

Data Collection

Lecture Notes in Transportation Systems Engineering

@tvm@iitb

Prof. Tom V. Mathew

@tvm@iitb

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1 Overview

The four-stage modeling, an important tool for forecasting future demand and performance of a transportation system, was developed for evaluating large-scale infrastructure projects. Therefore, the four-stage modeling is less suitable for the management and control of existing software. Since these models are applied to large systems, they require information about travelers of the area influenced by the system. Here the data requirement is very high, and may take years for the data collection, data analysis, and model development. In addition, meticulous planning and systematic approach are needed for accurate data collection and processing. This chapter covers three important aspects of data collection, namely, survey design, household data collection, and data analysis. Finally, a brief discussion of other important surveys is also presented.

2 Survey design

Designing the data collection survey for the transportation projects is not easy. It requires considerable experience, skill, and a sound understanding of the study area. It is also important to know the purpose of the study and details of the modeling approaches, since data requirement is influenced by these. Further, many practical considerations like availability of time and money also has a strong bearing on the survey design. In this section, we will discuss the basic information required from a data collection, defining the study area, dividing the area into zones, and transport network characteristics.

2.1 Information needed

Typical information required from the data collection can be grouped into four categories, enumerated as below.

1. **Socio-economic data:** Information regarding the socio-economic characteristics of the study area. Important ones include income, vehicle ownership, family size, etc. This information is essential in building trip generation and modal split models.

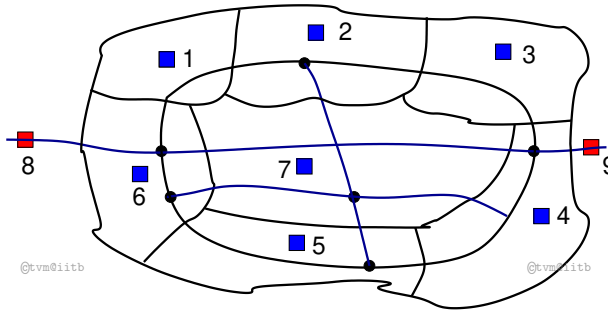


Figure 1: zoning of a study area

2. **Travel surveys:** Origin-destination travel survey at households and traffic data from cordon lines and screen lines (defined later). Former data include the number of trips made by each member of the household, the direction of travel, destination, the cost of the travel, etc. The latter include the traffic flow, speed, and travel time measurements. These data will be used primarily for the calibration of the models, especially the trip distribution models.
3. **Land use inventory:** This includes data on the housing density at residential zones, establishments at commercial and industrial zones. This data is especially useful for trip generation models.
4. **Network data:** This includes data on the transport network and existing inventories. Transport network data includes road network, traffic signals, junctions etc. The service inventories include data on public and private transport networks. These particulars are useful for the model calibration, especially for the assignment models.

2.2 Study area

Once the nature of the study is identified, the study area can be defined to encompass the area of expected policy impact. The study area need not be confirmed by political boundaries, but bounded by the area influenced by the transportation systems. The boundary of the study area is defined by what is called as *external cordon* or simply the cordon line. A sample of the zoning of a study area is shown in figure 1 Interactions with the area outside the cordon are defined via external stations which effectively serve as

doorways to trips, into, out of, and through the study area. In short, study area should be defined such that majority of trips have their origin and destination in the study area and should be bigger than the area-of-interest covering the transportation project.

2.3 Zoning

Once the study area is defined, it is then divided into a number of small units called traffic analysis zones (TAZ) or simply *zones*. The zone within the study area are called *internal zones*.

Zones are modeled as if all their attributes and properties were concentrated in a single point called the *zone centroid*. The centroids are connected to the nearest road junction or rail station by centroid connectors. Both centroid and centroid connectors are notional and it is assumed that all people have same travel cost from the centroid to the nearest transport facility which is the average for a zone. The intersection from outside world is normally represented through *external zones*. The external zones are defined by the catchment area of the major transport links feeding to the study area. Although the list is not complete, few guidelines are given below for selecting zones.

1. zones should match other administrative divisions, particularly census zones.
2. zones should have homogeneous characteristics, especially in land use, population etc.
3. zone boundaries should match cordon and screen lines, but should not match major roads.
4. zones should be as smaller in size as possible so that the error in aggregation caused by the assumption that all activities are concentrated at the zone centroids is minimum.

2.4 Network

Transport network consists of roads, junctions, bus stops, rails, railway station etc. Normally road network and rail network are represented separately. Road network is considered as directed graph of nodes and links. Each node and links have their own properties. Road link is normally represented with attributes like starting node, ending

node, road length, free flow speed, capacity, number of lanes or road width, type of road like divided or undivided etc. Road junctions or nodes are represented with attributes like node number, starting nodes of all links joining the current node, type of intersection (uncontrolled, round about, signalized, etc.). Similarly public transport network like bus transit network and rail network are represented, but with attributes relevant to them. These may include frequency of service, fare of travel, line capacity, station capacity etc. This completes the inventory of base-year transportation facility.

3 Household data

To understand the behavior and factors affecting the travel, one has got the origin of travel when the decision for travel is made. It is where people live as family which is the household. Therefore household data is considered to be the most basic and authentic information about the travel pattern of a city.

Ideally one should take the details of all the people in the study to get complete travel details. However, this is not feasible due to large requirement of time and resources needed. In addition this will cause difficulties in handling these large data in modeling stage. Therefore, some sample households are randomly selected and survey is conducted to get the household data. Higher sample size is required for large population size, and vice-versa. Normally minimum ten percent samples are required for population less than 50,000. But for a population more than one million require only one percent for the same accuracy.

3.1 Questionnaire design

The next step in the survey is the questionnaire design. A good design will ensure better response from the respondent and will significantly improve the quality of data. Design of questionnaire is more of an art than a science. However few guiding principles can be laid out. The questionnaire should be simple, direct, should take minimum time, and should cause minimum burden to the respondent. Traditional household survey has three major sections; household characteristics, personal characteristics, and trip details.

Household characteristics This section includes a set of questions designed to obtain socioeconomic information about the household. Relevant questions are: number of members in the house, no. of employed people, number of unemployed people, age and sex of the members in the house etc., number of two-wheelers in the house, number of cycles, number of cars in the house etc., house ownership and family income.

Personal characteristics This part includes questions designed to classify the household members (older than 5) according to the following aspects: relation to the head of the household (e.g. wife, son), sex, age, possession of a driving license, educational level, and activity.

Trip data This part of the survey aims at detecting and characterizing all trips made by the household members identified in the first part. A trip is normally defined as any movement greater than 300 meters from an origin to a destination with a given purpose. Trips are characterized on the basis of variables such as: origin and destination, trip purpose, trip start and ending times, mode used, walking distance, public-transport line and transfer station or bus stop (if applicable).

3.2 Survey administration

Once the questionnaire is ready, the next step is to conduct the actual survey with the help of enumerators. Enumerators have to be trained first by briefing them about the details of the survey and how to conduct the survey. They will be given random household addresses and the questionnaire set. They have to first get permission to be surveyed from the household. They may select a typical working day for the survey and ask the members of the household about the details required in the questionnaire. They may take care that each member of the household should answer about their own travel details, except for children below 12 years. Trip details of children below 5 years are normally ignored. Since the actual survey may take place any time during the day, the respondents are required to answer the question about the travel details of the previous day.

There are many methods of the administration of the survey and some of them are discussed below:

1. **Telephonic:** The enumerator may use telephone to fix an appointment and then conduct detailed telephonic interview. This is very popular in western countries

where phone penetration is very high.

2. **Mail back:** The enumerator drops the questionnaire to the respondent and asks them to fill the details and mail them back with required information. Care should be taken to design the questionnaire so that it is self explanatory.
3. **Face-to-face** In this method, the enumerator visits the home of the respondent and asks the questions and fills up the questionnaire by himself. This is not a very socially acceptable method in the developed countries, as these are treated as intrusion to privacy. However, in many developed countries, especially with less educated people, this is the most effective method.

4 Data preparation

The raw data collected in the survey need to be processed before direct application in the model. This is necessary, because of various errors, except in the survey both in the selection of sample houses as well as error in filling details. In this section, we will discuss three aspects of data preparation; data correction, data expansion, and data validation.

4.1 Data correction

Various studies have identified few important errors that need to be corrected, and are listed below.

1. **Household size correction** It may be possible that while choosing the random samples, one may choose either larger or smaller than the average size of the population as observed in the census data and correction should be made accordingly.
2. **Socio-demographic corrections** It is possible that there may be differences between the distribution of the variables sex, age, etc. between the survey, and the population as observed from the census data. This correction is done after the household size correction.

3. **Non-response correction** It is possible that there may not be a response from many respondents, possible because they are on travel everyday. Corrections should be made to accommodate this, after the previous two corrections.
4. **Non-reported trip correction** In many surveys people underestimate the non-mandatory trips and the actual trips will be much higher than the reported ones. Appropriate correction need to be applied for this.

4.2 Sample expansion

The second step in the data preparation is to amplify the survey data in order to represent the total population of the zone. This is done with the help of expansion factor which is defined as the ratio of the total number of household addressed in the population to that of the surveyed. A simple expansion factor F_i for the zone i could be of the following form.

$$F_i = \frac{a}{b - d} \quad (1)$$

where a is the total number of household in the original population list, b is the total number of addresses selected as the original sample, and d is the number of samples where no response was obtained.

4.3 Validation of results

In order to have confidence on the data collected from a sample population, three validation tests are adopted usually. The first simply considers the consistency of the data by a field visit normally done after data entry stage. The second validation is done by choosing a computational check of the variables. For example, if age of a person is shown some high unrealistic values like 150 years. The last is a logical check done for the internal consistency of the data. For example, if the age of a person is less than 18 years, then he cannot have a driving license. Once these corrections are done, the data is ready to be used in modeling.

5 Other surveys

In addition to the household surveys, these other surveys are needed for complete modeling involving four stage models. Their primary use is for the calibration and validation of the models, or act as complementary to the household survey. These include O-D surveys, road side interviews, and cordon and screen line counts.

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5.1 O-D survey

Sometime four small studies, or to get a feel of the O-D pattern without doing elaborate survey, work space interviews are conducted to find the origin-destination of employers in a location. Although they are biased in terms of the destination, they are random in terms of the mode of travel.

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5.2 Road side interviews

These provide trips not registered in a household survey, especially external-internal trips. This involves asking questions to a sample of drivers and passengers of vehicles crossing a particular location. Unlike household survey, the respondent will be asked with few questions like origin, destination, and trip purpose. Other information like age, sex, and income can also be added, but it should be noted that at road-side, drivers will not be willing to spend much time for survey.

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5.3 Cordon and screen-line survey

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These provide useful information about trips from and to external zones. For large study area, internal cordon-line can be defined and surveying can be conducted. The objective of the survey is primarily to collect the origin and destination zones and for this many suitable methods can be adopted. It could be either recording the license plate number at all the external cordon points or by post-card method.

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Screen lines divide the study area into large natural zones, like either sides of a river, with few crossing points between them. The procedure for both cordon-line and screen-line survey are similar to road-side interview. However, these counts are primarily used for calibration and validation of the models.

6 Summary

Data collection is one of the most important steps in modeling. Only if accurate data is available, modeling becomes successful. Survey design is discussed in detail. Household data gives important information required for data collection. Questionnaire should be simple, less time consuming and should be designed such that the required information is obtained with less burden on the respondent. Data collected should be prepared well before application. Various corrections should be made in data collection before they are used in modeling. Finally, other types of surveys are also discussed.

Exercises

1. Multiple choice or fill-in-the blanks kind of questions:
(a) The data that is useful for developing trip generation models is ... (a. Travel survey data, b. Land-use inventory data, c. Network data, d. None of these.)
(b) Which of the following is not a criterion for zoning? a. zones should match other administrative divisions, particularly census zones. b. zones should have homogeneous characteristics, especially in land use, population etc. c. zone boundaries should match cordon and screen lines, but should not match major roads. d. zones should have regular geometric shape.

References

1. Yosef Sheffi. *Urban transportation networks: Equilibrium analysis with mathematical programming methods*. New Jersey, 1984.
2. R Thomas. *Traffic Assignment Techniques*. Avebury Technical publication, England, 1991.

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Prof. Tom V. Mathew

Department of Civil Engineering

Indian Institute of Technology Bombay, India