# Chapter 7

# Trip generation

## 7.1 Overview

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. In this section basic definitions, factors affecting trip generation, and the two main modeling approaches; namely growth factor modeling and regression modeling are discussed.

### 7.1.1 Types of trip

Some basic definitions are appropriate before we address the classification of trips in detail. We will attempt to clarify the meaning of journey, home based trip, non home based trip, trip production, trip attraction and trip generation.

Journey is an out way movement from a point of origin to a point of destination, where as the word "trip" denotes an outward and return journey. If either origin or destination of a trip is the home of the trip maker then such trips are called home based trips and the rest of the trips are called non home based trips. Trip production is defined as all the trips of home based or as the origin of the non home based trips. See figure 7:1

Trips can be classified by trip purpose, trip time of the day, and by person type. Trip generation models are found to be accurate if separate models are used based on trip purpose. The trips can be classified based on the purpose of the journey as trips for work, trips for education, trips for shopping, trips for recreation and

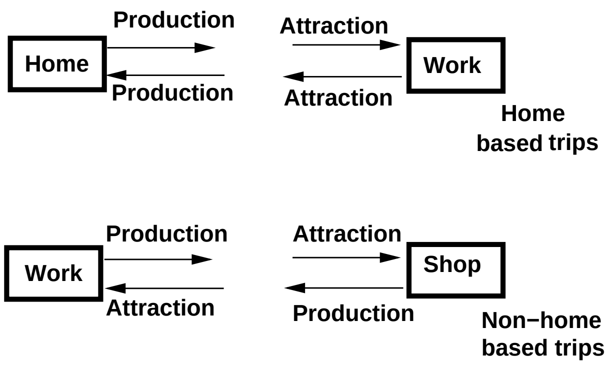


Figure 7:1: trip types

other trips. Among these the work and education trips are often referred as mandatory trips and the rest as discretionary trips. All the above trips are normally home based trips and constitute about 80 to 85 percent of trips. The rest of the trips namely non home based trips, being a small proportion are not normally treated separately. The second way of classification is based on the time of the day when the trips are made. The broad classification is into peak trips and off peak trips. The third way of classification is based on the type of the individual who makes the trips. This is important since the travel behavior is highly influenced by the socio economic attribute of the traveler and are normally categorized based on the income level, vehicle ownership and house hold size.

### 7.1.2 Factors affecting trip generation

The main factors affecting personal trip production include income, vehicle ownership, house hold structure and family size. In addition factors like value of land, residential density and accessibility are also considered for modeling at zonal levels. The personal trip attraction, on the other hand, is influenced by factors such as roofed space available for industrial, commercial and other services. At the zonal level zonal employment and accessibility are also used. In trip generation modeling in addition to personal trips, freight trips are also of interest. Although the latter comprises about 20 percent of trips, their contribution to the congestion is significant. Freight trips are influenced by number of employees, number of sales and area of commercial firms.

## 7.2 Growth factor modeling

Growth factor modes tries to predict the number of trips produced or attracted by a house hold or zone as a linear function of explanatory variables. The models have the following basic equation:

$$T_i = f_i t_i \tag{7.1}$$

where $T_i$ is the number of future trips in the zone and $t_i$ is the number of current trips in that zone and $f_i$ is a growth factor. The growth factor $f_i$ depends on the explanatory variable such as population (P) of the zone , average house hold income (I) , average vehicle ownership (V). The simplest form of $f_i$ is represented as follows

$$f_i = \frac{P_i^d \times I_i^d \times V_i^d}{P_i^c \times I_i^c \times V_i^c} \tag{7.2}$$

where the subscript " d" denotes the design year and the subscript "c" denotes the current year.

#### Example

Given that a zone has 275 household with car and 275 household without car and the average trip generation rates for each groups is respectively 5.0 and 2.5 trips per day. Assuming that in the future, all household will have a car, find the growth factor and future trips from that zone, assuming that the population and income remains constant.

#### Solution

Current trip rate $t_i = 275 \times 2.5 + 275 \times 5.0 = 2062.5$ trips / day.

Growth factor $F_i = \frac{V_i^d}{V_i^c} = \frac{550}{275} = 2.0$

Therefore, no. of future trips $T_i = F_i t_i = 2.0 \times 2062.5 = 4125$ trips / day.
The above example also shows the limitation of growth factor method. If we think intuitively, the trip rate will remain same in the future.

Therefore the number of trips in the future will be 550 house holds $\times$ 5 trips per day = 2750 trips per day .

It may be noted from the above example that the actual trips generated is much lower than the growth factor method. Therefore growth factor models are normally used in the prediction of external trips where no other methods are available. But for internal trips , regression methods are more suitable and will be discussed in the following section.

## 7.3 Regression methods

The general form of a trip generation model is

$$T_i = f(x_1, x_2, x_3, ....x_i, ...x_k) \tag{7.3}$$

Where xi's are prediction factor or explanatory variable. The most common form of trip generation model is a linear function of the form

$$T_i = a_0 + a_1 x_1 + a_2 x_2 + ...a_i x_i ... + a_k x_k \tag{7.4}$$

where $a_i$ 's are the coefficient of the regression equation and can be obtained by doing regression analysis. The above equations are called multiple linear regression equation, and the solutions are tedious to obtain manually. However for the purpose of illustration, an example with one variable is given.

**Example**

Let the trip rate of a zone is explained by the household size done from the field survey. It was found that the household size are 1, 2, 3 and 4. The trip rates of the corresponding household is as shown in the table below. Fit a linear equation relating trip rate and household size.

| Household size(x) | | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Trips | 1 | 2 | 4 | 6 |
| per | 2 | 4 | 5 | 7 |
| day(y) | 2 | 3 | 3 | 4 |
| $\Sigma y$ | 5 | 9 | 12 | 17 |

**Solution** The linear equation will have the form $y = bx + a$ where y is the trip rate, and x is the household size, a and b are the coefficients. For a best fit, b is given by

$$\begin{aligned}
b &= \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \\
a &= \bar{y} - b\bar{x} \\
\Sigma x &= 3 \times 1 + 3 \times 2 + 3 \times 3 + 3 \times 4 = 30 \\
\Sigma x^2 &= 3 \times (1^2) + 3 \times (2^2) + 3 \times (3^2) + 3 \times (4^2) = 90
\end{aligned}$$

$$
\begin{aligned}
\Sigma y &= 5+9+12+17=43 \\
\Sigma xy &= 1\times 1+1\times 2+1\times 2 \\
&+ 2\times 2+2\times 4+2\times 3 \\
&+ 3\times 4+3\times 5+3\times 3 \\
&+ 4\times 6+4\times 7+4\times 4 \\
&= 127 \\
\bar{y} &= 43/12 = 3.58 \\
\bar{x} &= 30/12 = 2.5 \\
b &= \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \\
&= \frac{((12\times 127)-(30\times 43))}{((12\times 90)-(30)^2)} = 1.3 \\
a &= \bar{y} - b\bar{x} = 3.58 - 1.3\times 2.5 = +0.33 \\
\bar{y} &= 1.3x - 0.33
\end{aligned}
$$

## 7.4 Summary

Trip generation forms the first step of four-stage travel modeling. It gives an idea about the total number of trips generated to and attracted from different zones in the study area. Growth factor modeling and regression methods can be used to predict the trips. They are discussed in detail in this chapter.

## 7.5 Problems

1. The trip rate ($y$) and the corresponding household sizes ($x$) from a sample are shown in table below. Compute the trip rate if the average household size is 3.25 (Hint: use regression method).

| | Householdsize(x) | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Trips | 1 | 3 | 4 | 5 |
| per | 3 | 4 | 5 | 8 |
| day(y) | 3 | 5 | 7 | 8 |

**Solution** Fit the regression equation as below.

$$
\begin{aligned}
\Sigma x &= 3\times 1+3\times 2+3\times 3+3\times 4 = 30 \\
\Sigma x^2 &= 3\times (1^2)+3\times (2^2)+3\times (3^2)+3\times (4^2) = 90 \\
\Sigma y &= 7+12+16+21 = 56 \\
\Sigma xy &= 1\times 1+1\times 3+1\times 3 \\
&+ 2\times 3+2\times 4+2\times 5 \\
&+ 3\times 4+3\times 5+3\times 7
\end{aligned}
$$

$$
\begin{aligned}
&+ \quad 4 \times 5 + 4 \times 8 + 4 \times 8 \\
&= \quad 163 \\
\bar{y} &= 56/12 = 4.67 \\
\bar{x} &= 30/12 = 2.5 \\
b &= \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \\
&= \frac{((12 \times 163) - (30 \times 56))}{((12 \times 90) - (30)^2)} = 1.533 \\
a &= \bar{y} - b\bar{x} = 4.67 - 1.533 \times 2.5 = 0.837 \\
y &= 0.837 + 1.533x
\end{aligned}
$$

When average household size =3.25, number of trips becomes,
$y = 0.837 + 1.533 \times 3.25 = 5.819$