind of decisions undertaken by individuals of a certain kind. For example, we may have a probability based on the fact that the person has a child or not; If there is a child, there is a probability of the child going to school or not; if the child goes to school, there a probability of the person escorting the child to school, at a particular destination, at a particular time of day. All these decisions are linked and together this entire decision chain is modeled and then we determine the activity schedule of a particular day of each individual. So, it is very evident that the process in very computationally intensive, with the need of lots of data for developing a realistic model. Data requirement for tour based models is higher than that of trip based models, and for activity-based models, it increases even further. At the same time, activity-based models are very policy sensitive as well. Since these models are based on behavioral data, we can achieve more accurate representation of the travel demand as compared to a tour based model.

Activity travel patterns are simulated for each synthetic person using individual activity travel records, which are similar to travel surveys. Once the activity patterns are estimated, a static network assignment can be done to obtain a representation of different time periods from the network. Then we can estimate a continuous representation of activity engagement pattern for a particular individual. Activity based modelling has got several components, few of which are mentioned below:

- Activity generation model.
- Escort activity models.
- Activity duration model to determine how long each of the activities last.
- Work and school activity schedule models.
- Destination choice models which are constrained models. Destination choice is based on time of the day.

- Mode choice models which are again constrained models based on the activity, based on the destination, based on the time of the day.
- Interdependencies in activity travel choices across household members are also considered.

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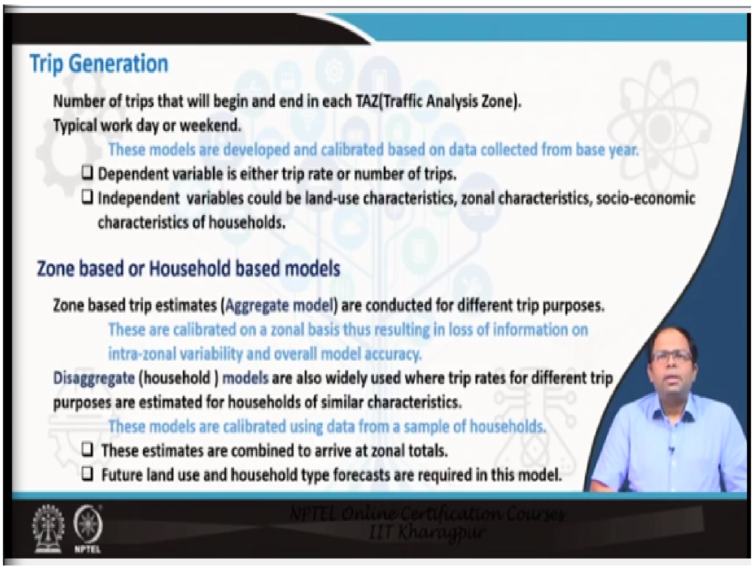

Trip Generation:

In the basic trip based models, total number of trips are determined that start and end at a particular traffic analysis zone (TAZ), during a typical workday or weekend. Since travel patterns differ between workdays and weekends, they are modelled separately. These models are further calibrated using data collected from the base year. Then coefficients of different variables are estimated that have been used in the models. The variables that are used in these models can be trip rates of different kinds of trips, or they can be simply the number of different types of trips. Trip rate could be based on household sizes, different types of households, certain kinds of land use, whereas number of trips is an aggregate measure for a particular zone. Independent variables which determine the total amount of trips generated from a particular zone or a household depends on land use characteristics, zonal characteristics, socio economic characteristics of the household etc.

As already mentioned briefly, trip generation models can be zone based as well as household based. In zone based models, also called aggregate models, the trip estimates are calculated for different trip purpose. That means we divide the trips into different purpose categories like work trip, school trip, shopping trip, recreational trip and so on. For each of these trips, we determine how many trips are generated for each zone. These models are calibrated at zonal level i.e. zone-to-zone trips and the trips that start and end in the same TAZ are not captured. As a result, information of intra zonal variability is not captured and the overall model accuracy is also compromised. At the same time, this makes the model easy to evaluate and sometimes policy analysis is also convenient. In disaggregate or household based models which are also widely used, trip rates for different trip purposes are estimated for households with similar characteristics. For this, households are categorized under certain socio economic groups and then trip rates are determined for each type of household. The total number of households of each type can be multiplied with respective trip rates to get the total number of trips made by each household category. Further, these totals can be used to get the zonal totals for number of trips generated for each zone. Future landuse and household type forecasts are also required for this kind of modelling. That means based on different kinds of households and number of households in a particular zone; land use categories and areas in the zone, like residential area, commercial area etc., and the trips generated or attracted by respective landuse, trip estimates are made.

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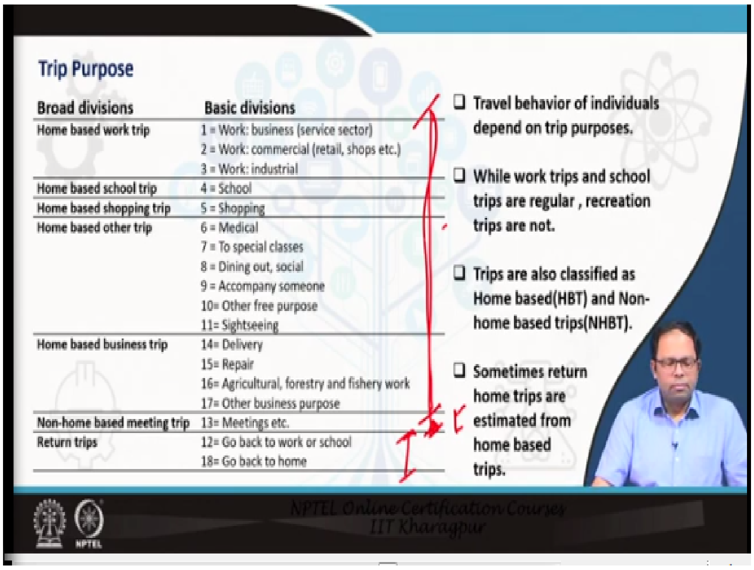

As already mentioned in the beginning, trips can be categorized in many ways, but classifying them based on purpose have been found to give better results. The given table is an example of different kinds of trip purposes that we can have. The broad division can be home based trips and non-home based trips. Home based tips can be further divided into work trips, school trips, shopping trips, business trips, and other trips. Non-home based trips are trips like meetings that start and end at non-home locations like a meeting trip that starts from office and ends at office. Work trips can be trips like business work trips, commercial work trips, industrial work trips. Other trips can be trips like medical trips, trips for special coaching/ tuitions, trips for social events/ dining out, accompanying/ escorting trips, sightseeing/ recreational trips, leisure trips. Home based business trips can be trips like delivery trips, trips for some repair work, agricultural trips, forestry trips, fishery trips, other business trips. Work trips and educational or school trips are considered regular trips and constitute around 80%-85% of the total number of trips. All the remaining types of trips are not regular trips. The motivation behind such nomenclature is that the regular trips usually has a fixed travel time, whereas the travel times for trips belonging to the other category are flexible.

Sometimes, return trips can be estimated directly from the home based trips since, trips that start from home, will eventually return back and hence are same in number as the number of home-based trip. So, during estimation, often this part is ignored and is taken care of by taking a multiple of the home based trips. This multiple is taken because most of the return trips take place during evening peak hour, and it has been found that evening peak is more spread out as compared to the morning peak but is again expected to vary from city to city.

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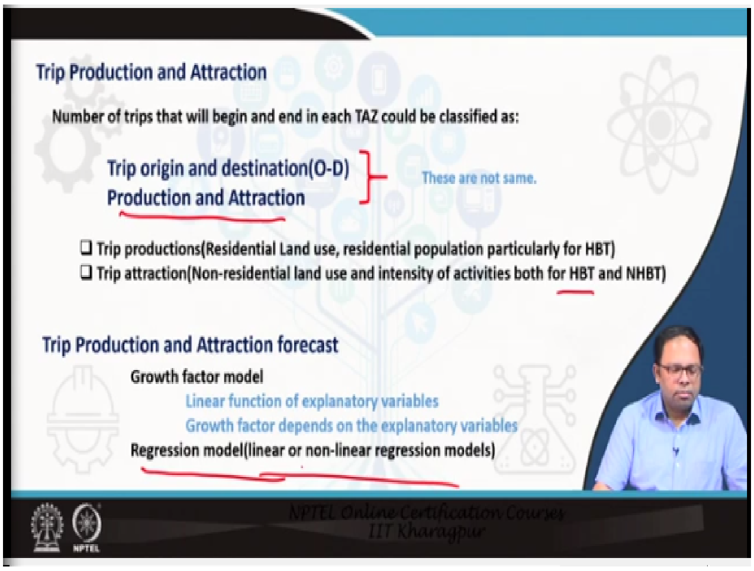

Trip production and attraction:

In trip generation models, trips beginning and ending at each TAZ needs to be determined. The trips can be classified based on trip origin and destination (O-D) or it can be classified as production and attraction. The first classification, trip origin and destination is used when we develop our travel matrices, like where the trip originates, where and where it reaches. But this classification may cause ambiguity, as an origin may become a destination during the return trip. So, production and attraction is used to classify trips as a more clear way to represent the number of trips produced from a zone, and the number of trips are attracted to a zone.

Trip productions are based on residential land use and residential population, particularly for home based trips, whereas trip attractions are based on non residential land use and intensity of activities both for home based and non-home based trips. For production of non-home based trips, non-residential landuse and intensity of activities also plays a role as meeting trips may be produced (for example: in a business district) due to these kind of landuse. Residential areas may also attract trips to a TAZ. For example: A man might have guests arriving at his place from some other TAZ, hence a home based trip is attracted to a residential area. Trip attraction is primarily the number of trips attracted both by residences as well as by non-residences.

Trip production and attraction forecasts are usually done using different models or different ways. One is the growth factor model, where we use a linear function of explanatory variables to determine the kind of growth that might happen for a particular production and attraction, for a particular zone. Growth factor of an explanatory variables is the amount of growth that is contributed by that variable. A more popular approach is the regression based model, which could be linear or a non-linear combination of explanatory variables that play a role in determining the growth of an area. The coefficients of the variables show their relationship (directly proportional/ inversely proportional) with total number of trips. Linear regression or multiple linear regression (for regression involving multiple variables) is covered in separate section.

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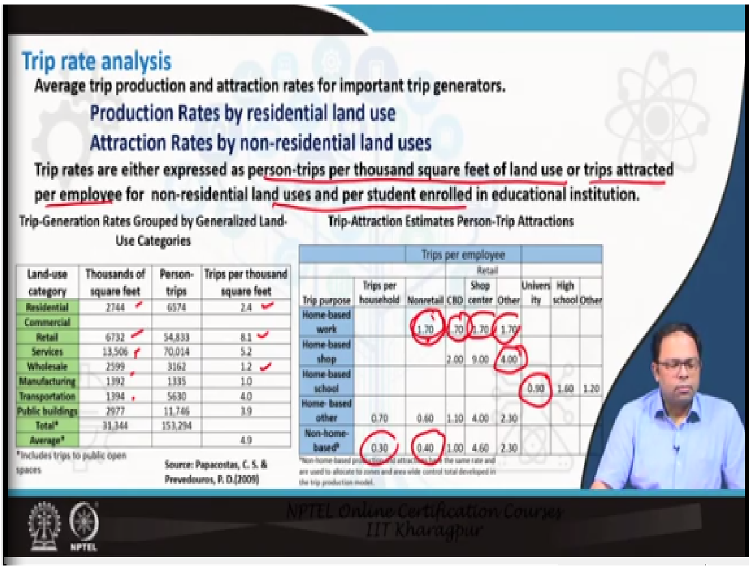

Trip rate analysis:

An example of trip rate analysis is shown where average trip production and attraction rates for important trip generators are listed. For example, production rates could be derived from residential land use, whereas attraction rates could be derived from non residential land uses. Trip rates are either expressed as '*person trips per 1000 square feet of land use*' for production, and '*trip attracted per employee for non residential land use'* and '*per student enrolled in educational institutes'* for attractions. In the 2 tables shown, for different land use categories like residential, commercial, retail and so on, for a particular zone, the area (in thousand sqft.), respective person trips, and trips rates (trips per 1000 sqft. of landuse) is given. For example, for each 1000 square feet, 2.4 trips are produced by residential area; 8.1 trips are produced by retail area; 1.2 trips are produced by wholesale areas; and so on.

Trip attractions can also be determined based on person trip estimates. As shown in the table, trips are attracted by non-retail employees and retail employees. This can be further subdivided into CBD area, Shopping center, etc. 1.7 home based work trips are attracted per employee in non-retail activities. In case of retail, the number of home based shopping trips attracted are 2 per employee in CBD, 9 per employee in shopping centers, and 4 per employee in other retail activities. If there is a university in a zone, it attracts 0.9 home based school trips per student enrolled in the institution. Non home based trips are also attracted at the rate of 0.3 trips per household, 0.4 per non retail employee, 1 per retail employee in CBD, 4.6 per retail employee in shopping centers, and 2.3 per employee in other kinds of retail activities.

So, these are the different ways trip rates can be ascertained, either based on land use or based on number of employees in a zone. Based on this, we can also estimate the total number of trips generated in a particular zone.

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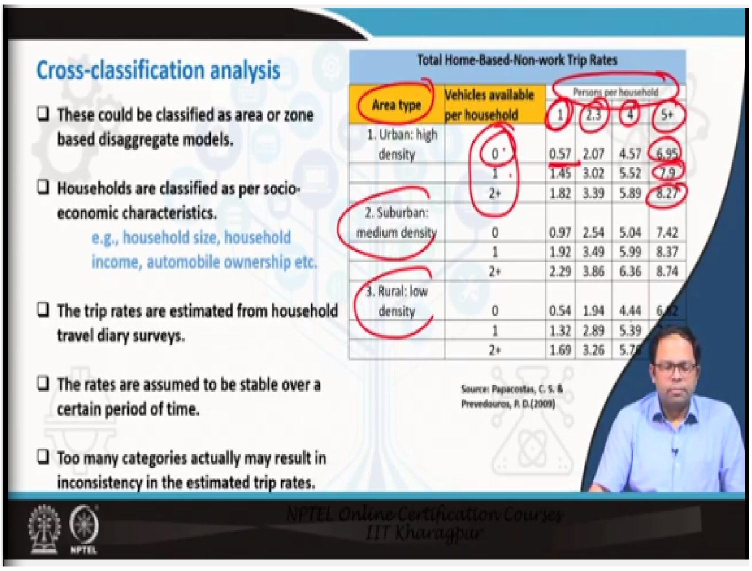

Cross classification analysis:

Cross classification analysis is another approach for trip generation modelling which could be classified as area or zone based disaggregate models. In order to carry out cross classification, households are classified as per different socio economic characteristics like household size, household income, automobile ownership, similar to how it is done in synthetic population generation for micro simulation. Different categories may have different trip rates for different types of trips. All these information can be obtained from travel diary surveys. Travel surveys of the entire household, can also help in determining what sort of trips the household members undertake. Averaging it or aggregating it over the zone for similar group of families can give us the trip rates for a particular family belonging to a particular type of household. Additionally, as the number of people in a household type changes, automatically the total number of trips will also change. So, this is how we can estimate existing trip rate and total number of trips from a zone. Trip rates estimated from household travel diaries are assumed to be stable over a certain period of time after which the surveys need to be redone.

Having too many categories often results in inconsistency in the estimated trip rates. For example, if 100 people are surveyed in a particular zone and we have around 20 categories, each category gets only 5 persons, which is very less to have a reliable estimate. So, we need to do a trade-off between number of categories and number of samples to maintain the reliability of the estimate.

The given example shows a table for the total home based non work trip rates for three kinds of areas, high density urban, medium density suburban, and low density rural. For each of the area category, household categories are shown based on the number of vehicles owned per household. Trip rates per household for different household sizes are given for each of the household categories based on the number of vehicles owned for all the three areas. So, in this way we can determine the trip rates of different kinds of families and accordingly we can determine the final total number of trips that are generated from a particular zone.

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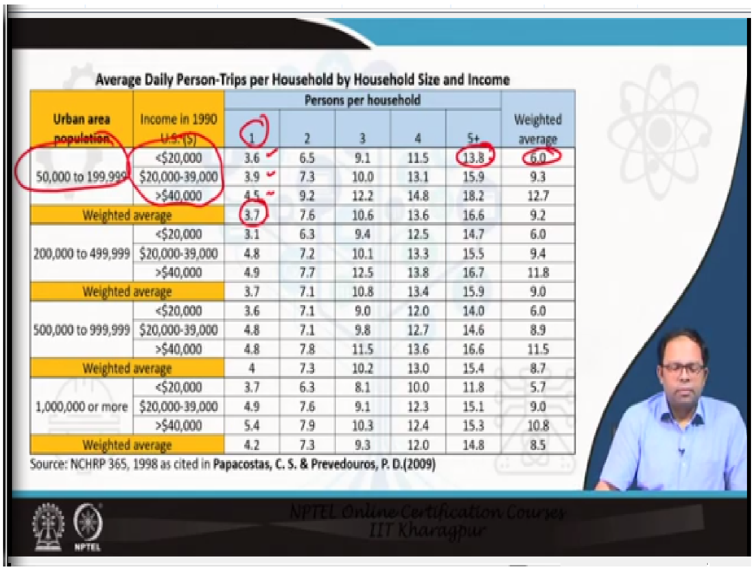

Average Daily Person-Trips per Household by Household Size and Income

Urban area population	Income in 1990 U.S. ($)	Persons per household					Weighted average
		1	2	3	4	5+	
50,000 to 199,999	<$20,000	3.6	6.5	9.1	11.5	13.8	6.0
	$20,000-39,000	3.9	7.3	10.0	13.1	15.9	9.3
	>$40,000	4.5	9.2	12.2	14.8	18.2	12.7
Weighted average		3.7	7.6	10.6	13.6	16.6	9.2
200,000 to 499,999	<$20,000	3.1	6.3	9.4	12.5	14.7	6.0
	$20,000-39,000	4.8	7.2	10.1	13.3	15.5	9.4
	>$40,000	4.9	7.7	12.5	13.8	16.7	11.8
Weighted average		3.7	7.1	10.8	13.4	15.9	9.0
500,000 to 999,999	<$20,000	3.6	7.1	9.0	12.0	14.0	6.0
	$20,000-39,000	4.8	7.1	9.8	12.7	14.6	8.9
	>$40,000	4.8	7.8	11.5	13.6	16.6	11.5
Weighted average		4	7.3	10.2	13.0	15.4	8.7
1,000,000 or more	<$20,000	3.7	6.3	8.1	10.0	11.8	5.7
	$20,000-39,000	4.9	7.6	9.1	12.3	15.1	9.0
	>$40,000	5.4	7.9	10.3	12.4	15.3	10.8
Weighted average		4.2	7.3	9.3	12.0	14.8	8.5

Source: NCHRP 365, 1998 as cited in Papacostas, C. S. & Prevedouros, P. D.(2009)

This is another example where categories have been made based on the population of an urban area (size) of 50,000- 200,000; 200,000- 500,000; 500,000- 1,000,000; 1,000,000 or more. For each size category, the population is segmented based on household income of less than 20,000; 20,000-40,000; 40,000 and more. For each of these household category (size and income), trip rated are provided based on the household size. For a particular urban area, average over income categories can be taken to obtain the trip rates based on household size for the particular urban area. Another type of inference can be made i.e., with the increase in income, tip rates are also increasing for that particular urban area. So, in this way we can interpret the entire table and this is known as a cross classification table.

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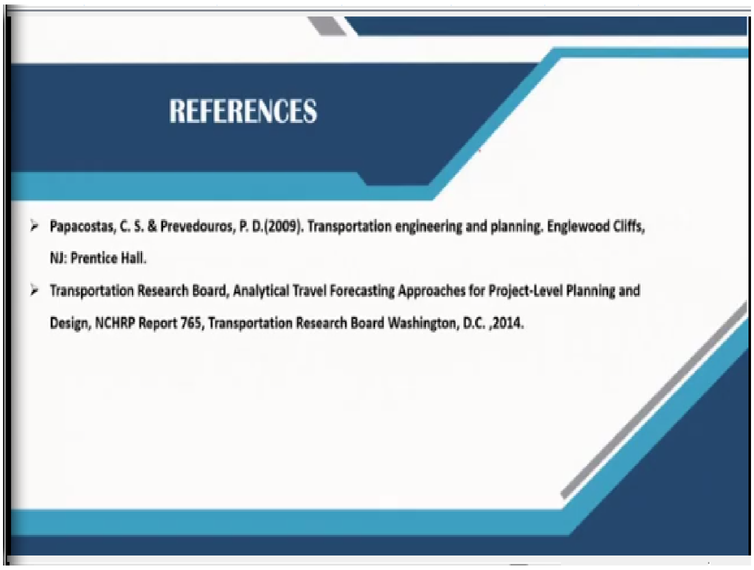

So, these are some of the references you can study.

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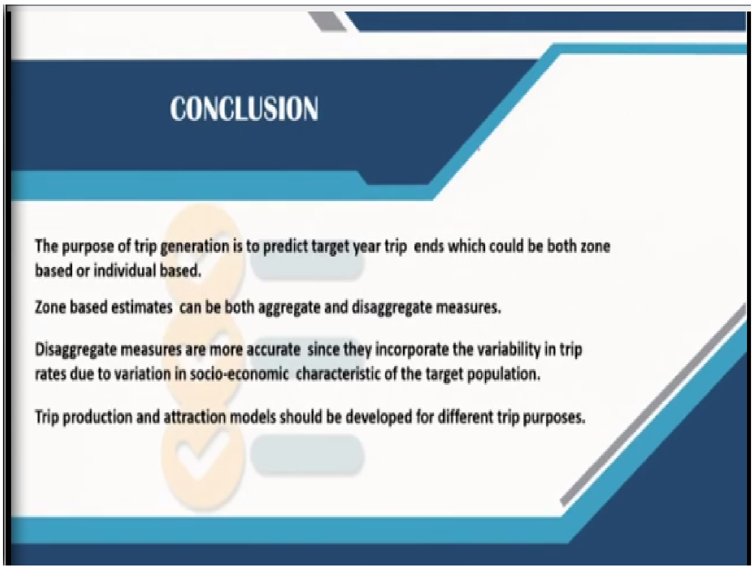

So, to conclude, the purpose of trip generation is to predict target year trip ends which could be both zone based or individual based. Zone based estimates can be both aggregate or disaggregate measures. Disaggregate measures are more accurate since, they incorporate the variability in trip rates due to variation in socio-economic characteristics of the target population. Trip production and attraction model can be developed for different trip purposes. Two ways to develop these kind of models will be covered in separate sections.