Travel Demand Modeling

Introduction

Transport Modeling is an important part of any large scale decision making process in any system. There are large number of factors that affect the performance of the system. It is not possible for the human brain to keep track of all the player in system and their interactions and interrelationships. Therefore we resort to models which are some simplified, at the same time complex enough to reproduce key relationships of the reality. Modeling could be either physical, symbolic, or mathematical In physical model one would make physical representation of the reality. For example, model aircrafts used in wind tunnel is an example of physical models. In symbolic model, with the complex relations could be represented with the help of symbols. Drawing time-space diagram of vehicle movement is a good example of symbolic models. Mathematical model is the most common type when with the help of variables, parameters, and equations one could represent highly complex relations. Newton's equations of motion or Einstein's Equation

$E = mc^2$, can be considered as examples of mathematical model.

No model is a perfect representation of the reality. The important objective is that models seek to isolate key relationships, and not to replicate the entire structure. Transport modeling is the study of the behavior of individuals in making decisions regarding the provision and use of transport. Therefore, unlike other engineering models, transport modeling tools have evolved from many disciplines like economics, psychology, geography, sociology, and statistics.

Transport Demand and Supply

The concept of demand and supply are fundamental to economic theory and is widely applied in the field to transport economics. In the area of travel demand and the associated supply of transport infrastructure, the notions of demand and supply could be applied. However, we must be aware of the fact that the transport demand is a derived demand, and not a need in itself. That is, people travel not for the sake of travel, but to practice in activities in different locations

The concept of equilibrium is central to the supply-demand analysis. It is a normal practice to plot the supply and demand curve as a function of cost and the intersection is then plotted in the equilibrium point as shown in Figure 1.

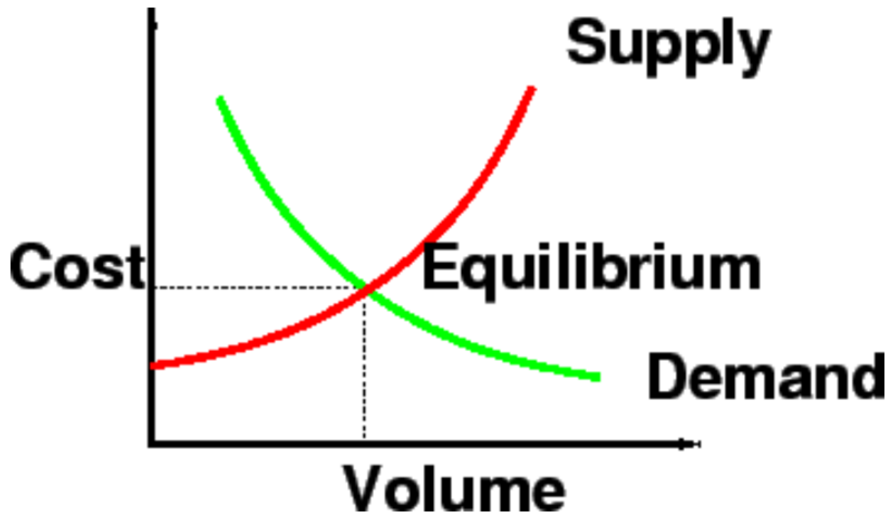

Figure 1: Demand supply equilibrium.

The demand for travel T is a function of cost C is easy to conceive. The classical approach defines the supply function as giving the quantity T which would be produced, given a market price C. Since transport demand is a derived demand, and the benefit of transportation on the non-monetary terms (time in particular), the supply function takes the form in which C is the unit cost associated with meeting a demand T. Thus, the supply function encapsulates response of the transport system to a given level of demand. In other words, supply function will answer the question what will be the level of service of the system, if the estimated demand is loaded to the system. The most common supply function is the link travel time function which relates the link volume and travel time.

Travel Demand Modelling

Travel demand modeling aims to establish the spatial distribution of travel explicitly by means of an appropriate system of zones. Modeling of demand thus implies a procedure for predicting what travel decisions people would like to make given the generalized travel cost of each alternatives. The base decisions include the choice of destination, the choice of the mode, and the choice of the route. Although various modeling approaches are adopted, we will discuss only the classical transport model popularly known as four-stage model (FSM).

The general form of the four stage model is given in Figure 2.

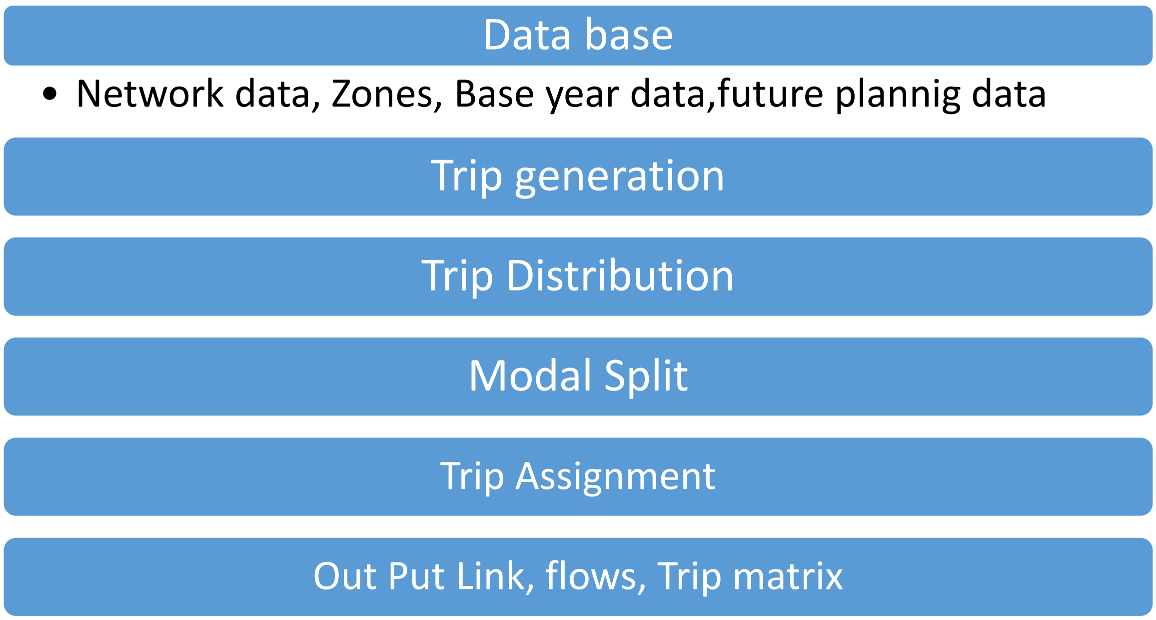

Figure 2: General form of the four stage modeling.

The classic model is presented as a sequence of four sub models: trip generation, trip distribution, modal split, trip assignment. The models starts with defining the study area and dividing them into a number of zones and considering all the transport network in the system. The database also include the current (base year) levels of population, economic activity like employment, shopping space, educational, and leisure facilities of each zone. Then the *trip generation* model is evolved which uses the above data to estimate the total number of trips generated and attracted by each zone. The next step is the allocation of these trips from each zone to various other destination zones in the study area using *trip distribution* models. The output of the above model is a trip matrix which denote the trips from each zone to every other zones. In the succeeding step the trips are allocated to different modes based on the modal attributes using the *modal split* models. This is essentially slicing the trip matrix for various modes generated to a mode specific trip matrix. Finally, each trip matrix is assigned to the route network of that particular mode using the *trip assignment models*. The step will give the loading on each link of the network.

The classical model would also be viewed as answering a series of questions (decisions) namely how many trips are generated, where they are going, on what mode they are going, and finally which route they are adopting. The current approach is to model these decisions using discrete choice theory, which allows the lower level choices to be made conditional on higher choices. For example, route choice is conditional on the mode choice. This hierarchical choices of trip is shown in Figure 3.

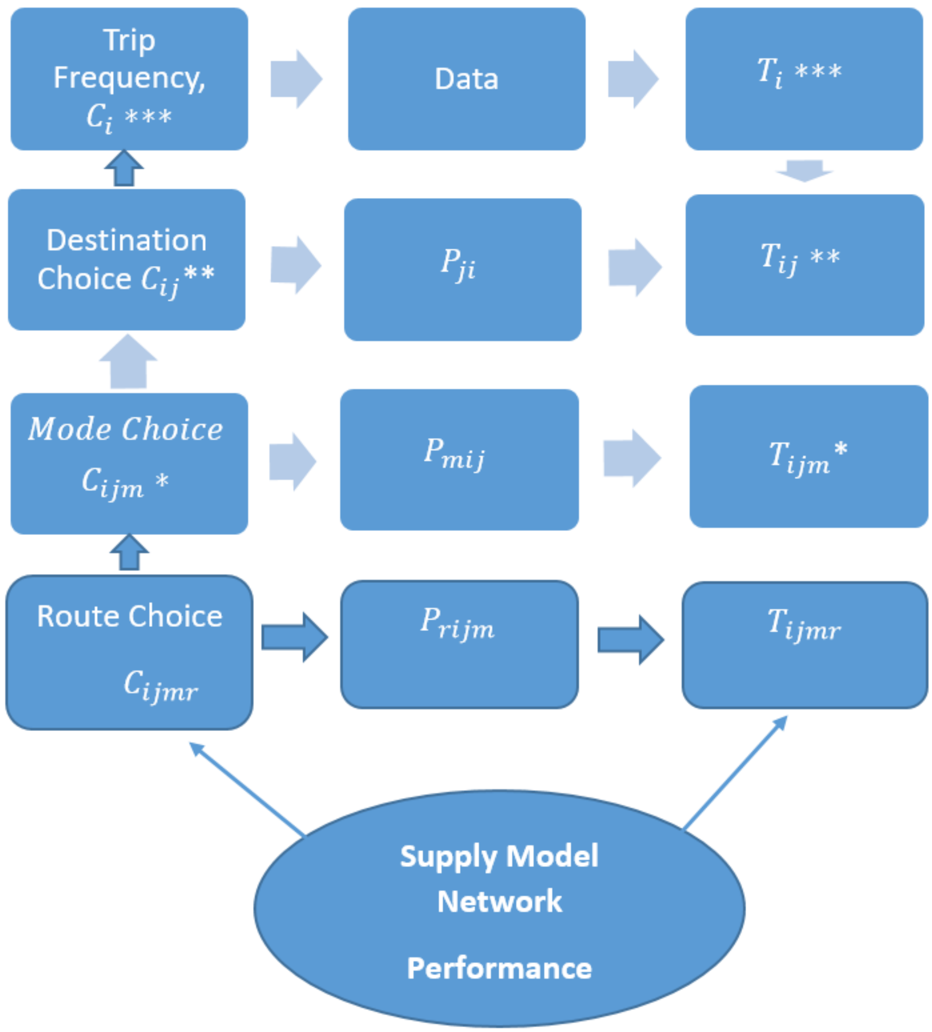

Figure 3: Demand supply equilibrium.

The highest level to find all the trips T_i originating from a zone is calculated based on the data and aggregate cost term C_{i***}. Based on the aggregate travel cost C_{ij**} from zone i to the destination zone j, the probability P_{mij} of trips going to zone i is computed and subsequently the trips T_{ij**} from zone i to zone j by all modes and all routes are computed. Next, the mode choice model compute the probability P_{mij} of choosing mode m based on the travel cost C_{jm*} from zone i to zone j, by mode m is determined. Similarly, the route choice gives the trips T_{ijmr} from zone i to zone j by mode m through route r can be computed. Finally the travel demand is loaded to the supply model, as stated earlier, will produce a performance level. The purpose of the network is usually measured in travel time which could be converted to travel cost. Although not practiced ideally, one could feed this back into the higher levels to achieve real equilibrium of the supply and demand.

The first phase of the transportation planning process deals with survey, data collection and inventory. The trip generation models strive to predict the number of trips generated by a zone. These models try to mathematically describe the decision to travel phase of the sequential demand analysis procedure. The analysis and model building phase starts with the step commonly known as trip generation. Conventionally transportation forecast is a four step process discussed below.

Trip generation

Trip generation is the first stage of the classical first generation aggregate demand models. The trip generation aims at predicting the total number of trips generated and attracted to each zone of the study area. In other words this stage answers the questions to how many trips originate at each zone, from the data on household and socioeconomic attributes.

Trip distribution

The decision to travel for a given purpose is called trip generation. These generated trips from each zone are then distributed to all other zones based on the choice of destination. This is called trip distribution which forms the second stage of travel demand modeling. There are a number of methods to distribute trips among destinations; and two such methods are growth factor model and gravity model. Growth factor model is a method which responds only to relative growth rates at origins and destinations and this is suitable for short-term trend extrapolation. In gravity model, we start from assumptions about trip making behavior and the way it is influenced by external factors. An important aspect of the use of gravity models is their calibration, which is the task of fixing their parameters so that the base year travel pattern is well represented by the model.

Mode choice

Mode choice models estimate how many people will use public transit and how many will use private automobiles. The most common form of the mode choice model is the logit model. The logit mode choice relationship states that the probability of choosing a particular mode for a given trip is based on the relative values of a number of factors such as cost, level of service, and travel time. The most difficult part of employing the logit mode choice model is estimating the parameters for the variables in the utility function. The estimation is often accomplished using one or more multivariate statistical analysis programs to optimize the accuracy of estimates of the coefficients of several independent variables.

Route assignment

Trip assignment involves assigning traffic to a transportation network such as roads and streets or a transit network. Traffic is assigned to available transit or roadway routes using a mathematical algorithm that determines the amount of traffic as a function of time, volume, capacity, or impedance factor. There are three common methods for trip assignment: all or nothing, diversion, and capacity restraint.