Demand estimation for public transport systems - Case study of Delhi

by

MUKTI ADVANI

Department of Civil Engineering

Submitted

In fulfillment of the requirements of the degree of Doctor of Philosophy

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI
NOVEMBER 2007

Public transport systems Transport infrastructure

CERTIFICATE

This is to certify that the thesis titled

Demand estimation for public transport systems - Case study of Delhi

submitted by Mukti Advani to the Indian Institute of Technology (IIT), Delhi for the award of the degree of Doctor of Philosophy is a record of the bona fide research work carried out by her under my supervision and guidance.

The thesis work, in my opinion, has reached the requisite standard fulfilling the requirements for the degree of Doctor of Philosophy. The results contained in this thesis have not been submitted in part or in full, to any other university or institute for the award of any degree or diploma.

(Dr. Geetam Tiwari)
Associate Professor
Department of Civil Engineering
Indian Institute of Technology
New Delhi 110016

ACKNOWLEDGEMENT

I am extremely grateful to my supervisor Dr. Geetam Tiwari under whose guidance this work has been completed. I am very thankful to her for her invaluable suggestions and constant encouragement right from the first day. She has provided the insight into the discrete choice models used in this research.

I am thankful to my thesis committee members: Prof. T.K.Datta, Prof. Arun Kanda and Prof. R.R.Kalaga. Prof. Kalaga offered many suggestions for the technical content of this thesis.

I would like to thank Prof. Dinesh Mohan for enlightening discussions that I hope we will continue to have. I thank everybody at TRIPP (Transportation Research and Injury Prevention Programme), for their support every time I needed and for the friendly atmosphere that they all have built along the years. I would like to thank particularly Mr. Mahesh Gaur and Ms. Anvita Anand for their many invaluable contributions to my work at different stages.

As in many research projects, collecting and treating data was one of the most tedious tasks of this work. The help from Rajendra Ravi (IDS) is deeply appreciated. I am also thankful to VREF (Volvo Research and Education Foundation) as their fund has been used for carrying different commuter's surveys, without which the work would not have been possible.

I'm thankful my friends B.Srirama and Neeru Jaiswal who served as resources to help me work more efficiently.

Many people contributed to my work by providing the necessary support, many thanks to all of them. I would like to express my special gratitude to my husband Lalit who helped me to develop many java programs used for this work. Thanks to my brother Bharat – inspiration of my studies, my parents (Maya and Manohar Advani) and my in-laws (Rekha and Hari Balchandani) for their invaluable contribution in each and every stage of this work. Last but not least, my small daughter Aashima who taught me the patience much needed for completing this - a long-term task.

Mukti Advani

ABSTRACT

Since large sums of money and other scarce resources are invested in creating transport infrastructure, it is important to avoid projects, which fail to provide expected benefits. The aim of the present study is to develop a travel demand model for public and private transport modes, which can provide better estimates of travel demand. This study examines the demand of public transport trips, including the ongoing metro network in Delhi.

The central research focus of this study is to find out the impact of access and egress trips on travel demand estimation. The study explores how different types of zoning affect the access and/or egress trips. The importance of access and egress trips in mode choice modeling along with its relationship to main line haul can't be minimized; hence including these explanatory variables along with vehicle ownership for estimation of expected ridership on the metro system and on the bus system has been studied. This study also includes the effect of different feeder modes on public transport ridership. The study also focuses on sensitivity between different modes to better understand the competitiveness between different travel mode options.

The empirical evidence from Indian cities makes a strong case for critical analyses of travel demand forecasts. Different parameters have been considered important in developing the demand estimation model for public transport services. Travel demand models based on better information of access trips, egress trips, total travel time, travel cost, income, socio economic and landuse attributes have to be developed for more accurate demand estimation.

Since access and egress trips have been considered very important in mode choice, this study develops a demand estimation models including details of distance, time and cost of access and egress trips based on two different methods of creating traffic zones which generates significantly different access and egress trip lengths. The model is run using the conventional traffic zone system where 90% of the zone's size is in the range of 2-5 sq km. Since this size hides the details of access and egress trips, which tend to be much smaller, a new zoning system based on creating zones around public transport stops/stations has been developed to capture the details of access and egress trips; 95% of the zones are of the area less than 1 sq.km, The first database set (database set-1) is created for zoning based on conventional traffic zones with the artificial collectors and second database set (database set-2) is based on creating zones around the service area of public transport service stops/stations. The mode choice model has been run on both the zoning systems to estimate the ridership.

The methodology includes a review of the present and proposed transport policies of Delhi and travel characteristics of different commuters in the study area. Commuter travel characteristics collected in the primary surveys have been used for developing the demand estimation model. Nested logit models for modeling mode choice behavior of different commuters have been developed. Statistical tests of the significance of different parameters show that not only the absolute value of access and egress trips but the ratio with the main line haul trip is also significant. The multinomial logit model implies equal competition between all pairs of alternatives. Though in both the database sets, this is not the case, when we consider the choice between car, two-wheeler, bus and metro. Accordingly, nested logit models have been developed for both the database sets. A

comparison of the sensitivity between different modes leads to a final nest for further analysis. The final nested model of database set-1 includes access and egress time, access and egress cost, main line haul time, the ratio of access-egress distance with the main line haul distance, the ratio of access-egress time with total time and the vehicle ownership. The model of database set-2, shows different estimation parameters for access and egress time, total time, the ratio of access plus egress time to main line haul time and ratio of access plus egress distance to total distance. Both the database sets have different results for nested logit model after the full metro network construction in the year 2021 is completed. The model estimates modal shares of motorized vehicle trips in four different scenarios. These include rerouting of current bus routes and expected improvement in the speeds of cars and buses, and decrease in speeds of cars and buses. The rerouting of bus trips has marginal effect on the number of trips by metro. Share of metro trips increase substantially when the speeds of cars, two wheelers and buses decrease. The model estimates 7% to 16% trips according to the database set-1 and 15% to 22% according to the database set-2 of the total motorized vehicular trips would be made by metro. Approximately, 15% to 30% trips of public transport would be made by the metro as per database set-1 and 27% to 36% according to the database set-2. All parameters have been tested and significant parameters have been used to prepare the final nested logit model. Interestingly both database sets accept the same nesting of modes and both the nested logit models show a significant sensitivity between bus and two-wheeler choice.

The mode choice model developed in this study predicts that after the construction of the full network of Delhi metro (256 km) in the year 2021, the number of trips made by metro will be between 1.38 million to 3.17 million (7% to 16% of the total

estimated trips in Delhi in the year 2021) as per database set-1 and 3.0 million to 4.3 million (15% to 22% of the total estimated trips in Delhi in the year 2021) as per database set-2. Database set-1 based on conventional zoning and artificial collectors does not capture the details of access and egress trips. Therefore, zoning based on smaller zones around public transport stops is recommended for better estimation of trips especially of public transport demand. Even after the construction of the complete network of 256 kms, the Delhi metro would be able to carry 15% to 31% trips of the total trips made by public transport and 85% or 69% of public transport trips will be on the bus according to the database set-1 results while as per database set-2, metro trips range between 27% to 36% of public transport trips. Since the majority of the city trips are short trips (less than 10 km), a road based system provides better accessibility in comparison to the metro system. While planning new metro systems the demand estimation must be reviewed in this context. Road based systems, which provide better network connectivity and shorter access distance can offer a viable alternative to private vehicles.

TABLE OF CONTENT