DEVELOPING A COMPREHENSIVE MODE CHOICE MODEL TO CAPTURE THE PREFERENCES FOR MASS RAPID TRANSIT IN DHAKA

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A thesis submitted to the Department of Civil Engineering of Bangladesh University of Engineering and Technology, Dhaka, in partial fulfilment of the requirements for the degree of

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The thesis titled **"Developing a Comprehensive Mode Choice Model to Capture the Preferences for Mass Rapid Transit in Dhaka"** submitted by Annesha Enam, Student No: 040804418 (P), Session: April 2008 has been accepted as satisfactory in partial fulfilment of the requirement for the degree of M.Sc. Engineering (Civil and Transportation) on 22nd November, 2010.

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It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

November, 2010

Annesha Enam

Dedicated

To

My Grandparents

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ABSTRACT

Dhaka, the capital city of Bangladesh and the home of 15 million people, is subjected to acute traffic congestion on a regular basis resulting in lost productivity, fuel wastage, commuter frustration and environmental degradation. The city is perhaps the only megacity with no well organized public transport system and one of the very few ones without Mass Rapid Transit (MRT). In Strategic Transport Plan for Dhaka (STP, 2005) recommendations have been made to launch new MRT systems like Bus Rapid Transit (BRT) and Metro Rail in order to strengthen the public transport system of the city. Planning of these new systems warrants comprehensive mode choice models that can help in quantifying the relative importance of attributes, determining the Value of Time (VOT) for cost-benefit analysis, predicting ridership, etc. The existing mode choice models however do not account for the deficiencies of existing data like missing choice sets, measurement errors in the level of service (LOS) variables, lack of information regarding the new modes etc. and can lead to incorrect travel demand predictions.

This has prompted the current research where Stated Preference (SP) data has been collected to capture the preference for proposed new alternatives (MRT), methodologies have been developed to address the other limitations of the existing Revealed Preference (RP) data and a comprehensive mode choice model has been developed combining RP and SP data.

In the SP survey conducted in the research, respondents have been presented with choice scenarios that included BRT and Metro alongside their current modes. Different levels of three attributes (travel time, travel cost and waiting time or frequency) were used to describe the new alternatives. The attributes and associated levels were selected based on the findings of an initial survey.

To address the unobserved choice sets of the respondents in the available RP data, a choice set generation model has been developed using SP data. The estimated parameters of the developed model have been used to predict the choice sets of the respondents (unobserved in the RP data) probabilistically. Regression analysis has been done to address the measurement errors of the travel time derived from network analysis

Discrete choice models have been developed using the corrected RP data and the collected SP data and the coefficients of the utility functions have been estimated using a maximum likelihood approach. The observed taste heterogeneity of the respondents have been taken into account by the introduction of socio-economic variables like income, age, gender, occupation, employment, etc. into the model and market segmentation tests have also been performed. The VOT of the people have been calculated from the ratio of the estimated parameters of travel time and travel cost. The VOT values have been found to be 29Taka/hour for bus/tempo, 64Taka/hour for rickshaw, 170Taka/hour for car and CNG/taxi, 40 Taka for BRT and 55 Taka/hour for Metro.

The introduction of socio-economic dummy variables into the model specification has been a significant improvement from the previous models which considered only the time and cost sensitivities. Also, the obtained VOT values from the combined model are more plausible compared to the values obtained from previous choice models as well as the disjoint RP and SP models. Further, the methodologies proposed in the current research can be a useful tool for other transport related analysis in Bangladesh as well as in other developing countries facing similar data issues.

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LIST OF NOTATIONS AND ABBREVIATIONS

ACC	Accident Cost
ACC	Accident Cost
ASC	Alternative Specific Constant
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BCL	Bangladesh Consultants Limited
BRT	Bus Rapid Transit
BRT	Bus Rapid Transit
CE	Choice Exercise
DCV	Direct Contingent Valuation
DHUTS	Dhaka Urban Transport Network Development Study
DIT	The Greater Dhaka Metropolitan Area Integrated Transport Study
DSTM	Dhaka Strategic Transport Model
DTCB	Dhaka Transport Coordination Board
DUTM	Dhaka Urban Transport Model
GEV	Generalized Extreme Value
HH	House Hold
HIS	Household Interview Survey
IIA	Independence of Irrelevant Alternatives
iid	Independent and Identically Distributed
JICA	Japan International Cooperation Agency
LOS	Level of Service
MNL	Multinomial Logit
MRT	Mass Rapid Transit
NWT	Non-work Time
O-D	Origin-Destination
PLC	Parameterized Logit Captivity
RE	Ranking Exercise
RP	Revealed Preference

RUC	Road User Cost
RUM	Random Utility Model
SP	Stated Preference
TT	Travel Time
TTC	Travel Time Cost
UNDP	United Nations Development Programme
VOT	Value of Time
WT	Waiting Time
WT	Work Time
WTP	Willingness-To-Pay

CHAPTER ONE
INTRODUCTION

1.1 Overview

Transportation system is one of the most fundamental components of the socio-economic and physical structure of an urban settlement. A well-planned and developed transportation system not only provides opportunities for mobility of the people, but also influences the growth pattern and the level of economic activity of a city (Meyer and Miller, 1984).

1.2 Overall Transport Scenario of Dhaka City

Although Dhaka is one of the most populous cities of the world, few detailed transport-planning studies have been conducted so far. This has led to an inadequately planned and under developed transportation system of the city. Dhaka is perhaps the only mega city with no well organized and properly scheduled public transport system and one of the very few ones without Mass Rapid Transit (MRT). The public transport modes of Dhaka consist of double decker bus, single deck large bus, minibus, collective transport (staff bus, school/college/university bus) and rail. A brief overview of the public transport system of Dhaka city is provided below.

The number of bus vehicles in the city account for 16% of all motorized vehicles which carry 77% of the population (STP, 2005). Though, the total length of the route is 200 km, only 107 km of the available road are of less than 24 km width and there has been a lack of sufficient connector roads in the east-west direction. Also, several operational weaknesses can be identified in terms of route planning, for example, deficient number of routes, competition of numerous small operators in the same route, absence of fixed schedule and passenger information system, etc. Moreover, no advantage is practiced by these buses in terms of separate right of way or signal priority. Also, the bus passengers are vulnerable to accidents, since the bus drivers often carry false driving license leading to increased congestion and indiscipline in the road.

In case of rail transport, ten stations are located within the city from Tongi to Kamlapur in the north region and from Narayangonj to Kamlapur in the south region. The rails in the north region carry small amount of local traffic and that of the south region are grossly underutilized (Hoque and Choudhury, 2009). Moreover, the at grade level crossing and the side friction along the rail route significantly reduce the operating speed of the vehicles.

The deteriorating traffic conditions are causing increasing delays and worsening air pollution, and seriously compromise the ability of the transport sector to serve and sustain economic growth and quality of life. Traffic congestion is an issue of great concern for the inhabitants of the city resulting in commuter's frustration, longer travel times, lost productivity, increased accidents, more fuel consumption, and deterioration in air quality. A recent study by Roads and Highways Department (RHD) has estimated that, the traffic congestion in Dhaka causes a loss of Taka 19,555cr a year (The Daily Star, 2010).

Congestion reduction primarily involves increasing the roadway capacity; either through building new roads to increase the physical accommodation capacity or by improving the operational capacity of the existing network by adapting optimum traffic management and control strategies. Increasing the physical capacity is a very difficult option for the city since the ratio of built-up areas is estimated to be around 72% (Bari and Hasan, 2001). Moreover, the household survey of STP (2005) reveals that, the distribution of person-trips travel is 52% by motorized modes (individualized motorized transport modes and transit) and 48% by non-motorized travel modes (walk, rickshaw, bicycle). Of the 52% of total person-trips by motorized modes, the distribution is 85% by transit and 15% by individualized motorized transport modes (private vehicle, taxi and auto rickshaw). Though, a very small percentage of the trips are being served by the individualized motorized transport modes, they occupy a significantly large portion of the roadway of Dhaka city and the number of registered individualized motorized vehicles have been increasing at a very fast rate. The registered numbers of private car, jeep and microbus have increased from 1,20,257 in 2003 to more than 2,19,455 within June 2010 (BRTA, 2010) in Dhaka. But, these modes of transport are not accessible to the major part of the residence of the city due to their limited affordability. MRT can provide good quality transport at an affordable cost for a large number of users. Mass transit like Bus Rapid Transit (BRT), Metro Rail and Sub-urban Rail, etc. can ensure more efficient use of the roadway space and can lead to less traffic congestion and lower amount of emissions as compared to the use of personal motorized vehicles by providing fast transport facilities for the mass travellers. This was also reflected in the Strategic Transport Plan (STP, 2005) where ten alternative strategies have been evaluated for improved transport system for Dhaka. These strategies include different combinations of improved road system (ROADS+, ROADS++, ROADS+++), Bus Rapid Transit (BRT) and Metro Rail system. The STP consultant team finally recommended a blend of mass rapid transit systems (BRT and Metro Rail) along with an extensive roads program. The selected strategy is shown in the following Figure 1.1.

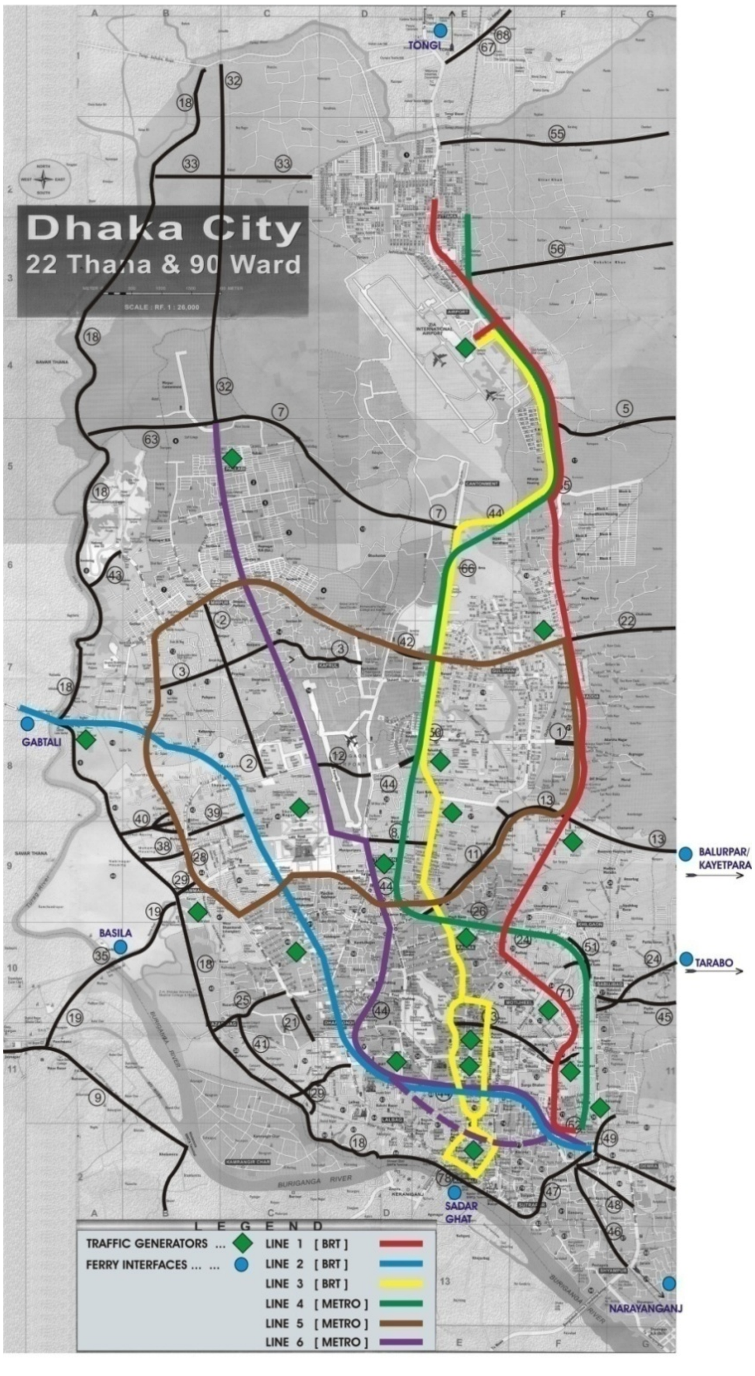

Figure 1.1: The selected transport strategy by STP (2005)

Detailed planning of a successful MRT requires vigorous mode choice models that can be used for designing the system, setting the fare, predicting ridership, selecting incentives, etc. And, these have prompted this research to develop a comprehensive mode choice model to quantify the preference for mass transit in Dhaka city.

1.3 Motivation of the Research

Travel demand forecast models are the fundamental analytical tools used in the planning process in order to produce the information needed to develop an informed understanding regarding transport options and investment decisions. The principal objective of these models is to predict the demand for transportation facilities and services in the future by extrapolating present travel behaviour, growth potential and changing socio-economic circumstances. The classical approach of travel demand modelling, conventionally known as the four step model, consists of trip generation, trip distribution, modal split and trip assignment. Within the travel demand modeling field, mode choice is arguably the most important determinant of the number of vehicles on roadways (Koppleman and Bhatt, 2006). Also, the mode choice decision is a more easily influenced travel decision compared to other trip making decisions such as route choice or destination choice. Factors which influence mode choice include travel time, cost, waiting time, number and ease of transfers, comfort, etc. and over the years mode choice models have been dealing with the general range of trade-offs individuals are willing to make among these factors (see Lerman, 1975, Ben-Akiva and Lerman, 1985, Koppleman and Wen, 2000, Bhat, 2000).

Travellers have different sensitivity towards the LOS attributes (e.g. travel time, waiting time, number of transfer, in-vehicle congestion, in-vehicle air conditioning, intermodal transfer facilities, etc.). For the successful planning and development of a new transport system, it is critical to know the sensitivity towards these LOS attributes and associated trade-offs and quantify their willingness-to-pay (WTP) for various travel attributes. Using this information, decision makers can make policies regarding facilities to be provided. It helps the decision makers to analyze the impact of different pricing policies on the demand of different services, take decisions on tax benefits required for making the services operational and perform cost-benefit analysis as well as sensitivity analysis. WTP depends on attitudes and personal preferences of the users and is strongly affected by socio-economic factors. People's willingness to pay for different attributes of the travel mode can be calculated from the estimated parameters of the mode choice models.

Mode choice models, however, have been found to be very heterogeneous and transferability of models among different regions has been a widely debated issue (Galbraith and Hensher, 1982, Bekhor and Prato, 2009). For example, Dhaka city has got a distinct socio-economic structure characterized by wide differences in affordability and accessibility leading to heterogeneity in the choice process as well as in the choice sets. Therefore, applicability of the state-of-the-art mode choice models in analysing the transport options in Dhaka city is likely to lead to incorrect results. Further, an 'imported' WTP from other countries is not expected to be adequate or dependable. The review of literature showed lack of comprehensive mode choice models for Dhaka. For example, the existing models do not account for the deficiencies of existing Revealed Preference (RP) data. Also, the existing RP data do not include information regarding the proposed new alternatives, BRT and Metro Rail. This prompted collection of SP data to capture the preference for proposed new alternatives (MRT). Disjoint SP models however reflect, only the stated preferences of the respondents which may contain different biases like policy response bias, omission of situational constraints, etc. (Ben-Akiva, 2008).

The current research therefore proposes a comprehensive mode choice model that combines RP and SP data and addresses the missing choice set in the available RP data and measurement errors in the LOS variables.

1.4 Research Objective

The overall objective of this research is to develop a mode choice model for Dhaka city using advanced discrete choice modeling techniques that can capture the preferences for the MRT in Dhaka city. The developed model is comprehensive in the terms that, it captures the preferences for both the existing and the proposed new modes. This study is perhaps the first of its kind for Dhaka city. Specific objective of this study include:

(i) Exploring STP data to identify the weaknesses of the available data;
(ii) Developing an SP survey to collect LOS data for the proposed new modes like BRT and Metro Rail as well as to avail the missing information in the STP data;

(iii) Developing methodologies to address the limitations of the existing RP data (e.g. accounting for the missing choice sets and correcting the measurement errors);

(iv) Developing a mode choice model combining RP data with the SP data using advanced discrete choice modeling techniques;

(v) Conducting market segmentation tests to address observed taste heterogeneity of the respondents;

(vi) Estimating aggregate measures like Value of Time (VOT) and comparing it with existing literature.

The developed model can be used to quantify WTP. The calculated WTP can be applied to predict ridership of different transport modes (both existing and proposed ones), to determine possible fare structure for different kinds of mass transit options and to get an idea about the kind of incentives required to increase the ridership of MRT. These can ultimately contribute to reducing the inclination towards personalized vehicles.

1.5 Thesis Organization

The organization of the rest of the thesis is as follows. Previous mode choice models for Dhaka city and related literature are reviewed and their limitations are explored in Chapter 2. Descriptions of the survey methods for collecting data for disaggregate model development are also presented in this Chapter with special focus on SP survey techniques. Finally, the state-of-art approaches of discrete choice modeling techniques are highlighted.

The data characteristics and the limitations of the RP data are presented in Chapter 3, which are followed by the detailed description of SP survey organization. The characteristics of the collected SP data are also illustrated in this Chapter. The Chapter ends up with the presentation of the overall modeling framework.

Chapter 4 deals with the development of the individual model components. The model structures and the estimation results of the choice set generation model are presented first which are followed by the methodology and estimation results of addressing the measurement errors in LOS data. Finally, the model structures and the estimation results with RP and SP data sources are described sequentially.

The detailed descriptions of the estimation of combined RP and SP data sources are presented in Chapter 5. The methodology to calculate the willingness to pay (WTP) is appended in the subsequent Sections of this Chapter. The calculated WTP from the estimated model parameters are also presented in the final Section of the Chapter.

The summary of the research are provided in Chapter 6. The major contributions of the research and the future research recommendations are also described in this Chapter.

CHAPTER TWO
LITERATURE REVIEW

2.1 Overview

The review of literature related to previous research on mode choice models and methodological and practical issues associated with development of these models are presented in this Chapter. The review of mode choice models for Dhaka city is presented in Section 2.2. This is followed by issues related to development of disaggregate models in Section 2.3. In this Section, the two types of data sources (RP and SP) typically used for discrete choice modeling are compared and issues related to SP survey are illustrated. The state-of-art discrete choice modeling techniques and associated methodological issues are presented in the end.

2.2 Mode Choice Models for Dhaka City

Dhaka is an old city with settlement dating back to 7th century and development of township dating back to 17th century. However, very few mode choice models have been developed for the city so far. In many cases these mode choice analyses were limited to exploratory analysis of factors affecting travel demand. For example, Ahsan (1990) explored the mass transit (bus) operating conditions (routes, fare, etc.) of the city and identified the bus passenger characteristics (gender, age, income, etc.), but detailed modeling of the mode choice was beyond the scope of the research. The mode choice models developed so far for Dhaka city are briefly reviewed below.

The Greater Dhaka Metropolitan Area Integrated Transport Study (DITS, 1993) was an initiative of the Government of Bangladesh with the assistance from United Nations Development Programme (UNDP). The major sources of data for the development of the model were Home Interview Survey (HIS), roadside Origin-Destination (O-D) survey and traffic count survey. The DITS (1993) travel forecasting model followed classical four step modeling procedure (i.e. Trip Generation, Trip Distribution, Modal Choice and Trip Assignment), where the mode choice model was simplified into sequential binomial choice models. A market segmentation approach was followed by dividing the transport market into three monthly income groups. The modes considered in the DITS model were walking, rickshaw, public transport (bus or tempo) and private motorized transport. A series of binomial logit models were used for distributing the O-D pairs into these four modes. The choice among multi-modes was simplified into binary choices between walking versus public transport or rickshaw, car versus public transport or rickshaw and finally rickshaw versus public transport. It was assumed that modal decisions are made in this simple process. In this model walking has been considered as a separate mode. But, the fact is, many people in Dhaka walk instead of availing any other mode not by a choice rather, because of the fact that they cannot afford any of the available modes. Therefore, to consider walking as an equally competing mode with other motorized and non-motorized modes is not logical. The model predicted 60% trips for Dhaka city to be walking trips, which seems unrealistically high.

Habib (2002) used a traditional four step travel demand model for Dhaka city (Dhaka urban transport model, DUTM) where a modal split model was calibrated using aggregate mode share data. The modes considered for the modeling are rickshaw, car, bus and auto-rickshaw. DUTM used three explanatory variables for the mode choice model viz. travel time, travel cost and comfort. The parameters of the model were calibrated to get the best match with the observed modal shares. The calibrated coefficients of travel time, travel cost and comfort were 0.06, 0.15 and 0.21 respectively. The coefficients of travel time and travel cost were positive which is counter intuitive. Moreover, the coefficient for comfort was greater than that of time and cost implying that the people are more sensitive towards the comfort provided by the mode than the travel time and travel cost of the mode which is also unrealistic.

Louis Berger Inc. and Bangladesh Consultants Ltd. (BCL) have conducted a wide scale house hold survey with the financial contribution from World Bank in 2004 to collect RP data from the travellers. In that project a Strategic Transport Plan (STP, 2005) was proposed which followed a traditional four step travel demand modeling procedure. For the modal split step the available modes of Dhaka have been divided in two groups, i.e. transit modes and auto modes. Non-motorized modes (rickshaws) were not considered in the modal split model, though rickshaws constitute 37% of the person trip of Dhaka city as reported by the same study (STP, 2005). In the auto mode group cars and taxis were grouped together overlooking their very different attribute values (e.g. running cost, availability, accessibility, etc.). Only two explanatory variables viz. travel time and travel cost were used for the modal split model and three different models were estimated for three income segments of Dhaka city. In the middle income segment the people with monthly income of Taka 12,500 to Taka 55,000 were grouped together. But, there are substantial variations in the lifestyle in terms of monthly transport expenditure, car availability in this wide range of income. Again, the absolute values of the time coefficient was greatest for the low income group of people and were smallest for the high income group of people implying that the low income people are more sensitive towards travel time than the high income people which is counterintuitive.

Hasan (2007) also developed a four step travel demand model (Dhaka strategic transport model, DSTM) where he adapted a semi-rule based mode choice model. In this model, a rule-based model was applicable for travellers with access to cars where it was assumed that these travellers will always select car as the travel mode regardless of other factors like trip distance, trip purpose, situational constraints, etc.). For the other travellers (i.e. those with no access to car), a Multinomial Logit (MNL) model was developed for the choice among rickshaw, auto-rickshaw, and transit. The mode choice model of DSTM can be presented as in Figure 2.1.

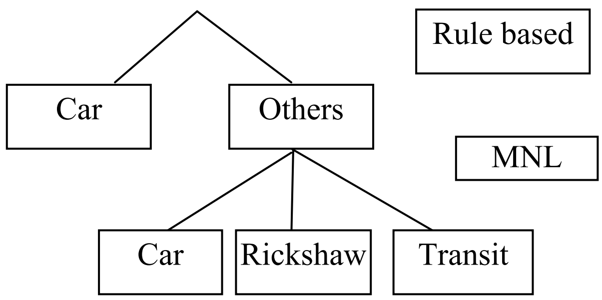

Figure 2.1: Mode choice model – DSTM

The main data source of DSTM was the household interview survey data collected in STP (STP, 2005). Hasan has supplemented the STP data by a small scale household interview survey (88 households) to get travel cost of different modes. To determine the travel time of different modes he used network derived distances and assumed travel speeds of vehicles. The measurement errors induced in this method was however not accounted in the model. A major limitation of Hasan's model was the rule adopted to address the mode choice of travellers with access to car. The car ownership per household in Dhaka is low (9% modal share has been estimated for personalized motorized vehicles from STP household survey which include both private car and taxi) and very often multiple family members share the same car where the allocation often depend on complex priority rules. For example, the elderly people and the children of a family generally get priority over the middle age group. Four different Multinomial Logit (MNL) models were developed for the choice among rickshaw, auto-rickshaw and transit for four group of people based on the purpose of trip (home base work trip, home base education trip, home base other trip and non-home base trip) . In the MNL model, it was assumed that all four modes were available to all travellers. Only two explanatory variables were used for the model specification (travel time and travel cost).

Aftabuzzaman et al. (2010) developed a mode choice model for the work trips of the middle income group of Dhaka city. The primary data source was the house hold interview survey of about 200 people. Only three modes i.e. rickshaw, bus and auto rickshaw were considered in the multinomial logit model development. The model development was started with three trip attributes i.e. in-vehicle travel time, out of vehicle travel time and travel cost and later coefficients to the travel and socio-economic interaction variables were introduced into the model in terms of travel cost/ household income and out of vehicle travel time/ O-D distance. The research work also presented three policy scenarios in terms of decrease in bus fare, decrease in out of vehicle travel time of bus and the increase in rickshaw fare. All the scenarios resulted in a rise in the modal share of bus and fall in the share of rickshaw and auto rickshaw. It was concluded that, people perceive roughly three out-of-vehicle minutes per minute of in-vehicle time and the rate of substitution approximates 30 Taka per hour of in-vehicle time which seems to be a generalization for all modes in Dhaka.

Most recently, Dhaka Transport Coordination Board (DTCB) in cooperation with Japan International Cooperation Agency (JICA) has conducted House Hold (HH) survey similar to that conducted in STP (DHUTS, 2010) and developed a two step mode choice model. In the first step of the mode choice model, modal split has been made among walking, rickshaw and other modes (which includes private car, bus and auto rickshaw) using O-D shortest path distance as the only explanatory variable. Further the trips using other modes have been divided into private car, bus and auto rickshaw using respective travel costs as the only explanatory variable. The model can be presented as the Figure 2.2. The mode choice parameters have been estimated separately for different income groups of people.

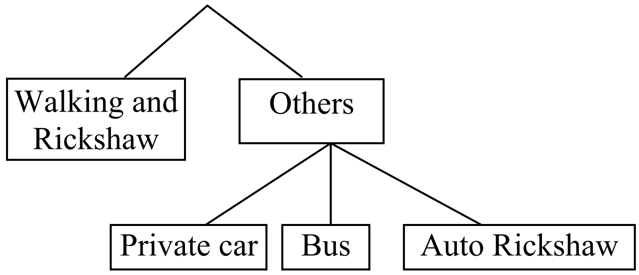

Figure 2.2: Mode choice model – DHUTS

From the above description it is evident that, no comprehensive mode choice models have been developed for Dhaka to date. In most cases, ad-hoc rule based choice sets have been used for the development of the models. Network derived level of service values have been used without correcting for the errors introduced in this method. Further, the models are not comprehensive and robust enough to account for the new MRT modes, particularly since, the LOS of MRT varies significantly from the current modes. It may be noted that, the limitations of the available datasets played key roles behind the deficiencies of the previously developed mode choice models and this has prompted the current research. In this research a stated preference survey has been conducted to overcome the data limitations. The details of the survey are illustrated in the next Section.

Due to the importance of mode choice models in predicting travel demand, there have been numerous researches in this area (see Ben-Akiva and Lerman, 1985, Train, 1998 for details). The performances of these models have a strong correlation with the quality of data. Over the years there have been enhancements both in the field of data collection and in model development. These are described in the following Section.

2.3 Survey Methods

For mode choice model development two methods of survey are widely used:

(i) Revealed Preference survey (RP survey);

(ii) Stated Preference survey (SP survey).

RP data reveals the trip diaries of the travellers and SP data reveals the response of the travellers to a hypothetical scenario. In some cases it becomes warranted to apply SP techniques even if there exits RP data.

The classical motivations for using SP techniques are summarized below:

(i) To get the response of the people regarding new alternatives (e.g. new modes of transport), new attributes (e.g. separate female compartment) and/or levels of attributes (e.g. large reduction in travel time) beyond the range of the RP data;

(ii) To improve the data quality by overcoming the limited variability and co-linearity of attributes in RP data;

(iii) To overcome the problems associated with the definition of choice set and measurement errors in attribute values;

(iv) To overcome the time and budget constraints.

From the above discussion it is clear that the SP methods have got some specific advantages over the RP method. The major advantages of the SP approaches over RP approach are given below:

(i) In RP data the analyst cannot observe the response to a non-existing alternative while in SP data it is possible to observe the response to a non-existing/forthcoming alternative;

(ii) RP data may contain measurement errors in the attribute values while SP data is free from this source of error;

(iii) In case of RP data attributes may be correlated while multi-co-linearity can be avoided by experimental design in SP data;

(iv) The ranges of attributes are limited in RP data but a wide range of attributes can be tested in case of SP data if required;

(v) The specification of the choice set can be a big problem in RP data but in case of SP data the choice sets are predefined in the experiments;

(vi) In case of RP data it becomes impossible to get multiple responses from one respondent while in SP data repetitive questioning can easily be implemented to get multiple responses per respondent;

(vii) The response can only be in the form of choice in case of RP data while various forms (e.g. ranking, rating, matching) of responses are available in case of SP data.

SP data has also got some disadvantages as well. The most likely biases of the SP data are summarized below (Ben-Akiva , 2008) :

(i) Indifference to the experimental task;
(ii) Policy response bias: Respondents sometimes have an intuition that if s/he answers for a product/service the authority may introduce it, though in actual situation s/he may not go for the product/service;
(iii) Justification bias;
(iv) Omission of situational constraints: Personal constraints of the respondents are not considered as constraints at the time of choice;
(v) Incomplete descriptions of alternatives: In the presented scenarios to the respondents the alternatives may not be presented in details;
(vi) Cognitive incongruity with actual behaviour: The respondents' response may oppose their actual behaviour.

In spite of the limitations, because of the advantages, particularly in prediction of demand for new modes and services, SP data have widely been used in choice modeling and that has lead to innovations in design and data collection techniques of the SP exercises. A brief description of the different techniques of SP survey is presented below.

2.3.1 SP techniques

The most effective techniques are direct (close-ended) contingent valuations (DCV), ranking exercises (RE), hypothetical referendum approaches (HRA) and stated preference choice exercises (CE) (Choudhury et al., 2008).

Direct Contingent Valuation (DCV)

In DCV, the respondents are directly asked to state a specific value for a particular aspect of improvement. For example, how much are you willing to pay for reducing your travel time by 10 minutes with all other things remaining the same?

Ranking Exercises (RE)

In RE, the respondents are asked to rank the attributes (e.g. travel time, travel cost, waiting time etc.) of interest according to their preference.

Hypothetical Referendum Approaches (HRA)

In HRA, the respondents are told how much they would have to pay if the measure passed and are then asked to cast a simple "yes" or "no" vote. For example, the respondents are asked, “would you be willing to contribute Taka Y to reduce your travel time by X minutes?).

Choice Exercise (CE)

The CE technique is based on the notion that a good or service can be described by attributes and levels which respondents are willing to trade-off between one another and it differs from other approaches in terms of the nature of the choice task. In the CE approach, respondents make choices among hypothetical choice scenarios where multiple attributes can vary.

Again the expression of preferences of the respondents may vary in choice exercise. The expression of preferences may be in the form of choice, ranking, rating and matching. These four techniques of the expression of preferences are summarized below:

Choice preference

The respondents are presented with a set of alternatives defined as bundles of attributes. The respondents are then asked to choose among the presented alternatives. An example of the CE where the preference of the respondent is given as choice is provided in Table 2.1.

Table 2.1: Example of choice preference

	Bus	**BRT**	**METRO RAIL**
Travel time (each way)	Same as now	10 minutes less than now	20 minutes less than now
Comfort	Same as now	Articulated low floor buses with A/C	Non-AC compartments
Cost	Same as now	Taka 10 more than current bus fare	Taka 15 more than current bus fare
Which mode would you choose?	**Bus**	**BRT**	**METRO RAIL**

Ranking preference

The respondents are presented with a set of alternatives defined as bundles of attributes. The respondents are then asked to rank each alternative relative to each of the others. For example if the Table 2.1 is presented to the respondents they will be asked to rank bus, BRT and METRO RAIL according to their preference.

Rating

The respondents are presented with a set of alternatives defined as bundles of attributes. Then the respondents are asked to put each alternative on a scale from good to bad.

Matching

In this case the respondents are not presented with the complete description of the alternatives. Rather they are asked to trade-off the relative values of the attributes of different alternatives. The trade-off is often done with a cost attribute. Example of the matching technique is provided in Table 2.2.

Table 2.2: Example of matching preference

Alternative 1		**Alternative 2**	
Cost 1	Time 1	____________	Time 2 (< time 1)
____________	Time 1 (<time 2)	Cost 2	Time 2

Now, the respondents will be asked, "What is the cost of alternative 2 that will make you indifferent between alternatives 1 and 2?" And, "What is the most you will be willing to pay for alternative 1?

CE offer some important advantages over the other methods, principally, the ability to estimate coefficient values for attributes with relative ease and capture the trade-offs among multiple attributes of interest (see Hanley et al., 1998 for a critical comparison). Moreover, CE is referred to as the closest to reality as they provide the respondents with the kind of choices they have to actually make in a real situation. These make the CE as the most preferred approach in most of the large-scale projects in spite of the relative difficulty in survey design, data collection and model development. CE have been used for conducting SP survey in the research work. Design of choice exercises is illustrated in the following Section which is started with the identification of the relevant terms.

2.3.2 Designs of choice exercises

In a typical SP experiment a respondent is asked to make a series of choices. Figure 2.3 shows N such choices which are organized into an experiment. In each choice the respondent must select one of the alternatives in the choice set. In the example the choice set has two alternatives which are identified by the names Rail and Auto. An alternative is characterized by its attributes and attribute levels. In the example Rail has four attributes: travel time, headway, cost and change. Travel time has three levels 40 minutes, 50 minutes and 60 minutes. The different combinations of the levels of attributes of an alternative are called profile while the combination of the attribute levels of different alternatives presented in a specific choice is called a scenario. SP survey design deal with the issues how Figure 2.3 should be constructed for each respondent.

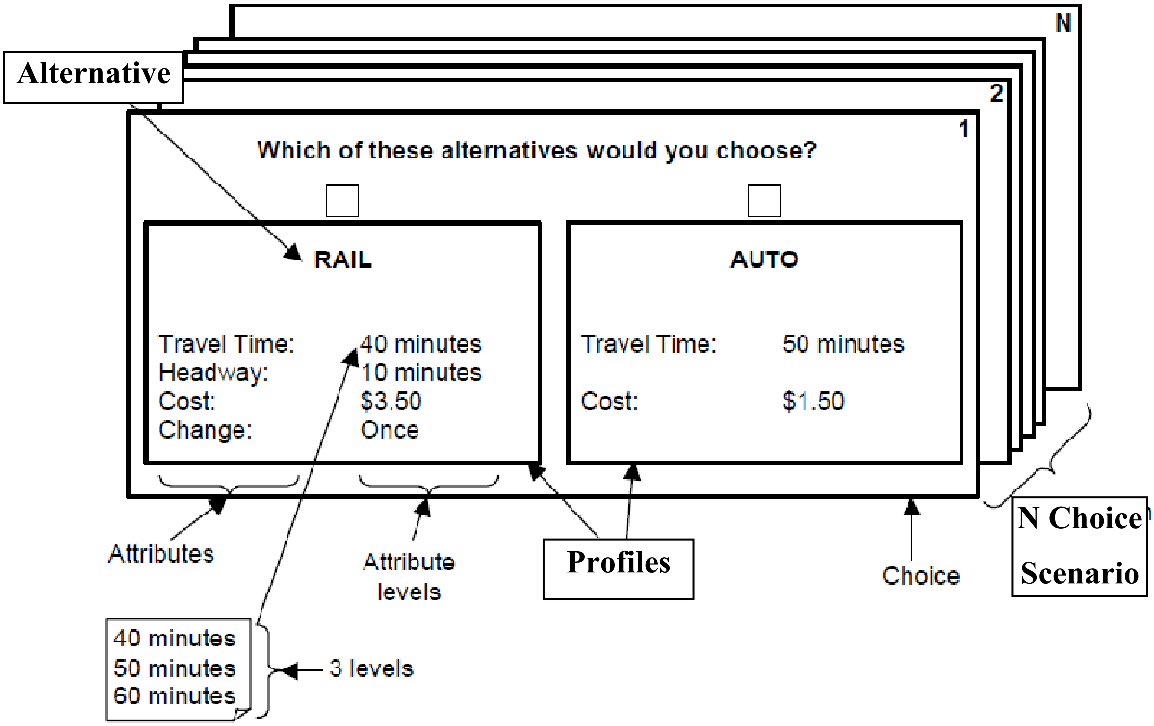

Figure 2.3: Choice based SP choice experiment (modified from Sanko, 2002)

In typical SP surveys, a focus group study is done first, followed by pilot and main surveys. These steps are elaborated below.

Focus group study

The first step of an experimental design is the identification of the alternatives and the selection of the attribute levels to be used in the survey. Traditionally the analysts thoroughly interview the people of interest to select the attributes and the attribute levels. This form of interview is commonly known as focus group study.

Full factorial design

After the identification of the attributes and the attribute levels the next task is to combine different attribute levels to present a profile. In full factorial design each level of each attribute is combined with every level of all other attributes to construct profiles (Ben-Akiva, 2008). For example an alternative with k attributes of 2 levels each has 2^k profiles. Table 2.3 shows the design for three attributes, each of two levels each.

Table 2.3: Full factorial design: three attributes, two level each (Ben-Akiva, 2008)

Profiles	**Attributes**		
	Fare	**Time**	**Frequency**
1	High	Slow	Infrequent
2	High	Slow	Frequent
3	High	Fast	Infrequent
4	High	Fast	Frequent
5	Low	Slow	Infrequent
6	Low	Slow	Frequent
7	Low	Fast	Infrequent
8	Low	Fast	Frequent

One important characteristics of full factorial design is orthogonality. Orthogonality means the attributes presented to the respondents are varied independently from one another so that the effects of each attribute level on the response are easily captured. However, as the number of attributes and the number of levels increases the number of profiles required for a full factorial design can be very large. For example, if there are four attributes each with four levels, the full factorial design requires $4^4 = 256$ profiles. If the respondents are presented with a very large number of choices there is a strong possibility that the respondents will experience fatigue in carrying out the choice exercises which will result in non-representative responses. Further, the respondents may sometimes ignore some choices if the number of combinations is too high (Pearmain et al., 1991). To overcome this problem the researcher need to reduce the number of profiles or choice scenarios. Reviews of literature suggest that there are a number of different strategies that can be adopted to reduce the number of combinations (Hensher and Rose, 2003). These are:

(i) Reducing the number of levels used within the design;
(ii) Removing the options that will dominate or be dominated by all the other options;
(iii) Using fractional factorial designs;
(iv) Blocking the design.

Reducing the Number of Levels

Reducing the number of levels within the design will dramatically reduce the design size, however such a reduction comes at a cost in terms of the amount of information the design obtains in terms of observations gained. To employ this strategy sometimes the extreme attribute levels are retained. At the least, each attribute will have only two attribute levels, both at the two extremes of the attribute level range. Such designs are known as end-point designs (Louviere et al, 2000).

Removing Dominated Options

This approach allows only limited reduction of options. It uses the proposition of dominance among the options. In the example provided in Table 2.3 option 8 is better than all the other options i.e. dominating the other options and option 1 is the worst option and is dominated by all the other options. These two options could be omitted with the assumption that the respondent will always choose option eight irrespective of the other alternative and will always ignore option one. The problem with this approach is that any respondent choosing randomly or irrationally will not be easily identified from their responses. If at least one best/worst option is kept intentionally, it will help in the identification of the reliability of the responses.

Using Fractional Factorial Design

A fractional factorial design is based on a systematic selection of a number of rows from a full factorial design. The main aim of the fractional factorial design is to reduce the number of scenarios offered to each respondent. This is achieved by carefully selecting a specific subset of scenarios from all the scenarios included in the full factorial design, in such a way that the main effects can still be properly estimated. The obvious advantage of a fractional factorial design is that it reduces the number of scenarios that are presented to respondents. A potential problem with fractional factorial designs is that orthogonality is lost in at least some respects. The trade-off is some or all of the interactions cannot be estimated and hence the implicit underlying assumption is that these are not significant in explaining preferences (Sanko, 2002). In practical research it has often been observed that indeed the main effects account for most of the observed variance in the preferences, and the interactions add little to that, although in some cases specific interactions may be of importance (Louviere, 1988).

Blocking the Design

In this approach the number of choices to be offered to a single respondent is reduced by dividing the full set of choices of a single experiment into two (or more) subsets (separate experiments or "blocks"), each of which is offered to different respondents. For example:

(i) A full factorial design may be subdivided into four fractional factorials; or

(ii) A fractional factorial may be subdivided into four partial subsets.

In first case, individual level estimation of the main effects is still possible, but the interactions can only be estimated by pooling data of multiple respondents. In second case even estimation of the main effects only requires pooling of observations. A key requirement for this is the underlying assumption that, homogeneity of the preferences across the respondents is a valid one (Sanko, 2002).

Creation of choice sets

The methods applied in the literature (e.g. Louviere et al., 2000) for combining scenarios to obtain choice sets fall into three typical groups. These are as follows:

Simultaneous choice set creation

The typical method of this type is the 'L^{MN}' procedure, giving choice sets of N alternatives with M attributes, each of L levels. For example, if L=2, M=3 and N=2, then there will be 64 choices which cover all possible combinations of the levels. This design can be represented in a single table by using separate columns for the attributes of each alternative, thus obtaining NxM=6 columns, and in this form a fractional factorial design can be developed by selecting specific rows (Sanko, 2002).

Sequential choice set creation

The fold-over design procedure creates the choice sets by creating profiles for subsequent alternatives based on the profile for the first alternative. The procedure starts from a full or fractional factorial design, which forms the profiles for first alternative. The profiles for the second alternative are then formed by a systematic transformation of the attributes, changing some to the next higher value, leaving others unchanged, etc. A simple change of all the attributes to their next level is called shifting; more complicated transformations, often involving a random element (shuffle) are called fold over designs (Sanko, 2002).

Randomised choice sets

Randomised choice sets are generally based on a full or fractional factorial design. Then scenarios are randomly selected (with or without replacement) from these to present to the respondent (Sanko, 2002).

2.4 Discrete Choice Modeling Techniques

In discrete choice modeling, decision makers are assumed to invoke a decision rule to choose from two or more alternatives. Usually, discrete choice models are derived under an assumption of utility-maximizing behavior by the decision maker. Thurstone (1927) originally developed the concepts in terms of psychological stimuli. Latter, Marschak (1960) interpreted the stimuli as utility and provided a derivation from utility maximization. Following Marschak, models that can be derived in this way are called Random Utility Models (RUMs). First, the overview of RUMs is presented and then the relevant methodological issues are discussed in further detail. The methodological issues include combination of RP and SP data sources, choice set model generation and addressing the measurement errors in the LOS data.

2.4.1 Random utility theory

In RUMs, the decision maker, n associates a certain utility, U with all the J alternatives in the choice set. Thus the utility, the decision maker derives from the alternative j is U_{nj}. The decision maker chooses the alternative that provides the greatest utility. But, the analyst or researcher does not have the full knowledge of the decision maker's utility U_{nj}. S/he only observes some attributes of the alternative X_{nj} and some characteristics of the decision maker S_n. Thus, the utility U_{nj} can be decomposed as $U_{nj} = V_{nj} + \epsilon_{nj}$, where V_{nj} is the part of the utility that is observed by the analyst and ϵ_{nj} captures the factors that affect utility but are neither included in V_{nj} nor observed by the researcher. Therefore, V_{nj} can be expressed as a function of X_{nj} and S_n as $V_{nj} = V(X_{nj}, S_n)\ \forall\ j$. The researcher does not know $\epsilon_{nj}\ \forall\ j$ and therefore treats these terms as random. Therefore, the researcher cannot certainly conclude that the decision maker will choose a particular alternative from the choice set; rather s/he can probabilistically predict the choice of the decision maker. The probability that decision maker *n* chooses alternative *i* can be expressed as in Equation (2.1).

$$
\begin{aligned}
P_{ni} &= \text{Prob}(U_{ni} > U_{nj} \ \forall\ j \neq i) \\
&= \text{Prob}(V_{ni} + \epsilon_{ni} > V_{nj} + \epsilon_{nj} \ \forall\ j \neq i) \\
&= \text{Prob}(\epsilon_{nj} - \epsilon_{ni} < V_{ni} - V_{nj} \ \forall\ j \neq i) \qquad (2.1)
\end{aligned}
$$

This probability is a cumulative distribution, namely, the probability that each random term $\epsilon_{nj} - \epsilon_{ni}$ is below the observed quantity $V_{ni} - V_{nj}$. The probability that individual n will choose alternative i can be found by integrating Equation (2.1) over the joint distribution of the random vector ϵ_n. Different discrete choice models are obtained from different assumptions about this distribution (For details reference can be made to Ben-Akiva and Lerman, 1985 and Train, 2009).

The integral takes a closed form only for certain specifications of joint distribution of ϵ_n. Logit and nested logit have closed-form expressions for this integral. They are derived under the assumption that the unobserved portion of utility is independently and identically distributed (iid) extreme value and a type of generalized extreme value, respectively. Probit is derived under the assumption that the distribution is a multivariate normal, and mixed logit is based on the assumption that the unobserved portion of utility consists of a part that follows any distribution specified by the researcher plus a part that is iid extreme value. With probit and mixed logit, the resulting integral does not have a closed form and is evaluated numerically through simulation or numerical integration. These models are discussed briefly below:

Logit (for details reference can be made to Train, 2009) is derived under the assumption that ϵ_{ni} is iid extreme value for all i. The critical part of the assumption is that the unobserved factors are uncorrelated over alternatives, as well as are having the same variance for all alternatives. This assumption, while restrictive, provides a very convenient form for the choice probability. The popularity of the logit model is due to this convenience. The assumptions, taken together, lead to the mathematical structure known as the Multinomial Logit Model (MNL), which gives the choice probabilities of each alternative as a function of the systematic portion of the utility of all the alternatives.

The development of other models has arisen largely to avoid the independence assumption within a logit. Generalized extreme value models (for details reference can be made to Train, 2009) are based on a generalization of the extreme value distribution. The generalization can take many forms, but the common element is that it allows correlation in unobserved factors over alternatives and collapses to the logit model when this correlation is zero. Depending on the type of GEV model, the correlations can be more or less flexible. The most widely used member of the GEV family is called nested logit which has got a closed form like logit.

Probits (for details reference can be made to Train, 2009) are based on the assumption that the unobserved factors are distributed jointly normal. When applied to sequences of choices over time, the unobserved factors are assumed to be jointly normal over time as well as over alternatives, with any temporal correlation pattern. The flexibility of the probit model in handling correlations over alternatives and time is its main advantage. Its only functional limitation arises from its reliance on the normal distribution.

Mixed logit (for details reference can be made to Train, 2009) is a highly flexible model that can approximate any random utility model (McFadden & Train, 2000). It obviates the three limitations of standard logit by allowing for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time. The defining characteristic of a mixed logit is that the unobserved factors can be decomposed into a part that contains all the correlation and heteroskedasticity, and another part that is iid extreme value. The first part can follow any distribution, including non-normal distributions. Its derivation is straightforward, and simulation of its choice probabilities is computationally simple. Mixed logit can approximate any discrete choice model and thus is fully general.

2.4.2 Combination of RP and SP data

The process of pooling RP and SP data and estimating a model from pooled data is often termed as data enrichment (Louviere et al. 2000). Morikawa (1989) first proposed this method in order to use SP data to identify the parameters that are not found in RP data and thereby to improve the efficiency of the model. This stream of research has been illustrated by the work of Ben-Akiva and Morikawa (1990), Ben-Akiva et al. (1992), Bradley and Daly (1994), Hensher and Bradley (1993), Adamowicz et al., (1994), Adamowicz et al. (1997), Hensher (1998), etc. In the data enrichment paradigm the analyst's view is that the RP data contain information about the equilibrium and trade-offs in a particular current market and the SP data are collected where the RP information is deficient (especially in case of attribute trade-offs). The RP and SP data may come from the same or different people. Then the SP data are pooled with the RP data to obtain a final choice model. For the estimation of the attributes of two data sets all the attributes need not be the same, but at least some of them must be common. The process of combining the two data sources imposes a restriction that the common attribute must have same parameter in both the data sources. But, the choice sets in the two data sources need not be the same. Assuming that the two data source has got two different scale factors (λ^{RP} and λ^{SP} for RP and SP data respectively) the choice probabilities can be expressed as in Equation (2.2a) and (2.2b).

$$P_i^{RP} = \frac{\exp[\lambda^{RP}(\alpha_i^{RP}+\beta^{RP}X_i^{RP}+\omega Z_i)]}{\sum_{j\epsilon C^{RP}}\exp[\lambda^{RP}\left(\alpha_j^{RP}+\beta^{RP}X_j^{RP}+\omega Z_j\right)]}, \quad \forall i\epsilon C^{RP}, \tag{2.2a}$$

$$P_i^{SP} = \frac{\exp[\lambda^{SP}(\alpha_i^{SP}+\beta^{SP}X_i^{SP}+\delta W_i)]}{\sum_{j\epsilon C^{SP}}\exp[\lambda^{SP}\left(\alpha_j^{SP}+\beta^{SP}X_j^{SP}+\delta W_j\right)]}, \quad \forall i\epsilon C^{SP} \tag{2.2b}$$

Where, i is an alternative in choice sets C^{RP} or C^{SP}, αs are data source specific alternative specific constants (ASCs), β^{RP} and β^{SP} are the utility parameters for the attributes common to both data sets, δ and ω are utility parameters for the unique attributes in each data set, and γ^{RP} and γ^{SP} are the scale factors associated with the error terms of the RP and SP data source respectively.

2.4.3 Choice set generation

A basic premise for the theoretical development and practical utilization of discrete choice models is that the analyst is correctly able to specify the set of modes from which an individual decision maker chooses a given alternative. However, in practical model development, it is often the case that only the chosen mode is known with certainty and it is unclear what modes were available in the choice context and/or were actually considered by the respondent while making the decision. The analyst is thus burdened with the task of specifying the choice set. In discrete choice models of pre-seventies, it was assumed that either all the alternatives were available to all the decision makers or some logical rules were used to better approximate an individual decision maker's actual choice set e.g. in mode choice models no car were assumed to be available to an individual without a driving license etc.

In classical economic choice theories, individual choice behavior in cases of unobserved choice sets has been modeled as a two-stage sequential process (Manski, 1977):

(i) The determination of an individual's choice set C_n; and

(ii) With the C_n well defined, the individual chooses an alternative according to some pre-established decision rules (e.g. utility maximization).

Over the years, discrete choice modeling has concentrated its attention on theoretical development of the second stage and there has been a paucity of theoretical development of the choice set generation stage (Swait, 1984).

For the analyst who has limited information about an individual's choice set can consider the choice set generation model as either deterministic or probabilistic depending upon the degree of confidence s/he places on information at hand. According to Manski (1977) the application of deterministic rule results in "expected choice set". There are numerous examples of the application of deterministic choice set in literature (e.g. Ben-Akiva and Lerman, 1974 and Train, 1980). An elaborate example of applying deterministic choice set is the work of Recker et al. (1983).

In the probabilistic approach, a separate choice set generation model is used to predict the choice set stochastically. From the perspective of an analyst who does not have the knowledge of the specific alternatives of an individual's choice set, the probability of observing the choice of some discrete alternatives must be expressed as in Equation (2.3) (Manski, 1977):

$$P_n(j) = \sum_{C \in G_n} P_n(j|C) P_n(C) \tag{2.3}$$

Where, C = an element of G_n ($C \subseteq M_n$); G_n = the set of all non-empty subsets of M_n; M_n= the set of all deterministically feasible alternatives for individual n ($M_n \subseteq M$); M = the universal choice set, made up of all possible alternatives available for the choice context and population in question. Equation (2.3) reflects a three part model of the choice process:

(i) A probabilistic choice model, $P_n(j|C)$, conditioned on the choice set being $C \in G_n$, which by definition yields choice probabilities of zero for $j \notin C$;

(ii) A deterministic choice set generation model that determines the subset M_n from the set M; and

(iii) A probabilistic choice set generation model, $P_n(C)$, expressing the probability that set $C \subseteq M_n$ is the individual's actual choice set.

A fully general formulation of the choice set generation model is prohibitive because of a high degree of computational complexity implied by Equation (2.3). For example, if |x| denotes the number of elements in any set X, then G_n is equal to $(2^{|Mn|} - 1)$, of which $(2^{|Mn|-1})$ choice sets actually contain any given alternative $j \in M_n$ (Swait, 1984). Therefore efforts have been directed towards the formulation of choice set generation model with a priori restriction on G_n.

McFadden (1976) was first to the best of the knowledge to formulate a model following the above choice processes; he considered a choice situation where an individual is either captive to an alternative or free to choose from M_n according to a Multinomial Logit Model. This model is known as logit captivity model in literature. The model was independently developed by Ben-Akiva (1977). Ben-Akiva (1977) has considered two other structures of G_n. These are as follows:

(i) Either the decision maker can choose from a full choice set or from the full choice set minus one alternative; and

(ii) A combination of the simple captivity case proposed by McFadden (1976) and (i) above. Gaudry and Dagenais (1979) also developed the model independently but their motivation was to circumvent the IIA (Independence of Irrelevant Alternatives) property of logit model and named it "Dogit"; since the model "dodges" the IIA assumption of the logit model. Mathematically, the logit captivity model can be expressed as in Equation (2.4).

$$P_n(i) = [\frac{\sigma_i}{(1+\sum_{j \in M_n} \sigma_j)}] + [\frac{1}{(1+\sum_{j \in M_n} \sigma_j)}] \frac{\exp(V_{in})}{\sum_{l \in M_n} \exp(V_{ln})} \quad (2.4)$$

Where, V_{in} is the systematic utility of the ith alternative, and σ is a vector of non-negative parameters that represents the odd of the individual being captive to each specific alternative. The first term of right side of Equation (2.4) represents the probability that the individual is captive to alternative i which makes the probability of choosing alternative i equal to one. The second term has two parts: the one involving the σ vector represents the probability that the decision maker is free to choose from the full choice set M_n, and the other is the logit model of probability of choosing i given that the choice set is M_n. In logit captivity model a single parameter (σ_i) has been used per alternative to represent the captivity of the decision maker. Later, this restriction has been relaxed in Parameterized Logit Captivity (PLC) model.

In PLC model the parameter σ_i is parameterized as functions of independent variables as in Equation (2.5).

$$\sigma_i(X) = \exp(DX_i), \forall_i \epsilon\ C \tag{2.5}$$

Where D = (d_1,…..,d_k,…..d_K) is a vector of parameters, and X_i is a vector of socio-economic characteristics of the decision-maker and attributes of alternative i. Where B = (b_1,……,b_l,…..b_L) is a vector of parameters of the MNL choice model, and Y_i is a vector of socio-economic characteristics of the individual and attributes of alternative i. It is to be mentioned that, the two vectors X_i and Y_i do not generally contain the same variables. X_i should include those variables thought to explain captivity to alternative i, whereas Y_i should include variables (perhaps partially or totally overlapping with X_i) which influence choice of i from among the alternatives of C.

A probabilistic choice set formation model with no priori restrictions on G_n is the Independent Availability Logit model (Swait, 1984). The derivation of the model follows that an alternative is available if all the relevant constraints are satisfied and unavailable otherwise. These constraints are random in nature in the sense that the decision makers may have a varied perception of the degree to which an operative constraint may limit their access to certain modes. This model assumes that the probability of availability of an alternative is independent of the availability or lack thereof any other alternative. The mathematical formulation of this model is:

$$P_n(C) = \prod_{i\,\epsilon\,C} \gamma_i \prod_{j\,\epsilon M_n - C}(1-\gamma_j)/[1-\prod_{l\,\epsilon\,M_n}(1-\ \gamma_l)], C\ \epsilon\ G_n \tag{2.6}$$

Where γ_i is the probability that alternative i ∈ M_n is available and other quantities are as previously defined. The notation M_n – C denotes the set of the alternatives in M_n less the alternatives in C. In Equation (2.6) the first term in the numerator represents the probability of availability of all of the alternatives in C, and the second the probability of unavailability of all the alternatives in M_n not in C. The denominator is a normalization factor to exclude the event of all alternatives being unavailable.

Both the Logit Captivity model and Independent Availability Logit models have been applied to investigate the mode choice process of the city of Maceio, Brazil (Swait and Ben-Akiva, 1985). The model focused on the home based work mode choice for full-time workers. The outcome of the model highlighted an important practical challenge. It indicated that the application of the probabilistic choice set generation process cannot be arbitrary. Rather, it must account for the population in question as well as the source of constraints on it. In this particular choice context the logit captivity model performed better than the Independent Availability Logit model in the low income group; the opposite was true for the high income group; and in the middle income group, the choice between the two models was indifferent.

A drawback of the probabilistic choice set formation models is the greatly increased difficulty of calibrating them. The departure from the standard logit linear-in-parameters formulation can be costly because the convenient property of concavity of the log-likelihood function, which guarantees the uniqueness of the parameters at the point of convergence, is lost. Hence a greater degree of care and sophistication on the part of the analyst as well as specialized estimation software are necessary.

Swait (1984) has derived various model forms in which he made a trade-off between generality and tractability. An effort has been made to restrict the number of subsets of choice set (G_n) by assuming that the decision makers are captive to a group of alternatives. In another attempt Swait (1984) considered the existence of maximum choice set size to formulate a choice set generation model motivated by the limited information processing ability of human being. Again, it has been argued that, human being do not evaluate the attributes of all the alternatives to restrict the choice set to a limited number of alternatives, rather they use some non-compensatory rules in the first stage which is followed by some compensatory rule in the second stage (Ben-Akiva and Boccara, 1995).

2.4.4 Addressing measurement errors

High quality LOS data are essential for accuracy of the estimates of the mode choice model. Measurement error is very often a type of endogeneity bias and disregarding the measurement error can lead to inconsistent estimates of the parameters (Walker el al., 2008). The endogeneity arises from the correlation of the explanatory variable with the error term. It has been identified by Walker et al. (2008) that there is a large literature on measurement error in economic literature but, very little of that is directly related to measurement error in discrete choice modelling or in transportation modelling. There has been a vast literature on measurement error correction in medical science also. Multiple data imputation technique has been used to correct measurement error in medical science by Cole et al. (2006).

Brownstone et al. (2001) has developed and demonstrated a technique to overcome the measurement errors in travel data. In this method, multiple imputed values are generated for each observation and separate choice models are estimated for each set of imputed data. But, this multiple imputation technique is applicable only when validation data are available (Ben-Akiva et al., 2002). Later on Steimetz and Brownstone (2005) presented a similar method for measurement error correction which also involves multiple imputations, but the drawback of the method is that it can only be used when one has a subsample of accurate observations. Jeffry and Shonkwiler (2002) have modeled travel time as latent variable to overcome the consequences of measurement error. Kim et al.(2006) has explored a criteria to detect error in the data collected by GPS based on distance between two consecutive GPS points, acceleration rate, deceleration rate, horizontal dilution of precision (HDOP), and the number of satellites. Bhatta and Larsen (2007) have explored the consequences of measurement error on estimates in transportation models, but did not discuss any solution. There are other works also which focus on the improvement of level of service measurements (e.g. Ortuzar and Ivelic, 1987; Ortuzar and Willumsen, 2001). The task of measurement error correction also extends to other types of transport models such as gravity models (e.g., Gunn and Whittaker, 1981).

Walker et al. (2008) has proposed a method to address the measurement errors in network derived level of service data for the work trip context of Chengdu, China. In the research work the true travel time was treated as latent variable known only to a distribution f_T and a set of estimated parameters Θ. It was assumed that the distribution of measured travel time is conditional on the true travel time and a set of estimated parameters τ. Therefore, to get the probability of choosing alternative i one need to integrate the probability of choosing mode i (conditional on a set of estimated parameters β and explanatory variable

t^{True}) over the distribution of t^{True}. Now accounting for the measured travel time the likelihood function for the entire framework becomes:

$$L(i, t^{Measured}|\beta, t^{True}) f_T(t^{True}; \theta) f_M(t^{Measured}|t^{True}; \tau) dt^{True} \quad (2.7)$$

Walker et al. (2008) have employed the above methodology to correct the travel time of bus in China and found that, the model fit did not improve significantly when compared with the logit model. But, the Value of Time (VOT) increased significantly from 7.72 yuan/hour to 12.94 yuan/hour. The estimated VOT using the hybrid model was more close to the average income of the area (15 yuan/hour).The practical limitation of the proposed methodology is that, each latent variable adds a dimension for integration and when the number of latent variables exceeds 3, simulation becomes a necessity.

2.5 Summary

In this Chapter, mode choice models for Dhaka are reviewed first and it is revealed that, no comprehensive mode choice models are developed for Dhaka to date. In existing models, rule based choice sets have been used and level of service values have been used without measurement error corrections. Moreover, the choice models have not been robust enough to account for new alternatives with significantly different attribute levels than the existing ones.

In later Sections of the Chapter, different available methods of stated preference survey are elaborated along with the relevant survey design techniques. This review is followed by the illustration of available discrete choice modeling literature. Special attention is given to the combination of RP and SP data sources; choice set generation method and the measurement error correction techniques of the level of service variables. The literature reviews of the methodology have provided useful insights and have guided the comprehensive mode choice model development for Dhaka in the subsequent Chapters.

CHAPTER THREE
DATA AND MODEL FRAMEWORK

3.1 Overview

In this Chapter, the data used for the model development is described and the model framework is proposed. The Household Interview Survey (HIS) conducted as part of the Strategic Transport Plan (STP) Study in 2005 is used as the main data source for the Revealed Preference (RP). This data is supplemented by Hasan (2007) with a small scale House Hold (HH) survey and network analysis to gather information about the travel times and costs of different modes. However, since improved mass transit options like BRT and Metro Rail, or modes of comparable level of service have never been implemented in our country, the RP data is not likely to be sufficient to determine the sensitivity towards attributes of these improved modes (which are likely to vary substantially from the currently available modes). This deficiency of data warranted designing and conducting a Stated Preference (SP) survey so that improved mass transit like BRT and Metro Rail can be included in the proposed mode choice model.

3.2 RP Data

3.2.1 Overview

In the STP HIS (STP, 2005) more than 6,000 households were interviewed and a huge amount of information were collected regarding the location and type of the households, socio-economic characteristics of its members, vehicle ownership of the households, daily trip information of the respondents and also some attitudinal information about the respondents. The socio-economic information data are immensely extensive with age, gender, education level, employment status, and occupation, driving license status, address of the worksite and educational institutions and household income. The daily trips of each member of the households are reported which revealed more than 30,000 trip information. The trip diary consists of the O-D locations, start and end time between origin and destination (but not for each modal segment of the trip chain), trip purpose and transport modes of each trip segment. The attitudinal question part comprises questions on reasons behind choosing the current mode of travel, existing problems of the current travel modes, and asks for suggestions for the improvement of the traffic situation to name a few. The survey questionnaire is attached in Appendix A.

This huge amount of data has been cleaned based on the following two criteria.

(i) The observations with any missing value are ignored;

(ii) The trips which did not involve any mechanized mode of transport (i.e. trips which were exclusively by walking) are also ignored.

These two criteria resulted in 7531 valid data points. The characteristics of the data points considered for model development are illustrated below:

The gender distribution of the respondents is quite balanced with 45% female and 55% male respondents, Figure 3.1. The majority of the respondents are aged twenty five to forty years, Figure 3.2.

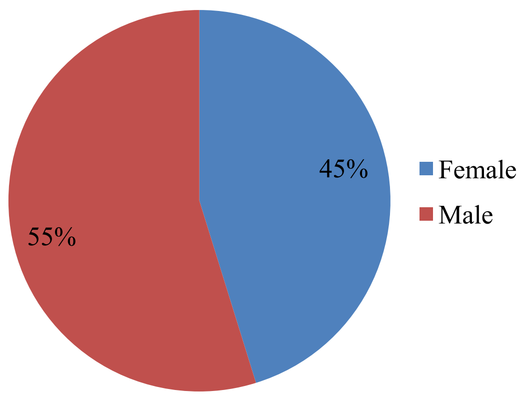

Figure 3.1: Gender distribution

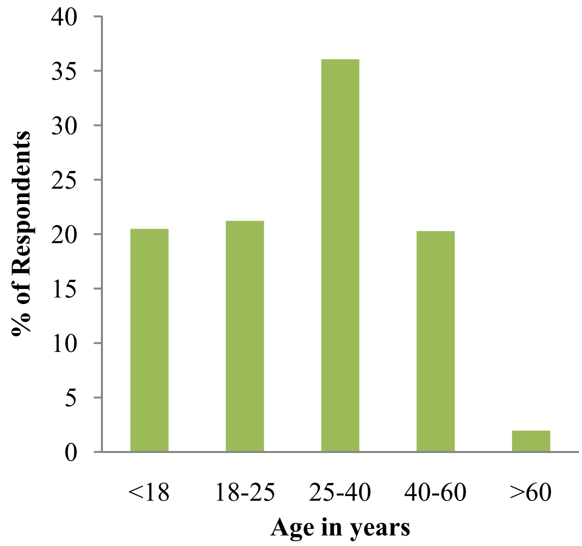

Figure 3.2: Age distribution

A large portion of the respondents (33%) is found to be in government or private services which are followed by 30% students and 26% housewife, Figure 3.3. The household incomes of about 34% of the respondents are between ten thousand to twenty thousand Taka, Figure 3.4. More detailed description of the data is available at STP (2005).

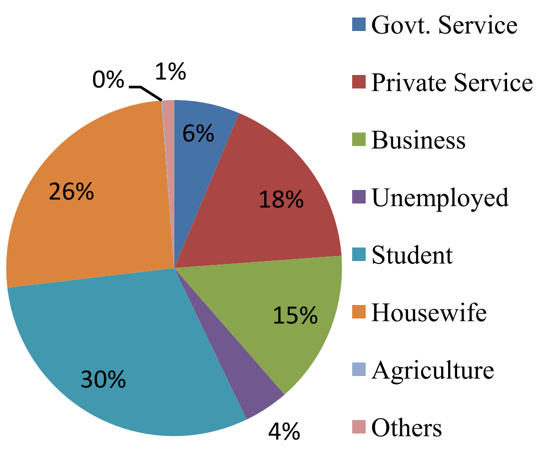

Figure 3.3: Occupation distribution

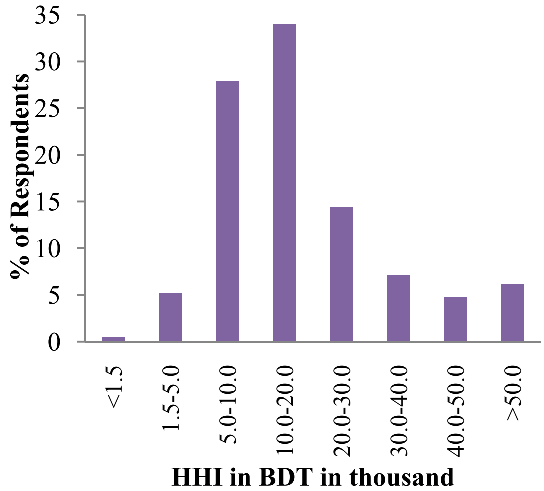

Figure 3.4: Income distribution

3.2.2 Data issues

STP data, though sufficient for aggregate modeling like trip generation and trip distribution, have several limitations in terms of disaggregate analysis like mode choice modeling. For example, the data revealed only the chosen mode of the travelers along with the stated travel time by that mode. However no information is available regarding the cost of the travel or the travel time by other alternative modes. Information regarding the choice set of the respondents is also missing. Moreover, the data has got limited variability in terms of trip attributes like travel time and travel cost and have not got any information about other attributes (e.g. waiting time, comfort, etc.). Detailed exploration of the RP data thus reveals four key limitations:

(i) Unobserved choice sets;

(ii) Unobserved LOS including absence of data on travel time for unchosen mode and cost for all modes;

(iii) Limited range of attributes;

(iv) Absence of preference regarding MRT.

To address the limitations of the RP data an SP survey, which includes the proposed new modes into the choice set of the respondents is conducted. The details of SP survey organization and modifications are presented in the following Sections followed by the illustration of the SP data characteristics.

3.3 SP Data

3.3.1 Overview

Among the various techniques of SP survey design reviewed in the preceding Chapter, Choice Experiment (CE) offers some important advantages over the other methods. This technique is referred to as the closest to reality as they provide the respondents with the kind of choices they have to actually make in a real situation. With this technique, the trade-offs among various attributes of a product or service (e.g. travel time, travel cost of different modes) can be captured relatively easily compared to other techniques. For these advantages CE is adopted as the preferred technique to conduct the SP survey for the research work. The survey is conducted in three steps; viz. initial survey, pilot survey and main survey. The schematic diagram of the steps of the SP survey is presented in Figure 3.5.

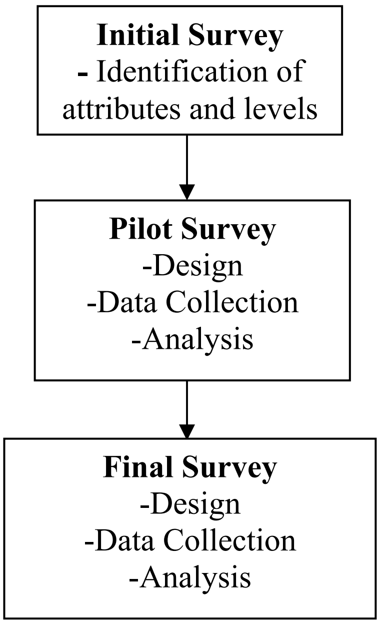

Figure 3.5: SP survey steps

3.3.2 Initial Survey

In SP survey design it is important to limit the number of attributes and attribute levels. Because, if the respondents are presented with a very large number of choices there is a strong possibility that the respondents will experience fatigue in carrying out the choice exercises which will result in non-representative responses. Generally focus group study or personal interview survey is conducted to identify the important attributes and associated levels to be used in the SP survey design. Literature review revealed existing work on focus groups in the context of mode choice in Dhaka by Mamun et al. (2009).

This recent study has identified a large number of attributes of mass transit system (bus) of Dhaka city and ranked them according to the preference of the users. However, the research work was limited among the bus users of Dhaka city and the users of other modes were regarded to be out of the scope of the study.

In order to select the most important attributes of different modes (bus, rickshaw, CNG, car etc.) an initial survey (personal interview survey) is conducted in this research work. Different questionnaire are used for the bus users and the non-bus users with an assumption that the affordability and mode specific variables of the two groups would vary significantly.

The main objectives of the initial survey are:

(i) To identify the important attributes of different transport modes as perceived by the users;

(ii) To get an idea about the upper limit and lower limit of different attribute levels for the improved mass transit (e.g. travel time, waiting time/frequency, travel cost, etc.).

Organization

The organization and the findings of the survey are elaborated separately for bus users and non-bus users.

a. For bus users

The initial survey among the bus users has been conducted on 13 September, 2009. The survey questionnaire can be broadly divided into three different sections. The aim of the first section is to reveal some data about the respondents' current trip (for example: origin & destination of the current trip, waiting time, travel time, fare, no. of transfers etc.). The second section consists of some open ended questions on the respondents' willingness to pay. This section is designed to get an idea about the trade-offs the users' are willing to make among various mode attributes. For example, the respondents are asked how much extra cost they are willing to incur for reduced waiting time, reduced travel time, reduced no. of transfers etc. It may be noted that the open ended questions on reduced travel time are grouped based on the duration of the trip. In this part the respondents are also asked to mark different attributes of transport modes as important or unimportant. The third part contains some questions about the socio-economic characteristics of the respondents. The full questionnaire is appended in Appendix B1.

b. For non-bus users

The travel pattern for work trips and non-work trips are different to some extent. For example, flexibility of time is relatively low in work trips compared to non-work trips, parents are usually accompanied by their children in non-work trips (recreational trips and social trips) etc. Considering the facts it is assumed that, the respondents' sensitivity would be different for various mode attributes in work trips and non-work trips. In order to capture the differences the survey questionnaire for non-bus users has two different versions for work trips and non-work trips. It is to be noted that, for bus users these trips are not considered separately because of the limited flexibility offered by the buses. The non-bus users are again divided into car users and CNG/taxi/rickshaw users for the initial survey only. The questionnaires of both versions for car and CNG/taxi/rickshaw users are appended in Appendix B2-B5.

Findings

Finding is also presented separately for bus users and non-bus users.

a. From bus users

Thirty two (32) completed survey questionnaires have been obtained from Airport, Mohakhali, Shahbag and Azimpur bus stops. The findings from the survey are summarized in the following two subsections:

Important mode attributes

To get an idea about the users' perspective about the importance of different transport modes they were asked to mark different attributes as important or unimportant. In each case, they were reminded that there will be a cost increase associated with the improvement. More frequent service is emerged as the most important attribute while reduction in travel time and cleaner and more comfortable buses are perceived as second and third important attributes by the users. Table 3.1 shows the ranking of different attributes as perceived by the users.

Table 3.1: Ranking of improved mass transit attributes (by bus users)

Attributes	Rank
More frequent service	1
Reduction in travel time	2
Cleaner and more comfortable buses	3
Have separate bus lanes	4
Buses will follow strict schedule	5
Rail based Metro Rail service	5
Underground Metro rail Service	7
Have better bus stops	8
Direct service to destination	9
Keep the same fare	10

Trade-offs among alternatives

I. Among waiting time and travel cost

The respondents were asked how much extra fare they were willing to pay for total 5 minutes waiting time (asked only to the respondents whose waiting time has been more than 5 minutes). The average willingness to pay (WTP) for all trip duration is found to be Taka 2.02 with a maximum of Taka 10 and a minimum of Taka 0 for all trip durations. However, it is found that the WTP for reduced waiting time are greater for short trips than for long trips.

II. Among travel time and travel cost

The respondents were asked how much extra fare they were willing to pay for 5, 10, 15 and 20 minutes reduction in their current travel time. For short trips WTP are greater than those for long trips. Rather than the average values obtained from the initial survey the ranges of the WTP i.e. the maximum and minimum values are used to determine the ranges of travel cost to be used in the SP survey design. Table 3.2 summarizes the maximum and minimum values of WTP as obtained from the initial survey for different trip duration.

The results thus have given useful indication on the ranges of the attribute levels (travel time, travel cost etc.) to be tested in the SP survey design. Sum of WTP for reduced waiting time (i.e. for increased frequency) and WTP for reduced travel time give indication on the total WTP. So, the maximum WTP as obtained from the initial survey is

20 Taka (maximum 10 Taka for reduction in waiting time and maximum 10 Taka for reduction in travel time).

Table 3.2: WTP ranges for reduced travel time for different trip durations (from bus users)

Reduction in Travel Time (minutes)	Trip Duration in Minutes					
	15 to 30		31 to 45		Greater Than 45	
	Min^{m} (Taka)	Max^{m} (Taka)	Min^{m} (Taka)	Max^{m} (Taka)	Min^{m} (Taka)	Max^{m} (Taka)
5	0	6	0	2	0	2
10	0	10	0	2	0	4
15	0	0	0	3	0	5
20	0	0	0	0	0	10

b. From non-bus users

It has been difficult to collect data from non-bus users for some practical limitations. In the potential data collection locations where the car stopped for a while (e.g. parking lots, CNG stations, office of registry of motor vehicles etc.) it has been very often difficult to reach the principal car user(s) since most of the time only the driver was waiting with the car. Similarly, in the potential data collection locations where CNG/ rickshaw users were available (e.g. CNG and rickshaw stands), generally only the CNG drivers and the rickshaw pullers are found waiting for the passengers. The passengers waiting for the CNG/rickshaw on the road-side are generally busy looking for a suitable empty transport to hire and not likely to be cooperative to answer the survey questions. To overcome this limitation, data from the non-bus users are collected over telephone and from households by personal contact. A total of seventy seven complete survey questionnaires are obtained (thirty seven for work trips and forty for non-work trips). The findings from the survey are summarized in the following two subsections:

Important mode attributes

More reliable and on time service is emerged as the most important mass transit attribute for the non-bus users. Cleaner and more comfortable buses and reduced travel time is the second and third most important mass transit attributes respectively for the non-bus users. Ranking of different mass transit attributes as perceived by the car users are given in Table 3.3.

Table 3.3: Ranking of improved mass transit attributes (by non-bus users)

Attributes	Rank
More reliable and on-time services	1
Cleaner and more comfortable buses	2
Reduced travel times	3
Better bus stops	4
More frequent services	5
Separate bus lanes	6
Rail based underground Metro Rail service	7
Direct service to destination	8
Rail based service	9

Trade-offs among alternatives

It is found that in many cases the car users had very little idea about the fare of the existing public transport modes (bus, mini-bus etc.) and in some cases they had no idea at all. So, it is difficult for them to answer when they were asked how much fare (total) they were willing to incur for a reduction in travel time by 5, 10, 15, 20, 30 and 40 minutes. Some respondents replied in terms of percentage of the current fare (like 30% more than now or 60% more than now) without knowing the current fare and some replied in terms of absolute value (like 10 Taka , 30 Taka etc.). It makes the task of finding the reasonable range for WTP more difficult. Maximum and minimum values of the WTP are summarized in a 3.4.

Though the table does not provide a very clear idea about the WTP ranges to be tested in the SP survey design; however the difference in WTP for work trips and for non-work trips is significant with higher (lower) WTP for work trips (non-work trips).

Table 3.4: WTP ranges for reduced travel time for different trip durations (from non-bus users)

Trip Duration (in Minutes)	TT Reduction (in Minutes)	For Work Trip		For Non-work Trip	
		Minimum (Taka)	Maximum (Taka)	Minimum (Taka)	Maximum (Taka)
15 to 30	5	0	30	0	20
	10	0	50	0	30
31 to 45	5	0	30	0	20
	10	0	35	0	23
	15	0	40	0	25

Table 3.4: WTP ranges for reduced travel time for different trip durations (from non-bus users) (continued)

Trip Duration (in Minutes)	TT Reduction (in Minutes)	For Work		For Non-work	
		Minimum (Taka)	Maximum (Taka)	Minimum (Taka)	Maximum (Taka)
46 to 60	5	0	100	0	25
	10	0	110	0	25
	15	0	120	0	30
	20	0	130	0	50
	30	0	140	0	40
Greater Than 60	5	0	0	0	30
	10	0	20% more than now	0	32
	15	0	25% more than now	0	34
	20	-	50% more than now	-	37
	30	-	75% more than now	-	40
	40	-	80% more than now	-	45

Additional information revealed regarding the non-bus users

In addition to the above findings the initial survey reveals some additional information regarding the travel behavior of the non-bus users. The car users identified that flexibility, safety and less travel time (faster than other modes) are the three principal reasons for choosing car over other modes. A significant difference is observed among the car users in willingness to switch to mass transit for work trips and non-work trips. Fifty four percent of the respondents were willing to switch on to improved mass transit system if introduced but in case of non-work trip only thirty five percent were willing to switch to improved mass transit mode. It is also found that there has been a lack of knowledge about the availability of public transport among the non-bus users. Fourteen percent of the respondents said that they didn't know whether any public transport (bus, minibus etc.) were available for their trips or not.

3.3.3 SP survey design

SP choice scenarios are constructed in such a way that the respondents' choice set is composed of their 'current mode' and two improved mass transit options (BRT and Metro Rail). The travel time of the new alternatives are presented as a reduction from the travel time of the 'current mode' of the respondents and travel cost of the new alternatives are presented as an increase from the 'current bus/tempo' fare in case of bus users and as an absolute fare in case of car, CNG/taxi and rickshaw users. Since, different mode users will experience different amount of reduction in their travel time, it is assumed that the reduction in travel time will dependent on the 'current mode' of the respondents with the maximum reduction for rickshaw users and minimum for car and CNG/taxi users. Four different versions of the questionnaire are prepared depending on the users' current mode of travel. These groups are as follows:

(i) Current bus/tempo user group;
(ii) Current car user group;
(iii) Current CNG/taxi user group;
(iv) Current rickshaw user group.

The SP survey questionnaire consists of the following sections:

Questions about the current travel behavior of the respondents

The questions on current travel behavior for public transport users (bus, tempo, etc.) and non-bus users comprises questions to get the information (in the context of their current trip) as presented in Table 3.5.

Table 3.5: Information collected regarding the current travel behavior

For bus users	For non-bus users
Name of bus-stop	Origin (Type and rough address)
Time of day	Destination (Type and rough address)
Origin (Type and rough address)	Approximate starting time
Destination (Type and rough address)	Approximate end time
Expected journey time	Availability of bus service
Current waiting time	Availability of other modes
Approximate fare	Reason for using car
Other available modes	Frequency making of that kind of trip
Reason for using the public transport	Access to car
Frequency of travel in that route	Driver appointment
Approximate fare	Approximate car cost per month
	Approximate car cost for the trip in discussion

SP scenario

In order to keep the choice task tractable, the number of attributes used to describe an alternative in the SP scenario has been limited to three. From the initial survey the top three attributes (according to the importance as perceived by the respondents) are frequency, travel time and travel cost. Multiple levels are assumed for each attribute. The upper and lower ranges of the levels are determined on the findings from the initial survey. The levels of travel time and travel cost are selected to vary with the trip duration of the respondents' current trip. Four different combinations of the two attribute values are set in a single questionnaire and the profile is selected instantaneously depending on the revealed trip duration of the respondent. The following ranges are used in this regard, Table 3.6.

Table 3.6: Trip class definitions

Trip class	Trip duration (minutes)
Short	15-30
Medium	31-45
Long	46-60
Very Long	>60

The profiles of the BRT and Metro Rail are generated separately with the statistical software SPSS using full factorial design. Four levels of travel time and travel cost each and five levels of frequency resulted in eighty different profiles (4^1x4^1x5^1) for BRT and Metro Rail. These one sixty profiles while combined with each other resulted in 3160 ($^{80}C_2$) different choice sets. Extreme/dominant combinations are eliminated from the choice sets. Dominant choices corresponded to two cases:

(i) Where the Metro Rail level of service is more than one level worse than BRT;

(ii) Where the ratio of 'reduced travel cost' to 'reduced travel time' is greater in BRT than in Metro Rail.

Because of the complexity of the choice task and unfamiliarity with the new alternatives, the choice task has been limited to one per respondent to avoid confusion. The choice sets are randomly selected after the removal of the dominant options.

In addition to the above two sections the questionnaire also got a section with queries on the socio-economic characteristics of the respondents and a question to judge the understanding of the choice task by the respondents. Sample questionnaires for bus/tempo, car, CNG/taxi and rickshaw users are appended in Appendix C.

3.3.4 Pilot survey

The pilot survey was conducted first with a small sample of respondents. The purpose of the survey is to:

(i) Analyze the data and test if the presented attribute levels are appropriate;

(ii) Estimate preliminary models and check if the trends of the coefficients match the priori hypotheses or can be justified by the supporting information.

The findings of the pilot survey are used to fine tune the main survey. The organization, analysis and modifications from the pilot survey are presented in the following subsections which are followed by the description of the final survey.

Organization

Presenting the SP choices has been very challenging from several aspects. In particular, the travelers are expected not to have a priori perception about BRT and/or Metro Rail. To overcome the difficulty elaborate descriptions of the alternatives have been provided to the respondents along with pictures of the two systems.

The show cards as in Figure 3.6(a) and 3.6(b) were used to demonstrate special features which people are likely to have difficulty in perceiving (e.g. dedicated lanes, shaded bus stops and passenger information system for BRT and overground, at-grade and underground right-of-way for Metro Rail).

Three different level of service in terms of travel cost were presented to the rickshaw users, car users and the CNG/taxi users assuming that the willingness to pay would have been different for these three user groups. The travel cost presented to the CNG/Taxi users were maximum; which was 2.5 times the average of the current bus service travel cost; for the rickshaw users it was 1.75 times the average of the current bus service travel cost and for the car users it was 1.5 times the average of the current bus service travel cost. The attribute Tables are presented in Appendix D.

The data collection from bus users was planned along the six BRT and Metro Rail routes proposed in STP (2005). In order to capture the preferences of users of other transport modes, data collection has been planned from offices located near the proposed routes. It may be noted that the data collection plan is based on the critical assumption that travelers who currently cannot afford any mechanized mode of transport like car, bus, taxi, tempo, rickshaw,CNG, etc. will not be able to afford mass rapid transit as well (which are expected to have much higher fares compared to the existing public transport system).

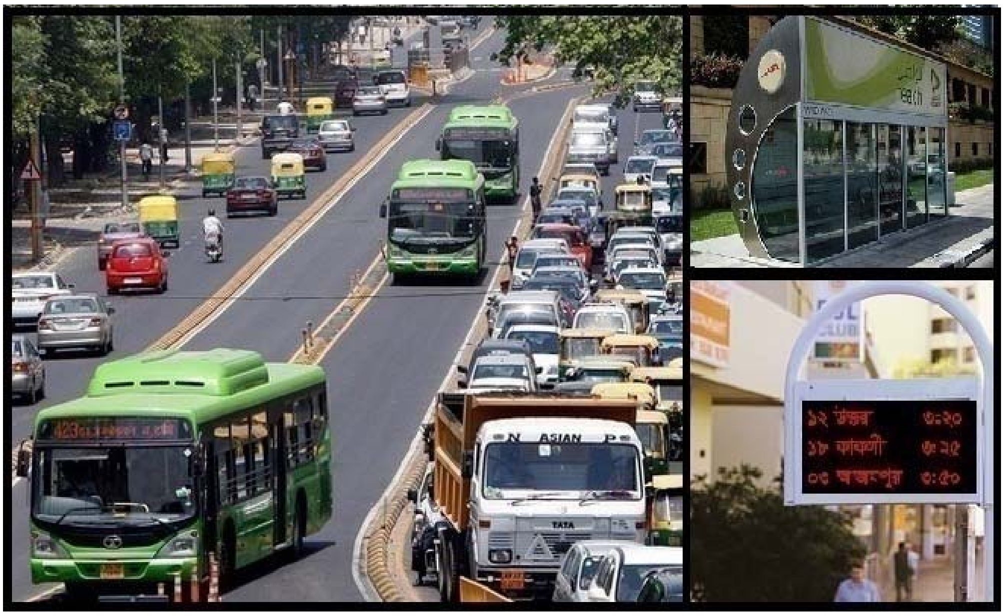

Figure 3.6 (a): BRT show card

Figure 3.6 (b): Metro Rail show card

Data

Seventy one (71) valid data were obtained from the bus users in the pilot survey. The data covered fair shares of all trip lengths. However, there were substantial numbers of very long trips (the travel time for 24 trips out of 71 were more than 60 minutes).

The pilot survey was conducted on 15 and 17 December, 2009 among the car, rickshaw and CNG/taxi users. Data were collected from shopping malls, schools near Uttara, Dhanmondi and Farmgate (from parents waiting to pick up their children). The collected data included responses from 54 Rickshaw users, 32 Car users and 39 CNG users.

3.3.5 Main survey

Modifications to the pilot survey

Few modofications are made to the main survey, based on the findings of the pilot survey. The modofications are illustrated seperately for bus users and non-bus users.

a. For bus users

Among the 71 bus user participated in the pilot survey 5, 38 and 28 respondents chose bus, BRT and Metro Rail respectively which indicated substantial 'trading' behavior (i.e. the levels of the new modes were high enough to make people switch to the new modes). A multinomial logit (MNL) model is estimated using these 71 observations. The estimated model results are presented in Appendix E1. The model has the anticipated signs for travel times and costs (negative signs indicating disutility with increase of the variable values) but a non-intuitive sign for waiting time (positive sign indicating increased utility with increase of the variable value).

For the above mentioned limitation (wrong sign of waiting time/frequency), the description of frequency was rephrased. The respondents were explicitly told that the frequency indicates up to how long they may need to wait for their ride. In addition, the frequency levels were updated (waiting time reduced) to represent more realistic waiting times. Since the travel time for 24 trips among the 71 trips were more than 60 minutes, an additional trip length 'very very long trips' (>90mins) was introduced. The subsequent survey thus had 5 different trip lengths (15-30mins, 31-45mins, 46-60mins, 61-90mins and >90mins). The updated attribute Table is presented in Appendix F, Table F1.

The modifications in the design have been checked with a limited number of respondents (93) and the estimated model (with 93 data points) revealed anticipated signs for all attributes. The results are presented in Appendix E2. The trip length distributions indicated a uniform distribution and the additional trip length group deemed to serve its purpose (only 17 out of 93 trips had travel time >90 mins that is 18% of the trip belonged to the ‘very very long’ category).

b.For non-bus users

Three different generic MNL models are estimated for car, CNG/Taxi and Rickshaw users. The estimation results are included in Appendix E3 – E5. Apart from the sign of frequency for Metro Rail and Car users, all coefficients have expected signs (the coefficient of frequency is statistically insignificant).

The values of the frequency levels are updated (waiting time reduced) (Appendix F, Table F5). No changes are made to the time levels. The cost levels are slightly adjusted for the main survey based on the detailed ranges of fares obtained from the current users in the pilot survey. For Car and Rickshaw users, BRT fare is kept same, but the Metro Rail fare are increased a bit compared to the BRT fare. For CNG/taxi users both the BRT fare and Metro Rail fare are increased from those used in the pilot survey. From the pilot survey it has been found that most of the presented BRT and Metro Rail fares were less than the CNG/taxi fares. Consequently sensitivity towards travel cost has been found to be insignificant in the estimated model. From the collected pilot data minimum values of the CNG/taxi fare are calculated for different trip lengths and were used as the baseline for presenting BRT fare and Metro Rail fare so that some of the presented BRT and Metro Rail cost would exceed CNG/taxi cost (Appendix F, Table F2 - F4).

Data characteristics

The full inventory of data (including pilot survey) is presented in Table 3.7. The number of valid samples are included in parenthesis.

Out of the 1016 total valid responses, the pilot data from bus users (71observations) have not been used for the model estimation. In addition income data were unknown for 17 respondents. Therefore, for the analysis purpose, the remaining 928 observations are used.

Table 3.7: Data inventory

Collection Mode	Modes	Numbers of Data Collected		
		Pilot Survey	Final Survey	Total by Mode
Surveyor Assisted	Bus	168 (164)	468 (461)	636 (625)
	Tempo	---	22 (22)	22 (22)
	CNG	39 (39)	56 (55)	95 (94)
	Taxi	---	18 (18)	18 (18)
	Rickshaw	54 (54)	87 (84)	141 (138)
	Car	32 (32)	87 (87)	119 (119)
Not Surveyor Assisted	Bus	---	12 (0)	12 (0)
	Tempo	---	---	0
	CNG	---	7 (0)	7 (0)
	Taxi	---	---	0
	Rickshaw	---	---	0
	Car	---	8 (0)	8 (0)
Total				1031 (1016)

The data are categorized in two ways. Firstly, all the trips are grouped into home based trips and non-home based trips; then the trips are classified as working trips, educational trips, shopping trips, social trips (visiting to friends' and relatives' house) and other trips. Percentage of the trips falling into different categories are shown in Figure 3.7(a) and Figure 3.7(b) respectively.

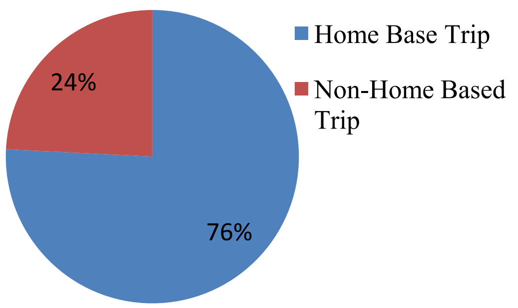

Figure 3.7 (a): Home base and non-home base trips

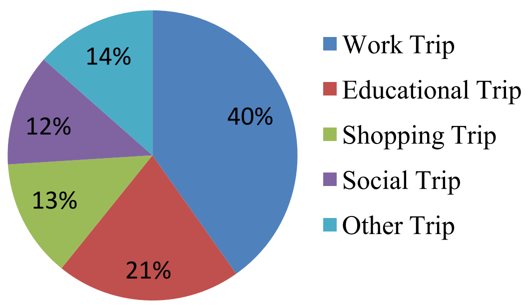

Figure 3.7 (b): Trip distribution by purpose

The respondents were asked to mention the reasons they feel important for choosing the mode they were using for that particular trip. A significant difference is observed among different mode users while mentioning the reason. For example, among the bus and tempo users low fare is the mostly chosen reason for using their mode while for the car, CNG/taxi and rickshaw users the most important reason for choosing their mode is accessibility. The bar chart in Figure 3.8 shows the number of respondents by mode choosing different attributes of their current modes.

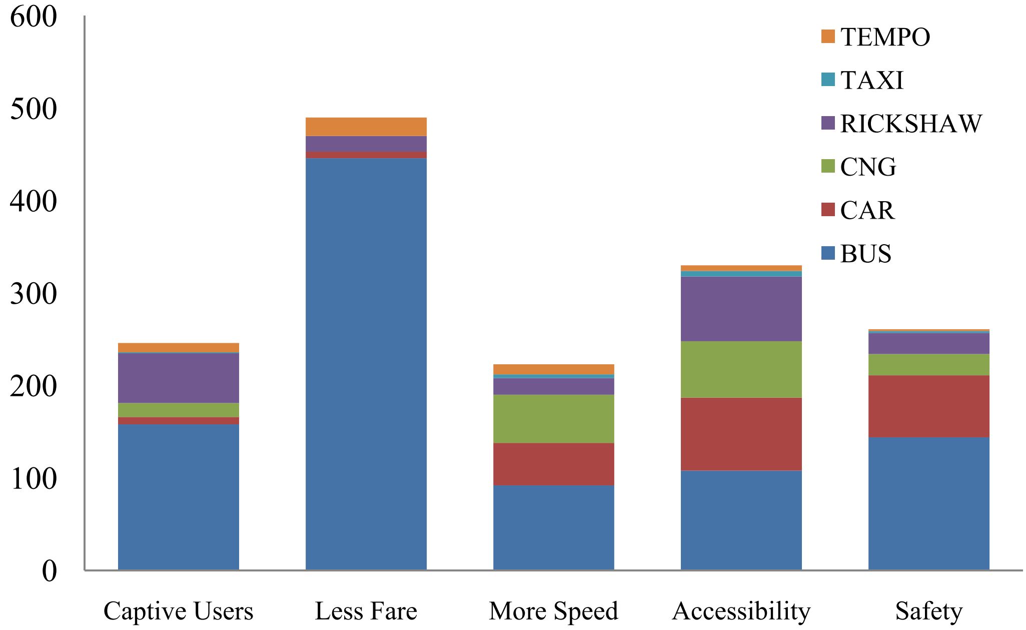

Figure 3.8: Reason behind choosing different modes

To get an idea about how dependable the data are (as provided by the participants / respondents) the respondents were asked how frequently they travel along the particular route and it have been found that most of the users are frequent users of the routes as depicted in Figure 3.9.

The data were collected for almost all lengths of travel (in terms of travel time). The trip length distribution of different modes is presented in the form of a bar graph, Figure 3.10. Trips are classified into short, medium, long, very long and very very long trips.

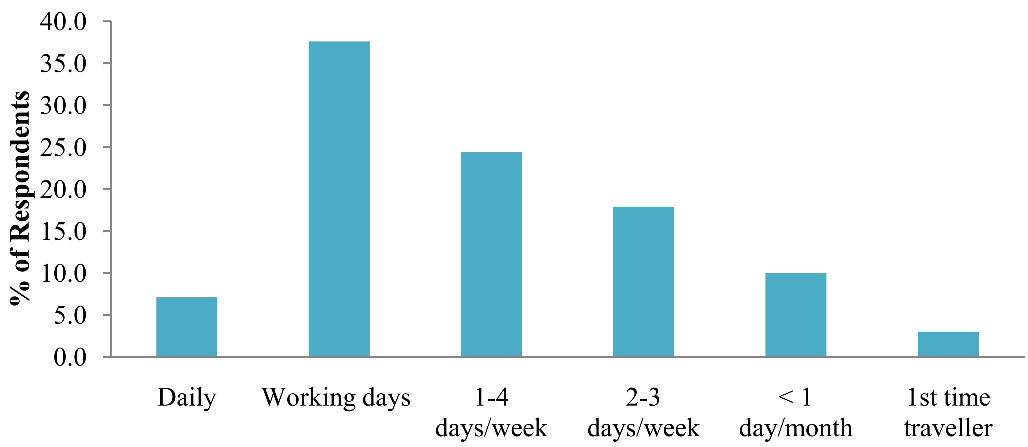

Figure 3.9: Travel frequencies of the users in the route

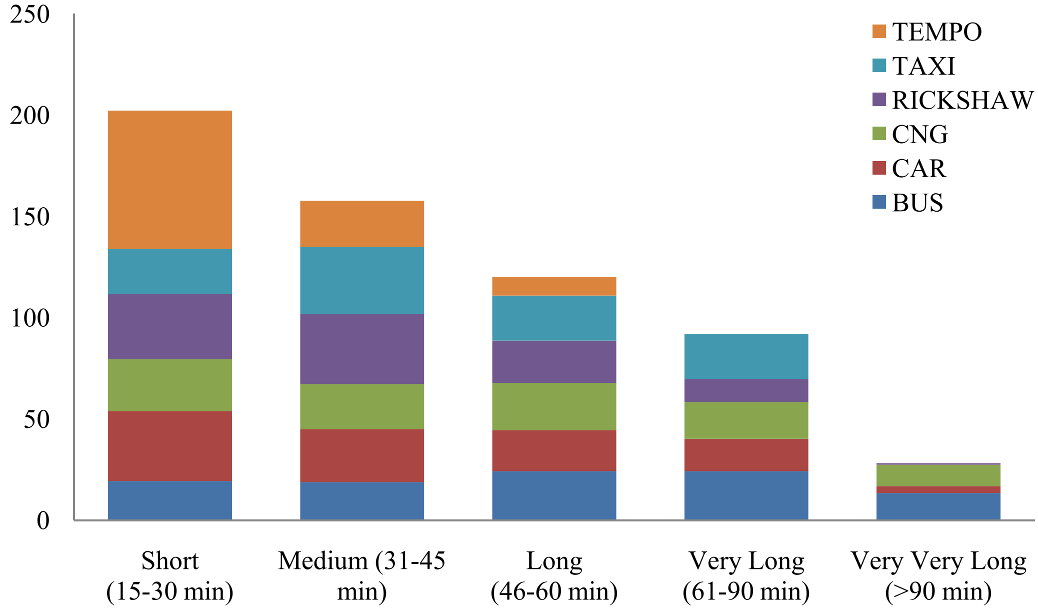

Figure 3.10: Trip length distribution by different modes

To ensure that the choice of all groups of people in terms of age, occupation, education, income etc. are being reflected in the survey, the respondents in the forms of pie charts or bar graphs in Figure 3.11 to 3.16. The average household size of the respondents is found to be 4.6 persons per household. More than 80% of the respondents are in the range of 18 to 40 years of old while in terms of occupation most number of the respondents (42%) are full time employees and 33% of the respondents are students.

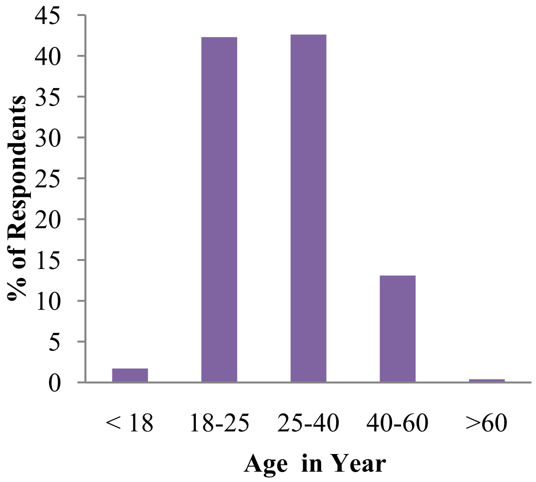

Figure 3.11: Age distribution

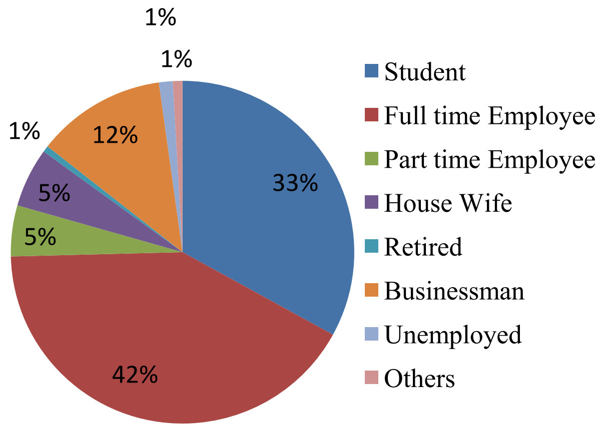

Figure 3.12: Occupation distribution

Two peaks are observed in the income distribution of the respondents; one at a household income of 20 to 30 thousand Taka per month and another at greater than 50 thousand

Taka per month. A high number (76%) of the respondents are male against 24% female respondets. Since, the major portion of the data (about 50%) were collected from the bus users (as they are anticipated be the most likely candidate to shift to mass rapid transit like BRT and Metro Rail) and small percentage of women use buses for their daily travel, the female participation in the survey has been very low. Moreover, it has also been found that female respondents are reluctant to answer the questions.

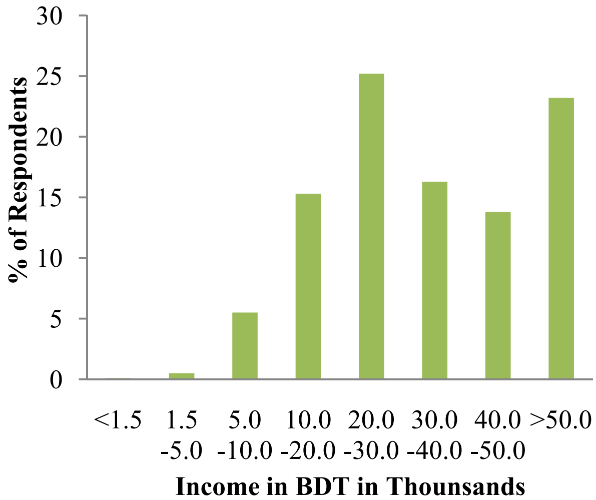

Figure 3.13: Income distribution

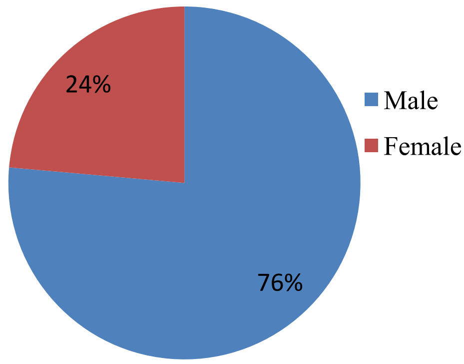

Figure 3.14: Gender distribution

The respondents were also asked about their private car/ motorcycle access and the type of ownership of those; like whether the car/ motorcycle is owned personally, by family or by office/ company. The car users were also asked whether they have a driver or they drive the car by themselves. 33.7% of the respondents had access to motorized private vehicles. The ownership of the vehicle and the driver status are shown in Figure 3.15 and 3.16 respectively.

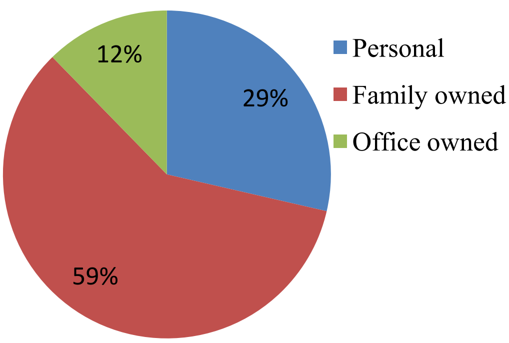

Figure 3.15: Car ownership

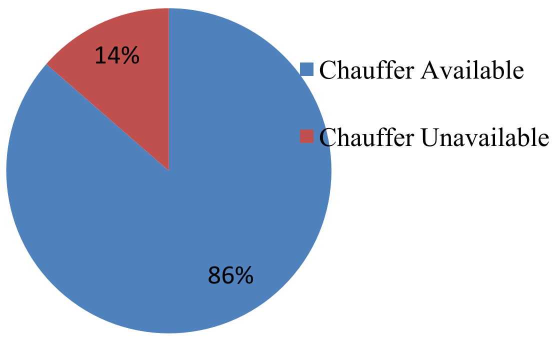

Figure 3.16: Chauffer availability

3.4 Model Framework

Review of the existing RP data reveals several limitations, the major ones being the absence of choice sets and limited variability of the LOS data (which is based on revealed preferences of travelers). To overcome the data limitations SP data have been collected along the proposed corridors of STP (2005). Discrete choice models are estimated in the following Chapter with the RP and SP data separately where the data limitations like missing choice set and measurement errors in LOS data are addressed. Finally, the two data sources are combined to develop a comprehensive mode choice model.

The overall model structure is presented in Figure 3.17 where observed variables are represented by rectangles and unobserved variables are represented by ovals, solid arrows indicate structural relationships and dashed arrows indicate measurement relationships. As shown in Figure 3.17, the choice set of the respondents (in case of RP data), attributes of modes and the utility of different modes are not directly stated by the respondents and therefore are unobserved to the analysts. The observed variables include the socio-economic characteristics of the respondents, measured values of the trip attributes from network analysis and the revealed and stated choices of the respondents in RP and SP surveys respectively. The analyst has to rely on the measurement relationships among the observed and unobserved variables to arrive to the unobserved variables. In this process error terms are associated with the unobserved variables. However, these error terms are assumed to be iid gumbel distributed leading to logit forms. The integrated model constitutes of following model components:

(i) Choice set generation;
(ii) Measurement error correction;
(iii) Revealed mode choice; and
(iv) Stated mode choice.

Ideally, the parameters of all these components should be estimated jointly. The correlations among errors in between component (i) and (iii) (choice set generation and revealed preference mode choice) have however been ignored and the parameters of the measurement relationships in the choice set generation model and RP-SP model have been estimated disjointly.

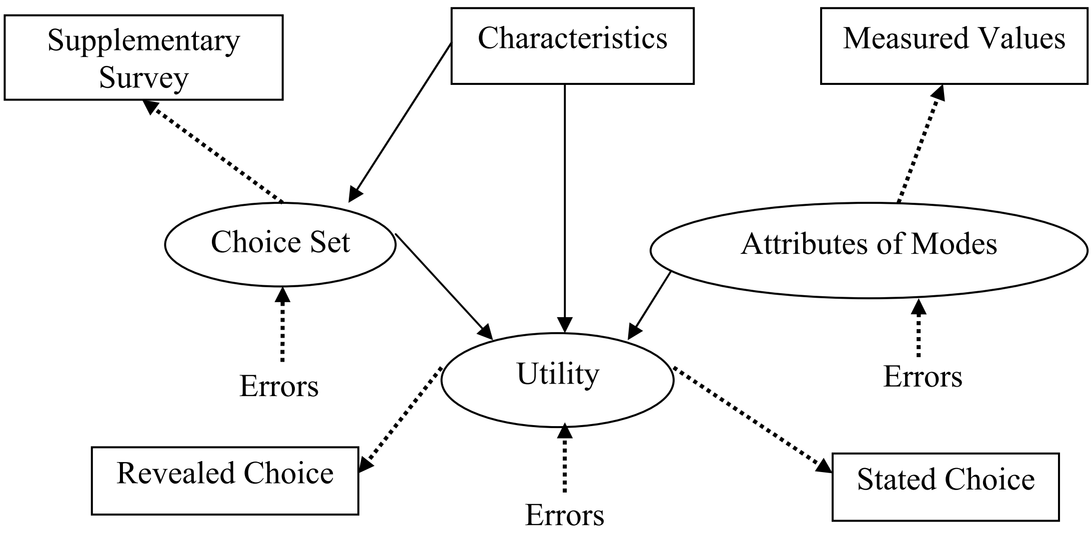

Figure 3.17: Integrated proposed mode choice model

In the estimation process, at first, socio-economic characteristics of the travelers collected from the supplementary SP survey are used to model the choice set of the respondents. The estimated parameters of this model are used to probabilistically predict the unobserved choice sets of the respondents in the RP data. The measurement errors of the network derived (Hasan, 2007) mode attributes are addressed by regression analysis. The predicted choice set values and the corrected LOS data are used to arrive to the utility parameters with the revealed choice of the respondents. The utility parameters of different modes are also estimated using the stated choice of the respondents. Finally, the two data sources are combined to establish the utility parameters of the existing modes and the proposed new modes.

3.5 Summary

In this Chapter, the characteristics of the RP data collected in STP (2005) is explored and four major limitations for estimating disaggregate models are identified as missing choice set, measurement errors in LOS values, limited variability in LOS variables and absence of the preference for MRT. SP survey design and modifications into the survey is also elaborated in this Chapter. Finally, the proposed model framework is presented and the overall methodology is briefly elaborated. The model estimation results with these two data sources are presented in the following Chapter.

CHAPTER FOUR
ESTIMATION OF MODEL COMPONENTS

4.1 Overview

This Chapter focuses on the development of separate models with existing RP data and data collected from SP surveys. As mentioned in Section 3.4, the model development methodology is to develop the following individual components of the integrated model at the beginning and then to estimate the RP-SP combined model.

(i) Choice set generation;
(ii) Measurement error correction;
(iii) Revealed mode choice; and
(iv) Stated mode choice.

With that view in mind, a choice set generation model is estimated first in this Chapter with the collected SP data. The estimated parameters are used to forecast the choice sets of the respondents in RP data probabilistically. A technique is proposed to address the measurement errors in the LOS variables of the available RP data. The predicted choice sets and the correction factors of the LOS values are used to estimate the utility parameters of the RP only mode choice model. The utility parameters are also been estimated separately by using collected SP data. Ultimately, RP data is combined with the SP data using advanced discrete choice modeling technique in the proceeding Chapter.

4.2 Choice Set Generation Process

As illustrated in Section 2.4.3, the accuracy of the mode choice model depends largely on the accurate prediction of the choice set considered by an individual. To further elaborate the point the following example can be considered, Figure 4.1. Let us assume that, the universal choice set of a city 'X' consists of bus, car, taxi, CNG, tempo and rickshaw and for a particular trip the traveler 'Y' chose taxi as his final choice of mode. Now, if the analyst does not have the idea of the set considered by the traveler before arriving to his final choice, the analyst can determine by some preset rules that the set considered by the traveler was the set {car, CNG, rickshaw, taxi}. And if the actual set considered by the traveler was the set {CNG, rickshaw, taxi}, then the probabilities are inappropriately assigned to car while there should be none.

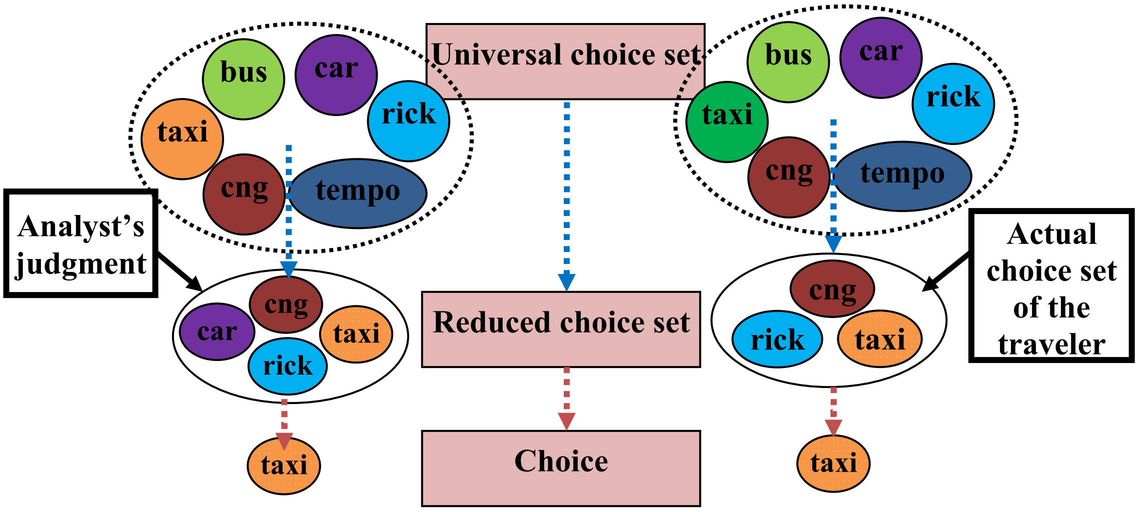

Figure 4.1: Reduced choice set development process (modified from Fillone et al., 2006)

In case of developed countries the transport network data, car ownership and driving license possession provide reasonable bases for constructing the choice sets for mode selection. But, in case of developing countries like Bangladesh, the transport network data are not structured. Para-transits like human-haulers (and even in some cases traditional transits like buses) operate beyond their permitted routes which make it impossible to infer the availability to these modes for a trip between a particular O-D pairs using transport network data. Moreover, in our country the affordability of people plays a vital role in determining the choice set, both for business and non-business trips. Because of large household sizes and low car ownership rates, the number of users per car is generally very high and car ownership alone is often not a suitable proxy for car availability. For instance, if there are five members and a single car in the household, some household members may get priority over others for the car usage (e.g. school going children, elderly people, etc.). Moreover, multi-use of the same chauffeur driven car adds complexity in the car availability since possession of a driving license no longer has correlation with car availability either. Therefore, a car is often not chosen, not because of the LOS considerations (e.g. trade-offs among time, cost, comfort, etc.), but rather because it is not in the choice set in the first place.

On the other hand, the affluent people who have access to car are often unaware of what public transport options exist. This is escalated by the fact that the public transport modes have very poor traveler information systems. For example, there are no published timetables, no information regarding the routes or timetable in the bus stops, no options to access public transport related information via internet or phone, etc. Therefore, a bus or para-transit is often not chosen, not because of the LOS considerations, but rather because of its exclusion from the choice set.

As described in Section 2.2, in the previous mode choice models developed for Dhaka City, different deterministic rules have been used for specifying the choice sets (e.g. for car owners car is always in the choice set, public transports are available either for all (STP, 2005) or only to the non-car owners (Hasan, 2007, etc.). Such simplistic rule-based choice sets can lead to wrong definitions of choice sets and subsequently wrong parameter estimates. The importance of correctly specifying choice sets and the deficiencies in the choice set generation of the previous mode choice model prompts this research where a choice set generation model is developed that predicts the choice set probabilistically for the choice context of Dhaka using socio-economic characteristics, O-Ds and trip purposes.

4.2.1 Model structures

In the proposed approach a choice set probability model is developed first using stated preference (SP) survey data. In the survey, an explicit question was included on the availability of different modes as perceived by the respondents. Each respondent was presented with a list of typical travel modes in Dhaka and asked what modes were available to them for this particular trip. The answer of the respondents explicitly revealed the modes considered by the respondents for the trip in question. These stated choice sets along with the comprehensive socio-economic and trip related data of the travelers are used as to probabilistically predict the choice sets of the respondents in RP data.

For the mode choice context and the population of Dhaka city the universal choice set consists of bus/tempo, car, CNG/taxi and rickshaw. In the extreme cases, the traveler is captive to a single mode or considers all modes in the choice set. The total number of non empty subsets of this universal choice set is fifteen. The subsets of the universal choice set are as follows:

(i) bus, tempo;
(ii) bus, rickshaw, tempo;
(iii) bus, CNG/taxi, tempo;
(iv) bus, CNG/taxi, rickshaw, tempo;

(v) bus, car, CNG/taxi, rickshaw, tempo;

(vi) bus, car, rickshaw;

(vii) bus, car, CNG/taxi;

(viii)bus, car;

(ix) rickshaw, tempo;

(x) CNG/taxi, tempo;

(xi) CNG/taxi, rickshaw;

(xii) car, rickshaw;

(xiii)car, CNG/taxi, rickshaw;

(xiv)car, CNG/taxi;

(xv) car.

These choice sets can be broadly categorized into one of the following six groups.

(i) Public transport group includes bus and tempo;

(ii) Public and personalized public transport group includes bus/tempo, CNG/taxi and rickshaw;

(iii) Personalized public transport group includes CNG/taxi and rickshaw;

(iv) All mode group includes all the four modes mentioned earlier;

(v) Car and personalized public transport group includes all the four modes except bus/tempo;

(vi) Car group includes only car.

The candidate socio-economic attributes and mode characteristics to be affected the choice set generation process and related a priori hypotheses are presented in Table 4.1.

Table 4.1: Candidate variables and a-priori hypotheses

Attributes	General Casual Relationship
Monthly Household Income (HHI)	Due to considerable disparity in monthly household income, household income is supposed to play a vital role in the determination of the choice set of the individual, the propensity of having choice sets with cars and individual modes increasing with income.
Gender	Due to social norms and culture male and female passengers do not feel free to share transit vehicles especially in congested situation and also female passengers try to avoid public transit due to safety concerns. Female respondents are therefore less likely to have information about public transport routes and include these modes in choice sets.
Education & Occupation	These variables are supposed to be somewhat correlated with HHI; and highly educated white-collar employees are likely to have higher propensities of having choice sets with cars and individual modes.
Trip Purpose	Consideration of the modes may also be strongly affected by the purpose of the trip; e.g. people may be willing to consider transits in choice sets for work trips while they may exclude the same modes from their choice sets for social trips with family members.

Table 4.1: Candidate variables and a-priori hypotheses (Continued)

Attributes	General Casual Relationship
Age	Due to relatively low fare students are typically more inclined towards public transit and more familiar with the routes and timetables. They are therefore more likely to include these modes in choice sets. Aged people on the other hand are less likely to have choice sets that include public transport modes.
Travel Duration	Due to ease of accessibility and door-to-door service there are higher probabilities of inclusion of rickshaws in the choice sets for shorter trips while for long trips mobility is more important and rickshaws are not considered as viable options

To get an idea about how these variables are going to affect the availability of different modes in the choice sets of an individual, an explorative analysis is done where the correlation with the choice sets is found to be highest for income, age and gender of the traveler and duration and purpose of the trip. The analysis results are appended in Appendix G.

Based on these findings, a discrete choice modeling technique is used to estimate the utility parameters of different choice sets. A linear utility function is associated with each choice set. The utility of a choice set *i* of individual *n* can be expressed as in Equation (4.1).

$$U_{in} = \beta_i X_{in} + \varepsilon_{in} \text{ , } \forall i \in C_n; \qquad (4.1)$$

Where, X_{in} = socio-economic characteristics of the individuals and attributes of different modes, β_i = Coefficient of X_{in}, ε_i= Random error term and C_n = Universal choice set or the choice set determined deterministically for individual n.

4.2.2 Estimation results

As discussed earlier choice set or consideration set is affected by the attributes of the alternative modes and the socio-economic characteristics of individuals. However, not the entire candidate variables mentioned in Table 4.1 are found to be statistically significant and/or have intuitive signs. The estimation is started with monthly household income and other attributes are added step by step. The variables are included only if there is a significant improvement in the goodness-of-fit (adjusted Rho-square) and if the parameters are significant and their signs are intuitive. For example, the socio-economic attribute education is not found to be significant.

The utility functions are presented below which is followed by the description of the dummy variables in Table 4.2. It is to be mentioned that twelve of the fifteen different choice sets mentioned earlier are used for the choice set generation model. Three choice sets are not considered separately because of very small amount of observation. Those are merged with the choice sets whose characteristics are supposed to have close resemblance. For example, car only group is merged with car, CNG/taxi group.

$\mathbf{V_{all}}$ = $\alpha_{cng\_taxi} + \alpha_{rickshaw} + \alpha_{car} + \alpha_{bus\_tempo} + \beta_{income2}$ high income dummy

$\mathbf{V_{bus\_car}}$ = $\alpha_{bus\_tempo} + \alpha_{car}$

$\mathbf{V_{bus\_car\_cng\_taxi}}$ = $\alpha_{bus\_tempo} + \alpha_{cng\_taxi} + \alpha_{car}$

$\mathbf{V_{bus\_cng\_taxi}}$ = $\alpha_{cng\_taxi} + \alpha_{bus\_tempo} + \beta_{income1}$ low income dummy + $\beta_{ttvlong}$ long trip dummy + β_{tp} trip purpose dummy + β_{age} age dummy

$\mathbf{V_{bus\_cng\_taxi\_rick}}$ = $\alpha_{bus\_tempo} + \alpha_{cng\_taxi} + \alpha_{rickshaw} + \beta_{income1}$ low income dummy + $\beta_{ttvlong}$ long trip time dummy + β_{tp} trip purpose dummy + β_{age} age dummy

$\mathbf{V_{bus\_rick}}$ = $\alpha_{bus\_tempo} + \alpha_{rickshaw} + \beta_{income1}$ low income dummy + $\beta_{ttvlong}$ long trip dummy + β_{tp} trip purpose dummy + β_{age} age dummy

$\mathbf{V_{bus\_tempo}}$ = $\alpha_{bus\_tempo} + \beta_{ttvlong}$ long trip dummy + β_{tp} trip purpose dummy + $\beta_{income1}$ low income dummy + β_{age} age dummy

$\mathbf{V_{car\_cng\_taxi}}$ = $\alpha_{cng\_taxi} + \beta_{gender}$ gender dummy + $\beta_{income2}$ high income dummy

$\mathbf{V_{car\_cng\_taxi\_rick}}$ = $\alpha_{car} + \alpha_{CNG\_taxi} + \alpha_{rickshaw} + \beta_{gender}$ gender dummy + $\beta_{income2}$ high income dummy

$\mathbf{V_{car\_rickshaw}}$ = $\alpha_{car} + \alpha_{rickshaw} + \beta_{gender}$ gender dummy + $\beta_{income2}$ high income dummy

$\mathbf{V_{cng\_taxi\_rick}}$ = $\alpha_{cng\_taxi} + \alpha_{rickshaw} + \beta_{gender}$ gender dummy + $\beta_{income2}$ high income dummy

$\mathbf{V_{rickshaw}}$ = $\alpha_{rickshaw} + \beta_{ttvshort}$ short trip dummy + β_{gender} gender dummy + $\beta_{income2}$ high income dummy

Table 4.2: Description of the dummy variables

Dummy variables		Description
High income dummy	1	for HHI more than or equal to 50,000 Taka/month
	0	for HHI less than 50,000 Taka/month
Low income dummy	1	for HHI less than or equal to 20,000 Taka/month
	0	for HHI more than 20,000 Taka/month
Gender dummy	1	for female respondents
	0	for male respondents
Age dummy	1	for the respondents less than or equal to25 years of old
	0	for the respondents more than 25 years of old
Trip purpose dummy	1	for work and educational trips
	0	for other trips
Long trip dummy	1	for travel time more than 45 minutes
	0	for travel time less than or equal to 45 minutes
Short trip dummy	1	for travel time 15 to 30 minutes
	0	for travel time other than 15 to 30 minutes

The estimation results using BIOGEME (http://roso.epfl.ch/biogeme) are presented in Table 4.3.

Table 4.3: Choice set generation model estimation results

Parameters	Estimated values (t-stat)
Constants:	
bus_tempo, α_{bus_tempo}	0
car, α_{car}	0.344 (2.55)
cng_taxi, α_{cng_taxi}	1.140 (12.65)
rickshaw, $\alpha_{rickshaw}$	-1.150 (-13.60)
Coefficient of age dummy, β_{age}	0.555 (3.26)
Coefficient of gender dummy, β_{gender}	0.912 (4.42)
Coefficient of low income dummy, $\beta_{income1}$	2.280 (7.13)
Coefficient of high income dummy, $\beta_{income2}$	0.430 (2.10)
Coefficient of trip purpose dummy, β_{tp1}	1.090 (6.87)
Coefficient of long trip dummy, $\beta_{ttvlong}$	1.400 (8.73)
Coefficient of short trip dummy, $\beta_{ttvshort}$	2.030 (6.07)
No. of Observations	756
No. of Parameters	10
LL at Zero	-1878.589
LL at Convergence	-1372.242
Adjusted Rho-Square	0.264

The results indicate that all else being equal, the rickshaws have the smallest probabilities of being included in the choice set. The negative ASC is due to the fact that the network information is missing in the data. People know about the missing links for their O-D and therefore do not include rickshaw in their choice set. But the researcher does not have that information. As a result, an unexplained negative utility component is obtained. CNG/taxi on the other hand has the highest value of alternative specific constant (ASC) indicating higher likelihood of it being included in the choice sets. However, it should be noted that the ASCs in SP studies are not representative of market shares; rather, they merely indicate the part of the utility unexplained by the explanatory variables (Bliemer et al., 2009).

Coefficients of income have different value and sensitivity for different income groups. The coefficient of income for the range of less than or equal to Taka 20,000 monthly incomes is very significant (at more than 95% confidence level) for public and personalized public transport user group which is intuitive for the context of the city since members of this income group generally have no or shared access to car and well-aware of public transport availability. On the other hand, the coefficient of income for the range of greater than or equal to Taka 50,000 monthly incomes is statistically significant for the people whose choice set include car and does not include bus/tempo.

The dummy term introduced for female respondents indicates that female respondents have significantly high likelihood to consider the choice sets which include car, CNG/taxi and rickshaw.

The trip purpose dummy for educational and work trip exhibit significant high preference of the user for the choice sets which include bus/tempo and other personalized public transport for the same reason as the less than or equal to Taka 20,000 income group.

Two travel duration dummies are introduced in the model. Both of them are highly significant. The long trip duration dummy (trip duration more than 45 minutes) indicates that public transports are more likely to be included in the choice set for long trips while short trip dummy (trip duration 15 to 30 minutes inclusive) indicates that rickshaw is more likely to be included in the choice set for short trips.

The coefficient of age indicates that, as hypothesized, the young commuters have a significant preference for the choice sets which include bus/tempo.

4.3 Measurement Error Correction

High quality LOS data are essential for accuracy of the estimates of the mode choice model. In the context of Dhaka, the available data from STP Household Interview Survey (HIS) has only got the stated travel times of the respondents/travelers for the chosen mode. The travel times of the unchosen modes and the fare of all the modes are missing in the data set.

The data has been supplemented by Hasan (2007) who has calculated the distances between different Traffic Analysis Zones (TAZ) from network assignment using the network coded in EMME/2 for the STP study. These distances are used along with the assumed speeds of different vehicles for the determination of the travel time between O-D pairs by different modes. Hasan (2007) has also conducted a small scale HIS to calculate an average fare for different modes. It has been acknowledged that the resulting travel time would have some measurement errors resulting from two major sources stated below:

(i) The distances are the zone to zone distances i.e. they are not the actual distance between the origin and destination of the traveler. Though the zone to zone distances may suffice the needs of aggregate analysis (e.g. trip distribution and trip assignment) such assumptions may not be sufficient for the models that are done in the disaggregate level;

(ii) The traffic on the streets of Dhaka is heterogeneous in nature and due to congested traffic situation as well as chaos introduced from weak-lane disciplines, the vehicles do not necessarily run at their free flow speeds. In fact the speeds of the vehicles are not only a function of the mode rather it also depends on the road characteristics (e.g. widths, surface quality, traffic mix and presence of non-motorized traffic, etc.). Since a single speed for a mode has been used for the calculation of the travel time ignoring these sources of heterogeneity, it might have introduced some errors.

In the present study an effort is made to address this resulting measurement error.

4.3.1 Model structures

In the present study the stated travel time (which is available only for the chosen alternatives) is assumed as true value of the travel time. A relationship is developed between the true travel time and the travel time obtained from network assignment and assumed speed to explore potential systematic variations between the two and determine necessary correction factors.

In this regard, the data has been cleaned first and the observations with very high anomalies between zone to zone distance with the distances stated by the travelers between their origin and destination locations have been excluded. A regression analysis is then performed in the clean data to develop a relationship among the true and measured travel times between the O-D pairs. The stated travel times by the travelers are considered as the true measure of the travel time while the calculated travel times are used as the measured travel times with errors. The proposed relationship of the true and measured travel times can be expressed as in Equation (4.2).

$$T_{true} = \alpha + \beta \; x \; T_{measured} + \epsilon \tag{4.2}$$

Where,T_{true} is the true value of the travel time i.e. the stated travel time by the traveler; $T_{measured}$ is the measured value of the travel time; α , β are the systematic components to be estimated by regression analysis; ϵ is the random error component with zero mean. In this analysis, the hypothesis of the presence of systematic components of error is tested through statistical tests. It may be noted that α indicates the fixed component of the measurement error (if any), β indicates the systematic scale difference between the true and the measured values (if any) and ϵ represents the random part of the error.

4.3.2 Estimation results

The estimation is started by pooling all the modes together. The regression Equation obtained from the estimation is $T_{true} = -0.434 + 0.964 \; x \; T_{measured}$ with an adjusted R square value of 0.849. The constant α has been statistically insignificant with a t-statistics value of -0.880 and consequently has been ignored for the second trial of the estimation. Further separate models are estimated for different modes to check whether the separate models differ significantly from the pooled model or from each other.

Based on the estimated values of β the seven modes are combined into four groups and another set of regression analysis are done for each group separately. The final estimation results of the analysis are provided in Table 4.4

Table 4.4: Final estimation results of regression analysis

Modes	**Regression equation**	**Adjusted R square value**
Tempo & public transport (bus)	$T_{true} = 0.980\ x\ T_{measured}$	0.973
Taxicab & CNG	$T_{true} = 1.067\ x\ T_{measured}$	0.929
Private car/microbus & motor cycle	$T_{true} = 1.219\ x\ T_{measured}$	0.890
Rickshaw	$T_{true} = 0.780\ x\ T_{measured}$	0.873

The estimation results indicate that as hypothesized there are some systematic measurement errors and the above equations can be used to correct the measurement errors of the calculated travel times before estimating the mode choice models.

4.4 Mode Choice Model Development

Discrete choice analysis technique is used to develop mode choice models using the RP and SP data. The models are of Multinomial Logit Model (MNL) form. Different specifications of the models are tested based on some priori hypothesis using informal (e.g. sign of parameters) and formal judgments (e.g. Rho-square value, Chi-square test, etc.). The software BIOGEME (http://roso.epfl.ch/biogeme) and GAUSS 10.0 are used to estimate the models using Maximum Likelihood Estimation (MLE) technique.

Before going into the details of the model structures and the estimation results, the tests that have been used in this research to compare the fit of different model specifications, are presented. These are as follows:

Informal tests

The most basic test of the estimation results is to examine the signs of the estimated parameters with theory, intuition and judgment regarding the expected impact of the corresponding variables. A positive (negative) coefficient means that the variable has a positive (negative) impact on utility. In this case the mode attributes (travel time, travel cost and waiting time) are expected to have negative coefficients, so that the utility of the modes will decrease with the increase in travel time, travel cost or waiting time. The analysts generally have some expectations about the impact of decision-maker characteristics on different alternatives. This assumption implies that alternative specific variable coefficients should vary across alternatives. For example, female dummy can be negative if used in the utility function of bus/tempo, while can be positive if used in the utility function of car.

Individual test of parameters

The statistic (t-statistic) is used to test the null hypothesis that an estimated parameter is equal to zero is calculated from the ratio of the estimated parameter value and the standard error associated with that parameter. Sufficiently large absolute values of the t-statistic lead to the rejection of the null hypothesis. The rejection of this null hypothesis implies that the corresponding variable has a significant impact on the modal utilities and suggests that the variable should be retained in the model and vice versa. For two tailed test the critical value of t-statistic is 1.960 and 1.645 at 95% and 90% level of confidence respectively.

Test of generic vs. alternative specific

Likelihood Ratio (LR) test is used to test the null hypothesis that the generic model is the better model. The test statistic is:

$$-2 \text{ x } [LL_R - LL_U] \tag{4.3}$$

Where, LL_R is the log-likelihood of the restricted model (model with generic coefficients) and LL_U is the log-likelihood of the unrestricted (model with alternative specific coefficients) model. The test statistic is assumed to be χ^2distributed with n degrees of freedom. The null hypothesis is rejected if the test statistic is sufficiently greater thanχ^2.

Overall goodness of fit measure

The adjusted rho-square values ($\bar{\rho}^2$) are used as the decision criteria. The adjusted rho-square can be expressed as in Equation (4.4).

$$\bar{\rho}^2 = 1 - \frac{LL(\widehat{\beta})-K}{LL(0)} \tag{4.4}$$

Where, LL (0) represents the log-likelihood with zero coefficients (which results in equal likelihood of choosing each available alternative), LL ($\hat{\beta}$) represents the log-likelihood for the estimated model and *K* is the number of degrees of freedom (parameters) used in the model. $\bar{\rho}^2$ accounts for the improvement in log-likelihood with the number of model parameters and higher the $\bar{\rho}^2$, better is the goodness-of-fit with the data.

Market segmentation test

Likelihood Ratio test is done to test the null hypothesis that the un-segmented model is the better model. The test statistic is similar to that provided in Equation (4.3), where LL_R is the log-likelihood of the un-segmented model and LL_U is the log-likelihood of the segmented model. The null hypothesis is rejected if the test statistic is sufficiently greater than χ^2.

4.4.1 RP model

The model estimated with RP only data is presented in this Section. The estimated parameters of the choice set generation model are used to probabilistically predict the choice set of each of the 7531 RP observations. Each of the twelve choice sets is assigned a probabilistic value which implies the probability of that choice set be the consideration set of a particular observation. The estimated measurement error components have been accounted to modify the network derived travel time (Hasan, 2007) of different modes.

Model structure

The model structure can be illustrated as in Figure 4.2.

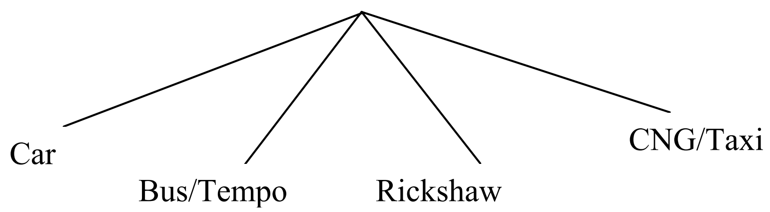

Figure 4.2: RP model structure – subjected to choice set

The choice set probabilities are taken into the model using Equation (4.5).

$$P_{in} = P_n(i|C_1) \text{x } P_n(C_1) + P_n (i|C_2) \text{x } P_n (C_2) + \ldots\ldots\ldots + P_n (i|C_n) \text{x } P_n (C_c) \tag{4.5}$$

Where, P_{in} is the probability of individual n choosing a mode i; $P_n(i|C_c)$ is the probability of choosing mode i given choice set C_c and $P_n(C_c)$ is the probability of C_c be the choice set of the individual n.

$$P_n(i|C_1) = \frac{e^{V_{in}}}{\sum_{j=1}^{M} e^{V_{jn}}} \tag{4.6}$$

Where, V_{in} is the deterministic utility portion of mode i and M is the total number of modes in the choice set C_1.

$V_{in} = \beta_i X_{in}, \forall i \in C_1;$ (4.7)

Where, X_{in} = attributes of different modes and socio-economic characteristics of the individual n and β_i = Coefficient of X_{in} to be estimated by discrete choice analysis technique.

The likelihood is calculated by Equation (4.8).

$$LL = \sum_{n=1}^{N} \mathrm{P_{in}} \times \mathrm{y_{in}} \quad (4.8)$$

Where, LL is the likelihood of all the observations, N is the number of observations and y_{in} is an indicator variable, the value of which is 1 if individual n chooses mode i and 0 otherwise.

In the present study the number of choice set available are 12 as mentioned in Section 4.2.1 and the number of modes were 4. The probability of each of these 12 choice sets being an individual's consideration set is calculated using the parameters estimated from SP data (given in Table 4.3).

Different specifications of MNL model are tested by using estimation software GAUSS 10.0. The priori hypotheses about different variables are illustrated in Table 4.5.

Table 4.5: Priori assumptions about the socio-economic characteristics for RP choice model

Variables	Assumptions
Travel time	People's sensitivity towards travel time may vary depending on: motorized/ non-motorized modes private/public modes
Fare	Fare sensitivity may also vary depending on the mode characteristics
Gender	Female traveler may have strong disliking for bus/tempo due to poor level of service
Age	Young people may have strong affinity towards bus and rickshaw due to comparatively low fare
Education level	High educated people may have a liking for car since car is used as a status symbol in our country

Table 4.5: Priori assumptions about the socio-economic characteristics for RP choice model (Continued)

Variables	Assumptions
House hold income	People with high HHI are inclined towards private mode of transport specially car due to better level of service and people with low HHI are inclined towards public mode of transport due to poor affordability
Trip duration	Mode choice can also be affected by the length of the trip: bus is preferred for long trips rick is preferred for short trips
Trip purpose	Trip purpose can also affect the choice of mode for example, people may be reluctant to use public modes or indirect modes while travelling with other family members and car may be preferred for the trips where flexibility is required
Employment status	Full time employed people may have affinity for car and other personalized modes due to their non-flexible work schedule

The model specification is started with generic travel time and generic travel fare and Alternative Specific Constants (ASCs) for bus/tempo, rickshaw, CNG/taxi and car. Later mode specific travel time and fare coefficients are also tested and are retained or rejected based on the sign of the coefficient and also on the overall goodness of fit measure (Adjusted R square). Different socio-economic parameters are also tested as dummy variables based on the priori hypothesis presented in Table 4.5 and some of them are retained based on the above mentioned criteria.

Estimation results

The RP model estimation result is presented in Table 4.6.

Table 4.6: RP model estimation results

Parameters	Estimated values (t-statistics)
Constants:	
bus/tempo	0
car	-6.7301 (-4.473)
CNG/taxi	-4.1685 (-4.346)
rickshaw	8.5446 (4.851)
Travel time coefficient:	
motorized modes	-0.2438 (-2.575)
non-motorized mode	-0.3034 (-4.580)

Table 4.6: RP model estimation results (Continued)

Parameters	Estimated values (t-statistics)
Fare coefficient:	
bus/tempo & rickshaw	-0.5608 (-2.691)
car	-0.1367 (-4.320)
CNG/taxi	-0.1033 (-4.150)
Gender dummy:	
bus/tempo	-1.0736 (-6.304)
Age dummy:	
bus/tempo	-0.3690 (-2.122)
Employment dummy:	
car	1.5818 (9.797)
Student dummy:	
rickshaw	2.2219 (4.357)
High income dummy:	
car	1.2242 (5.649)
Low income dummy:	
bus/tempo	0.8158 (4.834)
NHB dummy:	0.8062 (3.010)
car	
HBO dummy:	-0.9502 (-5.535)
bus/tempo	
No. of Observations	7531
No. of Parameters	16
LL at Zero	-10714.50
LL at Convergence	-7006.67
Adjusted Rho-Square	0.345

The description of the dummy variables is provided in Table 4.7.

Table 4.7: Description of the dummy variables

Dummy variables		**Description**
Gender dummy	1	for female respondents
	0	for male respondents
Age dummy	1	for the respondent's of age greater than 40 years
	0	for the respondent's of age less than or equal to 40 years
Employment dummy	1	for the respondents who are full time employed
	0	for the respondents who are not full time employed

Table 4.7: Description of the dummy variables (Continued)

Dummy variables		Description
Student dummy	1	for the student respondents
	0	for non-student respondents
High income dummy	1	for the respondents with HHI greater than 50,000 Taka/month
	0	for the respondents with HHI less than or equal to 50,000 Taka/month
Low income dummy	1	for the respondents with HHI less than 20,000 Taka/month
	0	for the respondents with HHI greater than or equal to 20,000 Taka/month
NHB dummy	1	for NHB trips
	0	for trips except NHB trips
HBO dummy	1	for HBO trips
	0	for trips except HBO trips

From the revealed preference estimation result, it is found that all things remaining same, rickshaw is the most preferred mode and car is the least preferred mode. People's travel time sensitivity does vary based over the motorized and non-motorized modes as hypothesized and fare sensitivity is also different over bus/tempo, rick, car and CNG/taxi. The negative coefficient for gender dummy and age dummy in bus/tempo indicate that, female commuters are reluctant to travel by bus/tempo and people over 40 years old also have a general disliking for bus/tempo mode. The negative parameter for HBO trips indicates, all else being equal, people's reluctance to use bus/tempo for HBO trips which include recreational trips, social trips etc.

The positive full time employment dummy in car implies all else being equal the people with non flexible work schedule prefer car over other modes. Also the positive student dummy in rickshaw indicates strong affinity of students' for this mode.

The high income dummy is positive in car and the low income dummy is positive in bus/tempo which reveals systematic taste heterogeneity of respondents based on income. Also the positive parameter in NHB dummy indicates people's preference for car for these types of trips, all else being equal.

4.4.2 SP model

Model developed using SP data is presented in this Section. In the individual SP choices, the choice sets consisted of the current mode, BRT and Metro Rail, in the analysis the choice sets are restricted accordingly. That is, the choice set of each individual consists of his/her ‘currently chosen mode’ and the new modes (BRT and Metro Rail). For example, for a ‘current bus/tempo user’, the choice set comprises of bus/Tempo, BRT and Metro Rail, for a ‘current car user’, the choice set comprises car, BRT and Metro Rail, etc.

In the SP survey the car users were asked about how much they could have saved if they had not used their own car for the trip (e.g. got a free ride from office/ friends) to get an idea about the running cost of car. But, most of the respondents were unware of the cost. Therefore, the cost associated with the car travel is generated as part of the analysis. Since it is very unlikely that the current car users will abandon their cars altogether after introduction of improved mass transit options, there will be no substantial change in the fixed costs. Therefore, it is assumed that the car cost associated with the trip in question is only fuel cost. Though the origin and destination of the trip is known, the route used for the trip or the distance traversed are unknown in the analysis. Therefore, the fuel costs are calculated as a function of current travel times (assuming a fuel consumption rate of 8km/cubic meter, average speed of 12km/hr and CNG price of 16Taka/cubic meter).

Model structure

As mentioned above, discrete choice modeling technique is used to estimate the utility parameters of of the modes. The SP model structure is provided in Figure 4.3.

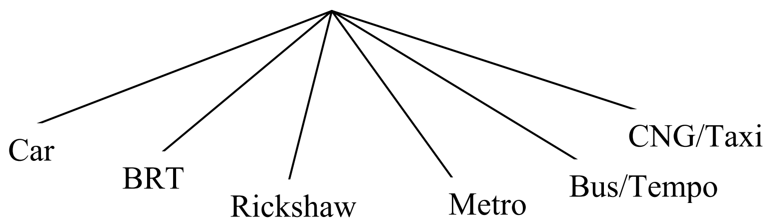

Figure 4.3: SP model structure (conditional on choice set)

A linear utility function has been associated with each mode. The utility of a mode *i* of individual *n* can be expressed as in Equation (4.9).

$$U_{in} = \beta_i X_{in} + \varepsilon_{in} , \forall i \in C_n; \qquad (4.9)$$

Where, X_{in} = attributes of different modes and socio-economic characteristics of the individual n, β_i = Coefficient of X_{in} to be estimated by discrete choice analysis technique, ε_i= Random error term and C_n = Choiceset for individual n. The priori hypotheses about different variables are presented in Table 4.8.

Table 4.8: Priori assumptions about the socio-economic characteristics for SP choice model

Variables	Assumptions
Origin & Destination	The people who's origin & destination or origin/destination is work and/or education may have stronger affinity for BRT and/or Metro Rail than others and people may prefer car for NHB trips and may want to avoid bus for HBO trips
Frequency	The people who are the regular users of the route may have a stronger affinity for BRT and/or Metro Rail than others
Age	Young people may have strong affinity for bus and rickshaw and old people may try to avoid bus
employment	(i) People who are fulltime employed and businessman or/and part time employed may have a stronger affinity for BRT and/or Metro Rail than others; (ii) Students can also be tested for stronger affinities towards BRT and/or Metro Rail and rickshaw than others (iii) Full time employed people may prefer to use car
Income	People with high HHI may prefer car over modes, while people with low HHI may prefer to use bus
Gender	Female respondents may have a strong disliking for the bus/tempo mode and also for BRT and Metro Rail

The model estimation is started with generic mode attributes (travel time, travel cost and waiting time). Alternative specific forms of these variables are also tested later. The socio-economic characteristics of the respondents are tested based on some priori assumptions.

Estimation results

The estimated parameter values for the final SP model are provided in the Table 4.9. The descriptions of the dummy variables have already been provided in Table 4.7.

Table 4.9: SP model estimation results

Parameters	Estimated Values (t-statistics)
Constants:	
BRT	0.452 (1.37)
bus/tempo	0.00
car	0.282 (0.72)
CNG/taxi	-0.602 (-0.82)
Metro Rail	-0.181 (-0.52)
rickshaw	1.43 (2.4)

Table 4.9: SP model estimation results (Continued)

Parameters	Estimated Values (t-statistics)
Fare:	
BRT	-0.0492 (-5.04)
bus/tempo	-0.101 (-4.52)
car	-0.0141 (-1.99)
CNG/taxi	-0.0141 (-1.99)
Metro Rail	-0.0352 (-3.99)
rickshaw	-0.101 (-4.52)
Travel Time:	
BRT	-0.0591 (-5.87)
bus/tempo	-0.0591 (-5.87)
car	-0.0591 (-5.87)
CNG/taxi	-0.0591 (-5.87)
Metro Rail	-0.0591 (-5.87)
rickshaw	-0.0385 (-1.73)
Low income dummy:	
bus/tempo	0.343 (1.11)
Gender Dummy:	
bus/tempo	-1.46 (-1.96)
HBO dummy:	
bus/tempo	-0.486 (-1.32)
Age dummy:	
bus	-0.204 (-0.44)
Waiting Time:	
BRT	-0.0383 (-4.61)
bus/tempo	-0.0383 (-4.61)
CNG/taxi	-0.0383 (-4.61)
Metro Rail	-0.0383 (-4.61)
rickshaw	-0.0383 (-4.61)
No. of Observations	928
No. of Parameters	16
LL at Zero	-1019.512
LL at Convergence	-856.195
Adjusted Rho-Square	0.144

It is to be mentioned that, though some of the parameters to the dummy variables are not significant at 90% level of confidence, still the parameters are retained in the model due to strong priori hypothesis about their importance and the potential improvement of significance after combination with RP data. The sign of these parameters are intuitive and the parameters are significant after combining with the RP data (details in Chapter 05). The parameters to the level of service attributes are negative. All things remaining the same, rickshaw is the most preferred mode according to the estimation result while CNG/taxi is the least preferred mode. Female passengers are significantly reluctant to travel by bus/tempo. The coefficient of travel time is different for motorized modes (CNG/taxi, bus/tempo, BRT, Metro Rail and car) and non-motorized mode (rickshaw) with higher values for motorized modes. Sensitivity towards travel fare is significantly different for different modes. The sensitivities towards waiting time did not vary over different modes. The negative coefficient of HBO trip dummy into bus/tempo implies that, all else being equal, people are reluctant to use bus/tempo for HBO trips and the positive low income dummy in bus/tempo indicates low income people's preference for bus/tempo. Also from negative age dummy in bus/tempo it can be inferred that people whose age is more than 40 years are not very willing to use bus/tempo.

4.5 Summary

In this Chapter the separate components of the integrated choice model are developed starting with the choice set generation model which is followed by the measurement error correction. The predicted choice set probabilities from the choice set generation model along with the corrected LOS data are used to develop the RP choice model. The SP choice model is also developed separately using the collected survey data. However, it has to be mentioned that, both the RP and SP choice models have got their own limitations. For example, the RP model does not include the proposed new alternatives, BRT and Metro Rail in the choice set and has got limited range of attributes. On the other hand, the SP model reflects only the stated preference of the respondents which may contain different biases like policy response bias, omission of situational constraints, etc. (see Section 2.3 for potential sources of biases in SP data). To overcome these limitations of the RP and SP only models, the two data sources are combined in the next Chapter.

CHAPTER FIVE

COMBINED MODEL ESTIMATION RESULTS

5.1 Overview

In the previous Chapter, two separate mode choice models are developed with only RP and only SP data. These disjoint RP and SP models have got some shortcomings. The RP model does not include the proposed new alternatives, BRT and Metro Rail in the choice set. Also, the RP data has got limited range of attributes. On the other hand, the SP model reflects only the stated preference of the respondents which may contain different biases like policy response bias, omission of situational constraints, etc. (see Section 2.3 for potential sources of biases in SP data). In this Chapter, the SP data is combined with the RP data to overcome the limitations of the SP and RP only models. The overall model structure is illustrated first which is followed by the estimation results of the base model. Details specification tests are performed next to enrich the model. The final model and market segmentation tests along with explanations are presented next. In the last Section of the Chapter an effort is made to predict the aggregate behaviour of the travellers inferred from the final model.

5.2 Combined Model Structure

In the present research the universal choice sets of the RP and the SP data source are different. The SP data considered two new alternatives, BRT and Metro Rail besides the conventional modes of transport in Dhaka city. The choice sets of the RP and SP data source can be presented as in Figure 5.1. The new alternatives in the choice set of SP data are shaded.

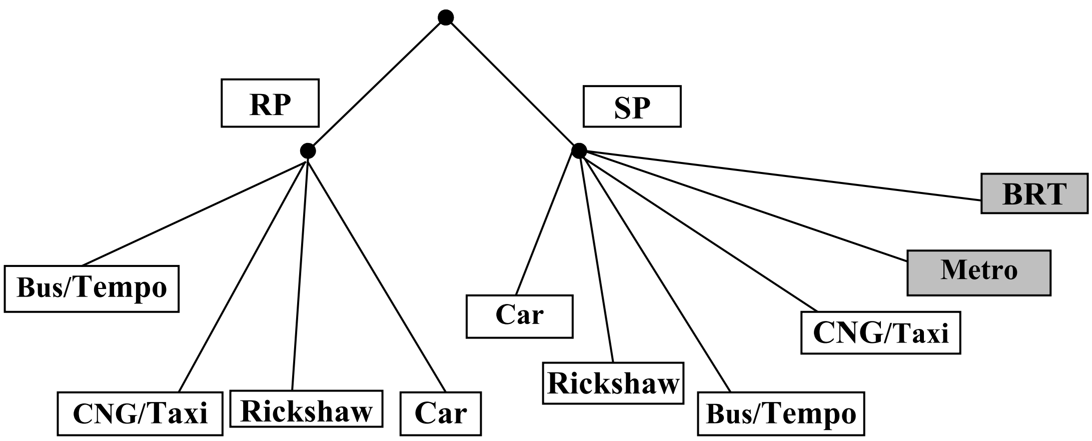

Figure 5.1: RP and SP choice set

As discussed in Section 2.4.2 choice probabilities for disjoint RP and SP models can be expressed as in Equations (2.2a) and (2.2b).

$$P_i^{RP} = \frac{\exp[\lambda^{RP}(\alpha_i^{RP}+\beta^{RP}X_i^{RP}+\omega Z_i)]}{\sum_{j\epsilon C^{RP}}\exp[\lambda^{RP}\left(\alpha_j^{RP}+\beta^{RP}X_j^{RP}+\omega Z_j\right)]}, \quad \forall i\epsilon C^{RP}, \tag{2.2a}$$

$$P_i^{SP} = \frac{\exp[\lambda^{SP}(\alpha_i^{SP}+\beta^{SP}X_i^{SP}+\delta W_i)]}{\sum_{j\epsilon C^{SP}}\exp[\lambda^{SP}\left(\alpha_j^{SP}+\beta^{SP}X_j^{SP}+\delta W_j\right)]}, \quad \forall i\epsilon C^{SP} \tag{2.2b}$$

Where, *i* is an alternative in choice sets C^{RP} or C^{SP}, αs are data source specific alternative specific constants (ASCs), β^{RP} and β^{SP} are the utility parameters for the attributes common to both data sets, δ and ω are utility parameters for the unique attributes in each data set, and γ^{RP} and γ^{SP} are the scale factors associated with the error terms of the RP and SP data source respectively.

From Equations (2.2a) and (2.2b), it is clear that any particular scale factor and parameters of its associated choice model are inseparable and multiplicative (Θκ), where Θ is the scale factor and κ is some parameter vector. Thus it is not possible to identify a scale factor within a particular data source while developing disjoint models. Again the process of combining two data sources involves imposing the restriction that the common attributes have the same parameters in both data sources, i.e., $\beta^{RP} = \beta^{SP} = \beta$. However, the estimated model parameters are confounded with the scale factor for each data set. Therefore, data enrichment involves pooling two choice data sources under the restriction that common parameters are equal, while controlling for the scale factor. Since both the scale factor cannot be identified one must be normalized. In the present study the scale factor of SP data source is set to one ($\Theta^{SP} \equiv 1$), and so the estimate of the scale factor of RP data source Θ^{RP} represents a relative scale with respect to the SP data scale. This can be viewed as estimating the RP variance relative to the SP variance**.** In the light of the above discussion the deterministic utility portion for a mode for both the RP and SP parts can be written as in Equation (5.1).

$$V_{in} = \theta^{RP}\,(\alpha_i^{RP} + \beta^{RP}X_i^{RP} + \omega Z_i) + \alpha_i^{SP} + \beta^{SP}X_i^{SP} + \delta W_i \tag{5.1}$$

Where, Θ^{RP} is the scale factor of RP data source with respect to the SP data scale.

5.2.1 Base model

The common level of service attributes between the RP and SP data sources are travel time and travel cost of the modes. Common generic parameters are used for these two attributes. Waiting time is the SP data source specific attribute. In addition data source specific ASCs are also estimated. The utility equations of the base model are provided in Table 5.1. And, the coefficients of the base model estimated by GAUSS 10.0 are provided in Table 5.2.

Table 5.1: Utility equations of the modes for RP-SP data source for the base model

Mode	For RP data source	For SP data source
Car	$\theta\,\alpha_{car}^{RP}$ + $\theta\beta_{tt}$ car travel time + $\theta\beta_{fare}$ car travel cost	α_{car}^{SP} + β_{tt} car travel time + β_{fare} car travel cost
Bus/tempo	$\theta\,\alpha_{bus\_tempo}^{RP}$ + $\theta\beta_{tt}$ bus/tempo travel time + $\theta\beta_{fare}$ bus/tempo travel cost	$\alpha_{bus\_tempo}^{SP}$ + β_{tt} bus/tempo travel time + β_{fare} bus/tempo travel cost + β_{wt} bus/tempo waiting time
CNG/taxi	$\theta\alpha_{cng\_taxi}^{RP}$ + $\theta\,\beta_{tt}$ cng/taxi travel time + $\theta\beta_{fare}$ cng/taxi travel cost	$\alpha_{cng\_taxi}^{SP}$ + β_{tt} cng/taxi travel time + β_{fare} cng/taxi travel cost + β_{wt} cng/taxi waiting time
Rickshaw	$\theta\alpha_{rickshaw}^{RP}$ + $\theta\beta_{tt}$ rickshaw travel time + $\theta\beta_{fare}$ rickshaw travel cost	$\alpha_{rickshaw}^{SP}$ + β_{tt} rickshaw travel time + β_{fare} rickshaw travel cost + β_{wt} rickshaw waiting time
BRT	None	α_{brt} + β_{tt} brt travel time + β_{fare} brt fare + β_{wt} brt waiting time
Metro Rail	None	α_{metro} + $\beta_{tt\_motorized}$ metro travel time + β_{fare_metro} metro fare + β_{wt} metro waiting time

Table 5.2: RP-SP base model estimation result

Parameters	Estimated values (t-stat)
ASCs in RP data source:	
bus/tempo	0
car	-1.2304 (-6.46)
CNG/taxi	-0.8060 (-6.42)
Rickshaw	0.3618 (6.142)

Table 5.2: RP-SP base model estimation result (Continued)

Parameters	Estimated values (t-stat)
ASCs in SP data source:	
bus/tempo	0
car	1.6092 (6.545)
CNG/taxi	1.7215 (6.434)
rickshaw	1.0053 (4.107)
Metro Rail	0.4458 (2.206)
BRT	0.8698 (4.334)
Generic travel time coefficient (RP and SP)	-0.0543 (-6.493)
Generic travel cost coefficient (RP and SP)	-0.0084 (-6.337)
Generic waiting time coefficient (SP only)	-0.0354 (-4.455)
Theta	7.8230 (5.405)***
No. of Observations	8459
No. of Parameters	12
LL at Zero	-13071.9
LL at Convergence	-8118.38
Adjusted Rho-Square	0.378

***t-stat with respect to 1

The scale factor in an MNL model is inversely related to the variance of the error term as in Equation (5.2) for all alternatives and respondents. Thus, the higher the scale the smaller the variance of the error term. The estimated scale factor of the RP data source is 7.823 which imply that the variance of error term is larger in SP data source than in RP data source.

$$\sigma^2 = \frac{\pi^2}{6\theta^2} \tag{5.2}$$

In the next Section the final model specification and estimation results is presented.

5.2.2 Final model

Observed taste heterogeneity is addressed in the final model by adding socio-economic attributes like gender dummy, age dummy, etc. Different specifications of the socio-economic characteristics and the mode attributes are tested based on some prior assumptions. The assumption that has given intuitive results and has improved the model statistically (significantly higher adjusted R square) is retained as the final specification of the model. The summary of the assumptions and the test results are presented in Table 5.3.

Table 5.3: Hypothesis regarding the socio-economic attributes and the consequent modification into the model specification

Variables	Priori hypothesis	Model specification(s)	Statistical test results
Travel time	Sensitivity towards travel time may vary over motorized and non motorized mode of transport	Addition of different travel time coefficients for motorized and non-motorized modes	Significant improvement
Travel cost	Travel cost sensitivity may over different types of modes	Different travel cost coefficient for bus/tempo and rickshaw, car and CNG/taxi and alternative specific travel time coefficient for BRT and Metro Rail	Significant improvement
Gender	Females have lower preference for mass transit	(i) Generic female dummy added in bus, BRT and Metro Rail (ii) Female dummy added in bus	(i) Improvement statistically not significant (ii) Significant improvement
Age	(i) Young people have higher preference for bus & rickshaw (ii) Old people have lower preference for bus	(i) Generic young age (<25 years) dummy added in rickshaw and bus (ii) Old age (>40 years) dummy added in bus	(i) Improvement statistically not significant (ii) Significant improvement
Income	(i) People with low HHI have high preference for bus (ii) people with high HHI have high preference for car	(i) Low income dummy (<20,000Taka/month) added in bus (ii) High income dummy (>50,000 Taka/month) added in car	(i) Significant improvement (ii) Significant improvement
Education	People with higher education have a higher preference for car	High education dummy added in car	Improvement statistically not significant

Table 5.3: Hypothesis regarding the socio-economic attributes and the consequent modification into the model specification (Continued)

Variables	Priori hypothesis	Model specification(s)	Statistical test results
Employment status	(i) People with non-flexible work schedule has a high preference for car (ii) people with non-flexible work schedule has a low preference for bus	(i) Full time employment dummy added in car (ii) Generic full time employment dummy added in bus and car	(i) significant improvement (ii) Improvement statistically not significant
Occupation	Student has high preference for rickshaw and bus	(i) Student dummy added in rickshaw (ii) Generic student dummy added in bus and rickshaw	(i) Significant improvement (ii) Improvement statistically not significant
Education	People with higher education have a higher preference for car	High education dummy added in car	Improvement statistically not significant
Trip purpose	(i) People prefer car for non home based trips due to better flexibility of stopping and riding (ii) people are reluctant to use bus for home based other trips	(i) NHB trip dummy added in car (ii) HBO trip dummy added in bus	(i) Significant improvement (ii) Significant improvement
Trip duration	(i) bus is preferred for long duration trips (ii) Rickshaw is preferred for short duration trips	(i) Long trip dummy (duration >60 minutes) added in bus (ii) Short trip dummy (duration < 30 minutes) added in rickshaw	(i) Improvement statistically not significant (ii) Improvement statistically not significant

Based on the statistical tests mentioned above, the generic model is modified by the addition of the above mentioned parameters to the socio-economic dummy variables. In the final model the ASCs are common to the RP and SP data source. The utility equations for the RP and the SP data source are provided in Table 5.4.

Table 5.4: Utility equations of the modes for RP-SP data source for the final model

Mode	For RP data source	For SP data source
Car	$\theta\,\alpha_{car}$ + $\theta\,\beta_{tt\_motorized}$ car travel time + $\theta\beta_{fare\_car,cng}$ car travel cost + β_{emp} non-flexible dummy + $\beta_{hincome}$ high income dummy	α_{car} + $\beta_{tt\_motorized}$ car travel time + $\beta_{fare\_car,cng}$ car travel cost + β_{emp} non-flexible dummy + $\beta_{hincome}$ high income dummy + β_{nhb} NHB dummy
Bus/tempo	$\theta\alpha_{bus/tempo}$ + $\theta\beta_{tt\_motorized}$ bus/tempo travel time + θ $\beta_{fare\_bus/tempo,rick}$ bus/tempo travel cost + β_{gender} gender dummy + β_{age} age dummy + $\beta_{lincome}$ low income dummy	$\alpha_{bus/tempo}$ + $\beta_{tt\_motorized}$ bus/tempo travel time + $\beta_{fare\_bus/tempo,rick}$ bus/tempo travel cost + β_{gender} gender dummy + β_{age} age dummy + $\beta_{lincome}$ low income dummy + β_{wt} bus/tempo waiting time + β_{hbo} HBO dummy
CNG/taxi	$\theta\alpha_{cng/taxi}$ + $\theta\beta_{tt\_motorized}$ cng/taxi travel time + $\theta\beta_{fare\_car,cng}$ cng/taxi fare	$\alpha_{cng/taxi}$ + $\beta_{tt\_motorized}$ cng/taxi travel time + $\beta_{fare\_car,cng}$ cng/taxi fare + β_{wt} cng/taxi waiting time
Rickshaw	$\theta\alpha_{rick}$ + $\theta\beta_{tt\_rick}$ rickshaw travel time + $\theta\beta_{fare\_bus/tempo,rick}$ rickshaw fare + $\beta_{student}$ student dummy	α_{rick} + β_{tt_rick} rickshaw travel time + $\beta_{fare\_bus/tempo,rick}$ rickshaw fare + $\beta_{student}$ student dummy + β_{wt} rickshaw waiting time
BRT	None	α_{brt} + $\beta_{tt\_motorized}$ brt travel time + β_{fare_brt} brt fare + β_{wt} brt waiting time
Metro Rail	None	α_{metro} + $\beta_{tt\_motorized}$ metro travel time + β_{fare_metro} metro fare + β_{wt} metro waiting time

The estimation results are appended in Table 5.5.

Table 5.5: Estimation results of the final combined RP-SP model

Parameters	Estimation results (t-stat)
ASC in car, $\boldsymbol{\alpha_{car}}$	-1.5924 (-7.171)
ASC in bus/tempo, $\boldsymbol{\alpha_{bus/tempo}}$	0
ASC in CNG/taxi,$\boldsymbol{\alpha_{cng/taxi}}$	-0.9622 (-7.136)
ASC in rickshaw,$\boldsymbol{\alpha_{rickshaw}}$	2.2598 (5.636)
ASC in BRT,$\boldsymbol{\alpha_{brt}}$	1.0443 (4.031)

Table 5.5: Estimation results of the final combined RP-SP model (Continued)

Parameters	Estimation results (t-stat)
ASC in Metro Rail, α_{metro}	0.4465 (1.684)
TT parameter to motorized modes, $\beta_{tt\ motorized}$	-0.0348 (-4.547)
TT parameter to non-motorized mode, $\beta_{tt\ rick}$	-0.0752 (-7.682)
Cost parameter to bus/tempo and rickshaw, $\beta_{fare\ bus/tempo,rick}$	-0.0709 (-4.182)
Cost parameter to cng/taxi and car, $\beta_{fare\ cng/taxi,car}$	-0.0123 (-5.322)
Cost parameter to BRT, $\beta_{fare\ brt}$	-0.0524 (-7.926)
Cost parameter to Metro Rail, $\beta_{fare\ metro}$	-0.0379 (-6.485)
Generic WT parameter, β_{wt}	-0.0412 (-5.095)
Parameter to employment dummy in car, β_{emp}	1.3638 (9.330)
Parameter to high income dummy in car, $\beta_{hincome}$	1.2851 (7.223)
Parameter to low income dummy in bus/tempo, $\beta_{lincome}$	0.6181 (4.382)
Parameter to gender dummy in bus, β_{gender}	-1.0890 (-7.013)
Parameter to age dummy in bus, β_{age}	-0.3712 (-2.388)
Parameter to student dummy in rickshaw, $\beta_{student}$	0.9901 (4.022)
Parameter to non-home base dummy in car, β_{nhb}	0.7972 (3.352)
Parameter to home base other dummy in bus, β_{hbo}	-0.8556 (-5.749)
RP scale factor relative to SP scale factor, θ	3.6260 (4.908)***
No. of Observations	8459
No. of Parameters	21
LL at Zero	-13071.9
LL at Convergence	-7936.69
Adjusted Rho-Square	0.394

*** t-stat with respect to one

The description of the dummy variables provided in Table 4.7 is repeated here.

Table 4.7: Description of the dummy variables

Dummy variables		Description
Gender dummy	1	for female respondents
	0	for male respondents
Age dummy	1	for the respondent's of age greater than 40 years
	0	for the respondent's of age less than or equal to 40 years
Employment dummy	1	for the respondents who are full time employed
	0	for the respondents who are not full time employed
Student dummy	1	for the student respondents
	0	for non-student respondents
High income dummy	1	for the respondents with HHI greater than 50,000 Taka/month
	0	for the respondents with HHI less than or equal to 50,000 Taka/month

Table 4.7: Description of the dummy variables (Continued)

Dummy variables		Description
Low income dummy	1	for the respondents with HHI less than 20,000 Taka/month
	0	for the respondents with HHI greater than or equal to 20,000 Taka/month
NHB dummy	1	for NHB trips
	0	for trips except NHB trips
HBO dummy	1	for HBO trips
	0	for trips except HBO trips

Estimated coefficients indicate that, all other things remaining the same, rickshaw is the most preferred mode which is followed by BRT and Metro Rail, while car is the least preferred mode next to CNG/taxi.

The sensitivity of people towards travel time does vary significantly over motorized and non-motorized mode of transports with higher value of coefficient for the travel time of rickshaw. Cost sensitivity also varies over different modes with highest absolute value of the parameter for bus/tempo and rickshaw which is followed by BRT and Metro Rail. People's sensitivity for travel cost is least for car and CNG/taxi. The sensitivity for waiting time is found to be same for all modes of transport.

The employment dummy and the high income dummy are positive in car which implies that, all else being equal, the people with non-flexible work schedule and/or the people with house hold income more than Taka 50,000 per month are inclined to car over other modes of transport. The positive parameter for NHB dummy in car indicates, all else being equal people prefer car for NHB trips due to better flexibility.

The negative age dummy and low income dummy in bus and tempo mode indicate that the traveler whose household income is less than Taka 20,000 per month and the traveler whose age is over 40 years are reluctant to use bus/tempo over other modes, all else being equal. Also the negative gender dummy implies female travelers have an additional disliking for bus and tempo modes compared to the male travelers. The negative parameter for HBO dummy in bus indicates, all else being equal, people are reluctant to use bus in HBO trips compared to other modes. The positive student dummy in rickshaw indicates students have additional preference for rickshaw compared to other modes.

Finally, the scale parameter ϴ was also found to be significantly different from 1 (t-stat 4.93) indicating a significant difference in the variance between the RP and SP data. Since, the scale factor is normalized for SP data source and the estimated value is greater than 1, it indicates that the variance of the error term of the RP data is smaller than that of the SP data.

The estimation results of the model parameters have got several policy implications. The estimated values of the parameters of the combined model indicate that, in general the female travelers, the middle and old age travelers and the travelers with comparatively high monthly incomes are reluctant to use public transport modes. Therefore in order to increase the ridership of these groups of people, special incentives need to be provided. Special incentives may include female only compartments, low floor vehicles, suitable seating arrangements for the aged travelers and on-time and reliable services. Since, public transport is already a popular mode of transport among the low income group of people; efforts can be made to retain ridership of this group of travelers. The effort may include providing different facilities in different compartments and charging variable fare depending on the compartment facility.

5.2.3 Market segmentation test

Market segmentation is done on the base model. To test the statistical significance of market segmentation likelihood ratio test is used (detailed description of the test is presented in Section 4.4). The segmentation is statistically significant on the basis of occupation of the people and the purpose of the trip. For the market segmentation based on occupation people are segmented into two groups:

(i) People who are full time or part time service holders in any government or public services and businessman;
(ii) People who do not belong to the first group.

For the market segmentation based on trip purpose the people were segmented based on the purpose of the trips into three groups:

(i) Home based work trips;
(ii) Home based education trips; and
(iii) Other trips which include both home base other trips (HBO) and non-home base trips (NHB).

Likelihood Ratio test is done to test the null hypothesis that the un-segmented model is the better model. The likelihood ratio test results are presented in Table 5.6.

Table 5.6: Statistical test results of market segmentation tests

Market segmentation based on	LL of restricted model	LL of the unrestricted model	LR	Critical χ^2 at 99.9% level of confidence	dof	LR test result
Occupation	-8118.38	Group i: -3260.86 Group ii: -4756.54	201.96	32.91	12	Null hypothesis rejected
Trip purpose		Group i: -2221.19 Group ii: -2170.78 Group iii: -3509.59	216.82	51.18	24	Null hypothesis rejected

The market segmentation has also been attempted for income and other socio-economic attributes like age, gender, etc., but there have been some identification problems probably due to the sample size and characteristics within segments (i.e. models did not converge in GAUSS).

5.3 WTP Calculation/ Interpreting the Results

Among the willingness to pay (WTP) for different trip attributes, willingness to pay for travel time savings which is commonly known as value of time (VOT) is a key concept in transport planning in terms of mode choice decisions of the users. It can provide information on expected return of the introduction of faster services (Alam et al., 1999). It also helps the decision makers to make pricing decisions, analyze the impact of different pricing policies on the demand of different transport services, take decisions on tax benefits required for making different services operational and perform cost benefit analysis (Alam et al., 1999). Although time savings constitute a major portion of the benefits of transport projects in developed countries, it is usually overlooked in developing countries (Thomas, 1977). Howe (1976) has argued that to omit a value for time savings from a feasibility analysis could be to exclude the main benefit and distort investments. And equally, to impute an incorrectly high value might bias investment towards the urban (car) dominated sectors of developing societies. He has suggested that evaluation of time savings should be included in all aspects of transport planning in developing countries as well.

A standard procedure for deriving behavioral values of different attributes is to use the trade-off implied by the coefficients of cost and other variables in mode choice models. The ratio of the estimated travel time and travel cost parameters provides an estimate of the value of time implied by the model; this can serve as an important test for evaluating the reasonableness of the model as well (Koppleman and Bhatt,2006). Thus, the VOT can be calculated as the ratio of the parameters for time over the parameter for cost. This ratio assumes that the utility function is linear in both time and cost and that neither value is interacted with any other variables. That is, when the utility function is

$$V_i = \cdots + \beta_{travel\ time} Time_i + \beta_{travel\ Cost} Cost_i + \beta_X X_i' \tag{5.3}$$

Where, V_i is the deterministic utility of mode i, $\beta_{travel\ time}$ is the coefficient of travel time, β_{cost} is the coefficient of travel cost, β_X is the coefficient of mode attribute X', $Time_i$ is the travel time of mode i for a particular observation and $Cost_i$ is the cost of mode i for a particular observation.

The value of time is given by Equation (5.4)

$$\text{VOT} = \frac{\beta_{travel\ time}}{\beta_{Cost}} \tag{5.4}$$

The units of time value are obtained from the units of the variables used to measure time and cost. And, the WTP for other variables (for example comfort, air condition, etc.) can be given by Equation (5.5).

$$\text{WTP} = \frac{\beta_X}{\beta_{Cost}} \tag{5.5}$$

5.3.1 VOT in Bangladesh

The Economic Circle under Roads and Highways Department of Bangladesh has published a report on the Road User Cost (RUC) (RHD, 2005) where they identified travel time cost (TTC) as an important component of RUC along with Vehicle Operating Cost (VOC) and Accident Cost (ACC). Survey data from four major divisional cities' main roads and feeder roads have been used for the estimation of TTC by RHD. The methodology of determining the TTC was based on the Average Wage approach. The average wage rates of the vehicle occupants were estimated to reflect the value of time for different types of vehicles. An assessment of the number of travelers in work time (WT) and non-work time (NWT) was also made for each vehicle type. The TTC for WT was then taken as the estimated wage rate and the value for NWT was taken as a proportion of the wage rate. The recommended financial and economic TTC of passengers by vehicle category for motorized vehicles is provided in Table 5.7.

Table 5.7: Recommended Financial and Economic TTC For FY 2004-05 (National Average) by RHD

Vehicle category	Financial TTC per occupant (Taka/hr)	Economic TTC per occupant (Taka/hr)
All buses	22.43	17.95
Micro bus	31.13	24.9
Car/utility	41.1	32.7
Tempo	13.76	27.53
Auto rickshaw	19.13	15.3
Motor cycle	30.2	24.1

The TTC for non-motorized vehicles have been reported separately for work time and non-work time where the NWT TTC has been taken as 35% of WT TTC. The reported values are summarized in Table 5.8.

Table 5.8: TTC for non-motorized vehicles for FY 2004-05 (National Average) by RHD

Vehicle category	WT value per occupant (Taka/hr)	NWT value per occupant (Taka/hr)
Rickshaw	5	3.5
Bi-cycle	7.4	10.5

Few mode choice models have also been found which were aimed towards determining the WTP for the improved transport services of Dhaka city. Alam et al. (1999) have conducted an SP survey among the people to measure the relative importance of four travel attributes: fare, travel time, in-vehicle congestion and air-conditioning. A pooled MNL model was estimated with travel time, travel cost, load factor and air condition as the four generic explanatory variables. From the estimated model parameters the average value of travel time savings for the population under the study was 22.17Taka/hour. The study also determined VOT among different market segments of the population based on gender, income, age, trip purpose and mode. The calculated values over these socio-economic groups revealed that the value of time savings for female passenger (30.94 Taka/hour) was significantly higher than that of the male passengers (19.55 Taka/hour). The VOT was highest for car with 45.12 Taka/hour which was closely followed by babytaxi (36.11 Taka/hour) and was lowest for rickshaw (12.87Taka/hour). The VOT for ordinary bus/minibus and improved bus were 18.76Taka/hour and 24.24Taka/hour respectively.

Another similar study was carried out among the intercity bus passengers traveling from Dhaka towards some major cities of Bangladesh by Ahsan et al. (2002). In this study MNL model was developed with the SP data collected among the intercity bus passengers only, from the three major bus terminals of Dhaka. From the pooled model the average VOT was found to be 54Taka/hour. The study revealed that the intercity bus passengers valued their travel time savings as 1.4 times higher than their hourly income. According to the study, the value of travel time varied significantly over different socio-economic group of people based on occupation, income group, age, trip purpose, etc. and over different destination as well. The VOT was as high as 174.82 Taka/hour for the people whose income was 6001 to 9000 Taka/month and was as low as Taka 15.40 per month for the people with income less than 2000Taka per month.

The RP data used in the current study has previously been used in STP (2005) and by Hasan (2007) (DSTM) to develop four step travel demand models. These studies have been reviewed briefly in Section 2.2. Both the studies developed MNL models to forecast the modal choice of the people of Dhaka city. STP (2005) has calibrated the MNL model for three different income groups of people of the city and Hasan (2007) has calibrated the model based on the trip purpose of the travelers. The VOT as obtained from these studies are presented in Table 5.9.

Table 5.9: VOT from recent studies for Dhaka city

Models	VOT (Taka/hour)
STP:	
Low income group (HHI < 12,500Taka/month)	37.26
Middle income group (HHI 12,500 to 55,000Taka/month)	2040
High income group (HHI > 55,000Taka/month)	1936.68
DSTM:	
Home base work trip (HBW)	195.48
Home base education trip (HBE)	477.42
Home base other trip (HBO)	298.44
Non-home base trip (NHB)	190.44

The VOT as obtained from STP are unrealistically high for the context of Dhaka city and the VOT as obtained from DSTM varies significantly for HBE trip and other trips and also the values are high in the context of the city of Dhaka.

5.3.2 VOT from the current study

In the current study three choice models have been estimated with three different data sources. The detailed specification and estimation results of the models with SP data only and RP only data are presented in Sections 4.4.1 and 4.4.2 respectively and that with combined data sources are illustrated in Section 5.2. The VOT as obtained from these three models is presented in Table 5.10.

Table 5.10: VOT from the current study

Data source	VOT (Taka/hour)
SP:	
Bus/tempo	35.10
Rickshaw	22.86
CNG/taxi	251.46
Car	251.46
BRT	72.06
Metro Rail	100.74
RP:	
Bus/tempo	26.10
Rickshaw	32.46
Car	106.80
CNG/taxi	141.60
Combined RP-SP:	
Bus/tempo	29.46
Rickshaw	63.66
CNG/taxi	169.74
Car	169.74
BRT	39.84
Metro Rail	55.08

From the VOT values provided in Table 5.10 it can be conferred that the VOT obtained from the stated choice of people is higher than that revealed from their actual choices as identified in literature due to policy response bias, justification bias, etc. (Ben-Akiva, 2008). VOT is a very important criterion for getting idea about the fare structure to be introduced for the new proposed modes of transport and even for the introduction of new attributes into an already existing alternative. In most of these cases, one has to rely on the SP data if the data of the comparable LOS or related to comparable attribute are not available. The combination of the SP data with the RP data therefore can increase the reliability of the findings in such cases. It can be noted that, the VOT of the car and CNG/taxi user group is substantially different from the other mode users which indicates that the affordability of car and CNG/taxi users is significantly higher than that of the other mode users in Dhaka city. This fact can be utilized by providing reliable and on-time services to these groups in order to attract them to the proposed BRT and Metro Rail.

VOT values obtained from the current study are more realistic than the VOT obtained from similar studies in recent past (STP, 2005 and Hasan, 2007). However, the estimated values are higher than those reported by RHD (2005). This may be due to the fact that, RHD values are estimated from the survey data of the rural highways of the whole country while the present study VOT values are only applicable for Dhaka city which has distinctly different socio-economic conditions to the rest of the country. The inflations over the last five years have also contributed to the discrepancy.

5.4 Summary

The RP-SP combined model is presented in this Chapter with vigorous specification and market segmentation tests. The VOT values are been presented and compared with VOT from other studies related to Dhaka and rest of the country. The values are found to be more realistic than previous studies. Summary of the research contribution and the future research recommendations are provided in the next Chapter.

CHAPTER SIX
CONCLUSION

6.1 Overview

In this Chapter, the summary of the research is presented followed by specific research contributions and future research recommendations.

6.2 Summary of Research

In this research, a comprehensive mode choice model has been developed combining RP and SP data using advanced discrete choice modeling techniques. STP household interview survey data have been used as the RP data source. Exploration of the RP data revealed four key limitations. Those were missing choice sets of the respondents, missing LOS for unchosen mode, limited range of attributes and the absence of preference for MRT. A SP survey has been conducted to collect LOS data for the proposed new modes like BRT and Metro Rail as well as to avail the missing information in the STP data. Methodologies have been developed to account for the missing choice sets and to correct measurement errors of the existing RP data. Observed taste heterogeneity has been addressed in the RP-SP combined model specification. Finally, the VOT of the respondents have been calculated and compared with the existing literature. The key aspects of the research are summarized below:

Exploration of available RP data

STP HH Survey Data was identified as the most extensive source of data related to transport in Dhaka to date. The amount of data collected during STP HH survey has been very extensive in nature with more than 30,000 daily trip diaries of individualized trips from more than 6,000 households (STP 2005). This data has been explored in detail and the limitations of the data have been identified. The key limitations have been found to be the absence of data regarding the choice set considered by an individual, absence of the LOS values of unchosen modes and limited data on LOS values of chosen modes (only travel time). Moreover the ranges of fare and travel time were limited to the existing modes as there were no MRT or modes of comparable LOS.

Collection of SP data

The objective of the SP survey was to overcome the limitations of the RP data. Among various methods of SP survey Choice Exercise (CE) has been adopted as a means of conducting the survey. There has been an explicit question regarding the availability of the modes to the respondents to find out their choice sets. The choice scenarios presented to the respondents comprised of BRT and Metro Rail and their current travel mode. Three attributes namely travel time, travel cost and frequency have been selected to depict the choice situation. The choice of these three attributes has been made based on an initial survey. A full factorial design of four levels of cost and time and five levels of frequency has been used after elimination of the dominant choices.

Accounting for unobserved choice set

A Multinomial Logit model (MNL) has been developed using SP data to probabilistically predict the choice set of an individual in RP data. The choice sets included different combinations of bus/tempo, rickshaw, CNG/taxi and car. Socio-economic characteristics of the individual (e.g. age, gender, income, trip purpose, etc.) as well as the characteristics of the trip (e.g. duration, purpose, etc.) were found to have a significant impact on choice sets.

Correcting the Measurement Errors in the LOS data

Regression analysis has been done to develop a relationship among the true and measured values of the attributes. Home based work mode choice data of STP HHS (STP 2005) has been used to calibrate the equation. The stated values of the LOS (travel time) has been treated as true values and the travel time obtained from network analysis (Hasan 2007) has been treated as observed values. The estimated model has been applied to the rest of the RP data for correcting the measurement error.

Combination of the RP and SP data sets

The collected SP data and the RP data available from the STP house hold survey have been pooled together to jointly estimate the parameters of the combined model using Maximum Likelihood Technique. Market segmentation tests have been done to account for systematic taste heterogeneity in the population based on income, gender, age, employment, trip purpose etc. Market segmentation on the basis of occupation and purpose were found to be significant. Besides the market segmentation test, the observed taste heterogeneity of the population has also been accounted for by the addition of parameters to the dummy socio-economic variables in the combined model specification.

Estimation of Value of Time (VOT)

The estimated model parameters have been used to determine the average VOT of the respondents. These estimated aggregate values have been compared with the existing values available in literature for Dhaka City. It was found that, VOT values are more reasonable compared to the VOT obtained from previous studies on Dhaka city.

Several policy implications have been identified from the model estimation results. For example, the estimated values of the parameters of the combined model indicated that, in general the female travelers, the middle and old age travelers and the travelers with comparatively high monthly incomes are reluctant to use public transport modes. Therefore in order to increase the ridership of these groups of people, special incentives need to be provided in terms of female only compartments, low floor vehicles, suitable seating arrangements for the aged travelers, on-time and reliable services, etc. It has also been found that, public transport is already a popular mode of transport among the low income group of people; therefore, efforts can be made to retain ridership of this group of travelers by providing varied facilities in different compartments and charging variable fare depending on the compartment facility.

6.3 Research Contribution

The major research contributions of the study are summarized below:

(i) Methodologies have been proposed to address the RP data issues like missing choice set information of the respondents and the measurement errors in the level of service variables. The estimated parameters of the choice set generation model have been used to probabilistically predict the choice set of the respondents of the available RP data (STP, 2005). Calibrated correction factors have been applied to correct the network derived travel time (Hasan, 2007) of the RP data source. The choice set generation model has been integrated to develop a mode choice model with RP data. It may be noted that, these methodologies are transferable to other developing countries which very often face similar data issues.

(ii) An extensive SP survey has been designed and conducted along the proposed BRT and Metro Rail corridors of STP (2005) to include new alternatives BRT and Metro

Rail in the mode choice model. A MNL model has been calibrated using the collected SP data.

(iii) A comprehensive mode choice model has been developed in this study by combining RP and SP data sources. This is the first model of this kind for Dhaka. This model explicitly addressed the systematic taste heterogeneity of the people by the introduction of dummy variables like, gender dummy, age dummy, high and low income dummy, occupation dummy, employment dummy, trip purpose dummy, etc. It may be noted that this is a significant improvement from the previous models where it was possible only to capture the time and cost sensitivities.

From practical point of view, these models are likely to provide better ridership predictions and more robust cost-benefit analysis. This was evident from the VOT results calculated from the estimated parameters of the mode choice models where the values were much more reasonable compared to values obtained from previous choice models. The results also support the necessity of combining RP and SP data because of the fact that VOT is over estimated if it is calculated from SP data only i.e. people tend to over state their VOT when they are asked to state their choice which is not revealed in the real life.

6.4 Future Research

The study has dealt with the modal split part of the four step travel demand model. The following recommendations can be taken into consideration to increase the dependability of the developed mode choice model.

(i) In this study the parameters of the choice set generation model and that of the mode choice model have been estimated sequentially. However, it is possible to further enhance the model by estimating the parameters of these models simultaneously and thus to increase the fit and efficiency of the estimated parameters.

(ii) In the present study, only the measurement errors of the travel time has been addressed; similar approach can be applied to address the measurement errors of the travel cost of different modes in the presence of stated travel fare by the respondents.

(iii) More advanced model structures (nested logit, cross nested logit, mixed logit) models can be estimated to better forecast the VOT of the population (Daly et al., 2010, Hess and Axhausen, 2004). The effects of attitudes and perception on the VOT of the respondents can also be explored (Abou-Zeid et al., 2011).

(iv) The ridership of different modes can be predicted by population synthesis.

(v) Comprehensive demand model can be developed by incorporating trip generation, trip distribution and trip assignment steps of the four step model with the mode choice model to better forecast the ridership of the diverse existing and proposed new modes.

(vi) In this research, people's WTP has been calculated only for travel time, WTP for other attributes like comfort, cleanliness of the vehicles, air-condition in the vehicles can be calculated by the design of more robust SP survey. Also, computer based adaptive surveys can be designed to present personalized choice scenarios to respondents.

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APPENDICES

Appendix A

STP (2005) Survey Questionnaire

Dhaka Transport Co-ordination Board (DTCB)
(Ministry of Communications)
Strategic Transport Planning Study
Dhaka Urban Transport Project

Household Interview Survey
Section 1: Dwelling Unit

	Ward			Sample			
Sample No.							

Upazila ………………………Thana…….………………… TAZ

GPS Coordinates

Sheet…………….. of ……………….

Household address Tel. :…………………………………………

Respondent's name: …………………………………………………………

Street number: …………………………………………………………………

Street name: ……………………………………………………………………

House / Flat No.: ……………….. City/Area: ………………………..

Zone number

	Date		Month		Year	
Travel Date (Date/Month)					0	4
Date of interview (Date/Month)					0	4

Interviewer No.

Interviewer signature: ………………………………..

Reasons, if any, for being incomplete: ………………………………………..

Remarks:……………………………………...………………………………………

Coded by:……………………………………………………………….

Date coded (Date/Month)					0	4

Checked by:……………………………………………

Date checked (Date/Month)					0	4

Housing type

1 Permanent
2 Semi-permanent
3 Thatch house
4 Shop / hotel / hostel / mess
5 Apartment / Flat
6 Hotel
7 Non-permanent
8 Slum
9 Other, describe ……………………

Dhaka Transport Co-ordination Board (DTCB)
Ministry of Communications
Strategic Transport Planning Study
Dhaka Urban Transport Project

Household Interview Survey
Section 2: Household Members
(describe each household member on one line of this Section 2)

Sample No. | | | | | |

Sheet _________ of __________

Name of the Respondent : ___________________________________

Person No.	Relationship		Sex	Age		Education level		Licensed driver	Employed	Occupation			Industry/Sector		Name & Address of work site		Income		Student	Current education level		Name & Address of school / College / University	
	Rel.	code	M/F	years	code	level	code	Y/N	Y/N	Primary	Secondary	code	Sector	code		TAZ Code	Tk/month	code	Y/N	Level	code		TAZ Code
A	B		C	D		E		F	G	J			K		L		M		N	O		P	
M1																							
M2																							
M3																							
M4																							
M5																							
M6																							
M7																							
M8																							

Relationship
1 self
2 father
3 mother
4 child
5 grandparent
6 in law
7 aunt/uncle
8 son/daughter in law
9 nephew/niece
10 Other, describe
____

Age Code
1 1 - 9
2 10 - 14
3 15 - 19
4 20 - 29
5 30 - 49
6 50 - 59
7 60 +

Education Level (E)
1 Illiterate/none
2 Primary
3 SSC (High School) or equiv.
4 HSC or equivalent
5 Graduate
6 Post Graduate
7 Technical Education
8 Other, describe
____

Employed
1 full time
2 part time
3 casual
4 unemployed
5 other, describe
____

Occupation
1 Govt. Service
2 Private Service
3 Business
4 Unemployed
5 Student
6 Housewife
7 Agriculture / farming
8 Others (Specify)
____

Industry / Sector
1 Cultivator (farmer)
2 Livestock
3 Fishing / Forestry
4 Mining & Quarrying
5 Manufaturing Industry
6 Manufaturing Industry other than HH
7 Construction
8 Trade & Commerce
9 Transportation and Storage
10 Communication
11 Agriculturel labour
12 Others (Specify)

Income range code (Tk./month)
1 Less than 1,500
2 1,500 to 1,999
3 2,000 to 2,999
4 3,000 to 4,999
5 5,000 to 9,999
6 10,000 to 29,999
7 30,000 to 49,999
8 50,000 to 59,999
9 60,000 and above

Dhaka Transport Co-ordination Board (DTCB)
Ministry of Communications

Strategic Transport Planning Study

Dhaka Urban Transport Project

Household Interview Survey
Section 3: Household Vehicles

Sample No. | | | | | | |

Sheet _____ of _____

Vehicle type		Owned / Available	Make		Year Manufactured		Utilization			
	code	O/A		code	year	code	Domestic Transport		Hire / Lease	
A		B	C		D		E	F	G	H

Vehicle type
1 bicycle
2 Rickshaw / van
3 Motor-cycle
4 car
5 other (describe)

Make
1 Toyota
2 Mitsubishi
3 Nissan
4 Maruti
5 Mazda
6 Honda
7 Isuzu
8 Hyundai
9 Daewoo
10 Suzuki
11 Ford
12 B M W
13 Volvo
14 Proton Saga
15 Mercedez Benz

Manufactured year code
1 Less than 5 years
2 5 to 10 years
3 More than 10 years

Dhaka Transport Co-ordination Board (Ministry of Communications)

Strategic Transport Planning Study, Dhaka Urban Transport Project

Household Interview Survey: Section 4 - Trip Report

Sample No.

Person ID	Trip No.	Daily Trip						Purpose		Transport Mode Used				
		From			To					Mode Code*				
		Place	TAZ Code	Start Time	Place	TAZ Code	Arrival Time	From Code	To Code	Leg-1	Leg-2	Leg-3	Leg-4	Leg-5
M1														
M2														
M3														

Note : Daily trip will be based on yesterday's trip, yesterday should be a normal working day. TAZ Code will be given later on.

* Leg refers to the stages of journey to make the trip complete.

Purpose Code	Purpose Code
1 Home	7 Regious
2 Work	8 Medical
3 School	9 Self Employment
4 Market	10 Salesman/ Service Goods
5 Social	11 Other
6 Recreation	

Code Mode of Transport			
1 Walking	7 Microbus/ Jeep	13 School Van	19 Bus (BRTC)
2 Bicycle	8 Minibus/ Bus (private)	14 AC Bus	20 Bus (non-BRTC)
3 Motor Cycle	9 Staff Bus	15 Rickshaw	
4 CNG/Mishuk	10 School/ College Bus	16 Taxi	
5 Auto Tempo	11 Truck	17 Water	
6 Car	12 Auto (private)	18 Rail	

Dhaka Transport Co-ordination Board (DTCB)
Ministry of Communications
Strategic Transport Planning Study
Dhaka Urban Transport Project

Household Interview Survey
Section 5 : Attitudinal Questions

These questions are to be asked of the head of the household

1 Sample Number:

Male Female

2 Household Person No. (as given in Section 2)

3 Are daily trips made to a work site? (encircle yes/no) yes / no yes / no

A How many times per week do you travel to and from your work place (round trips / week)

B How far is your work place from your residence (0.0 km)?

C How much time (minutes) does it take you to travel from your resdience to place of work?

1 typcial
2 maximum
3 minimum

How many time per week do you travel for non-work purposes?

D **What is your usual mode of travel (for work and non-work)?**

1 Walking
2 Bicycle
3 Motor-cycle
4 CNG (Auto rickshaw) / mishuk
5 Auto Tempo / leguna
6 Human Haular / maxi
7 Car (driver)
8 Car (passenger)
9 Microbus / jeep
10 Minibus / bus (private)
11 Staff bus (public)
12 School / college bus
13 Truck
14 Train
15 Boat

4 How much total fare (Tk) do you pay to travel from your resdience to place of work by your usual travel mode?(Average /day)

A typcial Usual Mode
B maximum Usual Mode
C minimum Usual Mode

5 Do you use public transport bus as usual travel mode ? yes / no

6 What are your reason(s) for using usual travel mode for travel to your place of work? (Multiple answers, Mark √ inside.)

1 Cheaper (less expensive)
2 Reliable (more dependable)
3 Time saving (less travel time)
4 Convenience (less waiting time)
5 Safer (less chance of accident)
6 Comfort
7 There is no other available travel mode
8 Diffficult to get parking
9 Other reason (describe the reason)

7 What are the existing problems you face in your travel mode ?

1 No service connection to my place
2 Bus stop away from my residence
3 Bus stop away from my home
4 Bus travel takes too much time
5 Needs too many transfers
6 Schedule not reliable
7 Bus is uncomfortable
8 Bus stops not convenient
9 Bus is unsafe
10 Fear of Danger

8 If you are non user of Public Transport, will you shift to public transport services? Yes No
If yes, on what ground? Please Specify

time saved
seat assured
reliable and comfortable
air conditioned
express service
proper stop

9 Suppose the existing Bus services are improvise, how much more fare would you be willing to pay ?

A As if travel time is reduced by:

Travel time reduction (Minute)	Definitely will pay	Probably I may pay	will not pay
10			
20			
30			

B If your travel is made more comfortable?

Comfortable	Definitely will pay	Probably I may pay	will not pay
Seat assured			
Entry in bus assured			
Waiting time reduced			
air conditioned			

*****(Note : Under each willingness criteria, indicate amount coressponding to respective level.)**

C Not interested to use Public Transport Services. (Mark √ inside)

How do you consider traffic situation in dhaka?(Multiple selections)

a. Usual and normal delay
b. Congested and delays
c. Very congested and huge dealys
d. intolerable delays
e. dead lock and failed to attend commitment
f. any other (specify)

What are your suggestions for improving the situations?(multiple selections)

a. More road corridor and bypasses
b. Better traffic management
c. Arterials free from slow moving veh.
d. Constraction of more flyovers
e. Automatic signaling and control
f. Any other (specify)

How would you like to see Transport System of your city in next 20 years period?

a. A good Transport system based on road transport
b. Bus rapid transit
c. Light Railway
d. Elevated Express Way
e. Metro rail System
f. Parking problem olved
g. any other specify

Signature of Investigator

Appendix B

Initial Survey Questionnaire

B1: For bus users

উন্নত পরিবহন ব্যবস্থা সম্পর্কে আপনার মতামত

পুরকৌশল বিভাগ, বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়, ঢাকা

এই বাস স্টপের নাম ঃ ____________________

গন্তব্যের বাস স্টপের নাম ঃ ____________________

সময় ঃ ____________________

আপনি হয়ত শুনেছেন ঢাকায় উন্নত বাস সার্ভিস বা Metro Train সার্ভিস শুরু হতে পারে। বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়ের পুরকৌশল বিভাগ Japan International Co-operation Agency (JICA) এর সহায়তায় এর একটি নিরপেক্ষ মূল্যায়ন করছে। আপনি নীচের প্রশ্নগুলোর উত্তর দিলে উপকৃত হব।

প্রথমে আমরা আপনাকে আপনার এখনকার ভ্রমন নিয়ে কিছু প্রশ্ন করব।

১. আপনি কোথা থেকে রওনা হয়েছেন? (Main Origin)
ক. নিজের বাসা খ. বন্ধু/আত্মীয়ের বাসা গ. অফিস
ঘ. স্কুল ঙ. দোকান/বাজার/শপিং মল চ. অন্যান্য ____________________
যার ঠিকানা হলোঃ ____________________
(যেমন, আজিমুপর, ধানমন্ডি, উত্তরা ইত্যাদি)

২. আপনি কোথায় যাবেন? (Final Destination)
ক. নিজের বাসা খ. বন্ধু/আত্মীয়ের বাসা গ. অফিস
ঘ. স্কুল ঙ. দোকান/বাজার/শপিং মল চ. অন্যান্য ____________________
যার ঠিকানা হলোঃ
(যেমন, আজিমুপর, শ্যামলী, উত্তরা ইত্যাদি)

৩. এই রুটে আপনি কত ঘন ঘন যাতায়াত করেন? (সম্পূর্ণ রুট অথবা এর কম পক্ষে ৫ কিমি)
ক. প্রতিদিন খ. সাপ্তাহিক ছুটির দিন ছাড়া প্রতিদিন গ. সপ্তাহে ১-৪ দিন
ঘ. মাসে ২/৩ দিন ঙ. মাসে ১ দিনের চাইতে কম চ. আগে কখনো যাতায়াত করিনি

৪. আপনাকে এই যাত্রায় (one way) কত টাকা বাস ভাড়া দিতে হবে বলে মনে করছেন? ____________________

৫. আপনি আজকে কতক্ষণ ধরে বাসের জন্য অপেক্ষা করছেন? ____________________ মিনিট
৫ মিনিটের কম হলে, আপনাকে সাধারণত কতক্ষণ বাসের জন্য অপেক্ষা করতে হয়? ____________________ মিনিট
৫ মিনিটের কম হলে, ৭ নং প্রশ্নে চলে যান।

৬. বাসের জন্য অপেক্ষার সময় ৫ মিনিটে কমিয়ে আনতে আপনি অতিরিক্ত কত ভাড়া দিতে রাজী আছেন? ______ টাকা

৭. বাসে ওঠার পরে, আপনার গন্তব্যের বাস স্টপে পৌছতে কত সময় লাগবে বলে মনে করেন? _____ ঘণ্টা _____ মিনিট
১৫ মিনিটের কম হলে ৯ নং প্রশ্নে চলে যান।
উন্নত বাস সার্ভিস বা মেট্রো ট্রেন চালু হলে এই সময় কমিয়ে আনা সম্ভব।

৮ক. ১৫-৩০ মিনিট হলে
উন্নত সার্ভিসে যাত্রার সময় ৫ মিনিট কম হলে আপনি অতিরিক্ত কত ভাড়া দিতে রাজী আছেন? __________ টাকা
উন্নত সার্ভিসে যাত্রার সময় ১০ মিনিট কম হলে আপনি অতিরিক্ত কত ভাড়া দিতে রাজী আছেন? __________ টাকা

৮খ. ৩০-৪৫ মিনিট হলে
উন্নত সার্ভিসে যাত্রার সময় ৫ মিনিট কম হলে আপনি অতিরিক্ত কত ভাড়া দিতে রাজী আছেন? __________ টাকা
উন্নত সার্ভিসে যাত্রার সময় ১০ মিনিট কম হলে আপনি অতিরিক্ত কত ভাড়া দিতে রাজী আছেন? __________ টাকা
উন্নত সার্ভিসে যাত্রার সময় ১৫ মিনিট কম হলে আপনি অতিরিক্ত কত ভাড়া দিতে রাজী আছেন? __________ টাকা

৮গ. ৪৫ মিনিটের বেশী হলে
উন্নত সার্ভিসে যাত্রার সময় ৫ মিনিট কম হলে আপনি অতিরিক্ত কত ভাড়া দিতে রাজী আছেন? টাকা
উন্নত সার্ভিসে যাত্রার সময় ১০ মিনিট কম হলে আপনি অতিরিক্ত কত ভাড়া দিতে রাজী আছেন? __________ টাকা
উন্নত সার্ভিসে যাত্রার সময় ১৫ মিনিট কম হলে আপনি অতিরিক্ত কত ভাড়া দিতে রাজী আছেন? __________ টাকা
উন্নত সার্ভিসে যাত্রার সময় ২০ মিনিট কম হলে আপনি অতিরিক্ত কত ভাড়া দিতে রাজী আছেন? __________ টাকা

৯. গন্তব্যস্থানে পৌছানোর জন্য আজকে কি আপনার বাস পরিবর্তনের দরকার হবে?
(ক) হ্যাঁ (খ) না
উত্তর না হলে ১২ নং প্রশ্নে চলে যান।

১০. উত্তর হ্যাঁ হলে, এই যাত্রায় কতবার বাস পরিবর্তনের দরকার হবে? ____________ বার

১১. উন্নত সার্ভিসে বাস/ট্রেন পরিবর্তনের দরকার না হলেম আপনি অতিরিক্ত কত ভাড়া দিতে রাজি আছেন? _______ টাকা

১২. আপনি আজকে নিম্নের কোন ধরণের বাস ব্যবহার করবেন?
(ক) এসি বাস (খ) নন-এসি বাস (গ) যে ধরনের বাস আগে আসে

১৩. আপনাকে এখন উন্নত সার্ভিসের কতগুলো বৈশিষ্ট্যের কথা বলবো। আপনি বলবেন এর মধ্যে কোনগুলো আপনি গুরুত্বপূর্ণ বলে মনে করেন?

আপনি কি মনে করেন	গুরুত্বপূর্ণ	গুরুত্বপূর্ণ নয়
উন্নত মানের বাস স্টপ (এতে কিন্তু ভাড়া বাড়বে)		
আরও ঘন ঘন বাস চালু করা (এতে কিন্তু ভাড়া বাড়বে)		
বাস সুনির্দিষ্ট সময়সূচী মেনে চলবে (এতে কিন্তু ভাড়া বাড়বে)		
বাসের জন্য আলাদা লেন চালু করা (এতে কিন্তু ভাড়া বাড়বে)		
পরিষ্কার এবং আরামদায়ক বাস চালু করা (এতে কিন্তু ভাড়া বাড়বে)		
যাত্রার সময় কমানো (এতে কিন্তু ভাড়া বাড়বে)		
সরাসরি গন্তব্যে পৌছানো যায় (বাস পরিবর্তন ছাড়া) এমন সার্ভিস চালু করা (এতে কিন্তু ভাড়া বাড়বে)		
মেট্রো ট্রেন সার্ভিস চালু করা (এতে কিন্তু ভাড়া অনেক বাড়বে)		
পাতাল রেল বা মাটির নীচের ট্রেন চালু করা (এতে কিন্তু ভাড়া অনেক বাড়বে)		
ভাড়া না বাড়ানো (সার্ভিসের কোন পরিবর্তন হবে না)		

১৩. এই যাত্রার জন্য আপনার কি আর কোন যানবাহন ব্যবহারের সুযোগ ছিল? (একাধিক উত্তর হতে পারে)
(ক) নিজের গাড়ি (খ) ট্যাক্সি (গ) সিএনজি (ঘ) রিক্সা (ঙ) টেম্পু (চ) জানা নেই

১৪. আপনি আজকের যাত্রার জন্য বাস ব্যবহার করছেন কেন? (একাধিক উত্তর হতে পারে)
(ক) এ ছাড়া আর কোন সুযোগ নেই (খ) অন্য যানবাহানের তুলনায় ভাড়া কম (গ) অন্য যানবাহনের চেয়ে দ্রুতগামী
(ঘ) সরাসরি গন্তব্যে পৌছায় (ঙ) অন্য যানবাহনের চেয়ে নিরাপদ (চ) অন্যান্য _____________

আমরা এখন আপনার সম্পর্কে কিছু জানতে চাই যেন আমরা ভালভাবে প্রতিবেদন তৈরী করতে পারি।

১৫. আপনার বয়স কত? _____________ বছর

১৬. আপনি কি করেন?
ক. ছাত্র খ. নিয়মিত (ফুলটাইম) চাকরী গ. খন্ডকালীন (পার্ট টাইম) চাকরী ঘ. গৃহিনী
ঙ. অবসরপ্রাপ্ত চ. ব্যবসায়ী ছ. বেকার জ. অন্যান্য

১৭. আপনি কতদূর লেখাপড়া করেছেন?
ক. মাধ্যমিকের কম (এসএসসি) খ. মাধ্যমিক (এসএসসি) গ. উচ্চ মাধ্যমিক (এইচএসসি)
ঘ. বিএসসি/বিএ/বিকম ঙ. উচ্চতর চ. অন্যান্য

১৮. আপনার পরিবারের মাসিক আয় কত?
ক. ৫ হাজার টাকার কম খ. ৫-১০ হাজার টাকা গ. ১০-২০ হাজার টাকা
ঘ. ২০-৩০ হাজার টাকা ঙ. ৩০ হাজার টাকার বেশী

১৯. ক. আপনি পুরুষ খ. আপনি মহিলা

আপনাকে প্রশ্নগুলোর উত্তর দেয়ার জন্য অসংখ্য ধন্যবাদ। আপনার ভ্রমন আনন্দময় হোক।

B2: For non-bus users – car (non-work trip)

Questionnaire on User Opinion on Improved Public Transport

Department of Civil Engineering
Bangladesh University of Engineering and Technology (BUET)

Non-Work trip

ID:

The Department of Civil Engineering at BUET in assistance with Japan International Cooperation Agency (JICA) is doing an independent evaluation of improved public transport options for Dhaka city. We would like to ask you some questions to know your opinion regarding this. Please take a moment to answer our questions.

First, we would like to ask you some questions about your **non-work** related trip (e.g. shopping, visiting friends/relatives etc.). Please think about the last such trip that you have made **by car**.

1. From where did you start the trip?
   a. Home   b. Friend/ Relative's home   d. School
   e. Store/ Shopping Mall   f. Other ___________ (please mention)
   The address of which is ______________________________
   (e.g. Azimpur, Dhanmondi, Shyamoli etc.)

2. Where did your trip end?
   a. Home   b. Friend/ Relative's home   d. School
   e. Store/ Shopping Mall   f. Other ___________ (please mention)
   The address of which is ______________________________
   (e.g. Azimpur, Dhanmondi, Shyamoli etc.)

3. When did you start? _______________

4. Was there any bus service (with reasonable walking distance and transfers) available for the trip?
   a. Yes   b. No   c. Don't Know

5. Why do you choose car for the trip? (you can choose multiple answers)
   a. Have no other options   b. Cheaper than other options   c. Faster than other options
   d. Is more flexible (i.e. I can leave/return when I want, can do other tasks on my way etc.)
   e. Safer than other options   f. Other ______________________________

6. If there is an improved public transport service in this route, are you willing to switch?
   a. Yes   b. No   c. Maybe

7. Now we are going to mention some features/attributes of improved public transport service. Which of the these do you think are important for you to switch to public transport for the trip?

Better bus stops (fare will be higher than current bus service)	Important	Unimportant
More frequent service (fare will be higher than current bus service)	Important	Unimportant
More reliable and on-time service (fare will be higher than current bus service)	Important	Unimportant
Separate bus lanes (fare will be higher than current bus service)	Important	Unimportant
Cleaner and more comfortable buses (fare will be higher than current service)	Important	Unimportant
Reduced travel times (fare will be higher than current bus service)	Important	Unimportant
Direct service to destination (fare will be higher than current bus service)	Important	Unimportant
Rail based service (fare will be **much** higher than current bus service)	Important	Unimportant
Rail based underground metro service (fare will be **much** higher than current bus service)	Important	Unimportant

8 Approximately how long did it take you to reach your destination? _______________

If less than 15 mins, go to question 10.
If 15-30 mins,
9a. If there is an improved service that **reduces** 5 min travel time, what **fare** are you willing to pay? Tk__
   If there is an improved service that **reduces** 10 min travel time, what **fare** are you willing to pay? Tk__

If 31 mins- 45mins,
9b. If there is an improved service that **reduces** 5 min travel time, what **fare** are you willing to pay? Tk__
   If there is an improved service that **reduces** 10 min travel time, what **fare** are you willing to pay? Tk__
   If there is an improved service that **reduces** 15 min travel time, what **fare** are you willing to pay? Tk__

If 46mins - 60 mins,
9c. If there is an improved service that **reduces** 5 min travel time, what **fare** are you willing to pay? Tk__
   If there is an improved service that **reduces** 10 min travel time, what **fare** are you willing to pay? Tk__
   If there is an improved service that **reduces** 15 min travel time, what **fare** are you willing to pay? Tk__
   If there is an improved service that **reduces** 20 min travel time, what **fare** are you willing to pay? Tk__
   If there is an improved service that **reduces** 30 min travel time, what **fare** are you willing to pay? Tk__

If more than 60 mins,
9d. If there is an improved service that **reduces** 5 min travel time, what **fare** are you willing to pay? Tk__
   If there is an improved service that **reduces** 10 min travel time, what **fare** are you willing to pay? Tk__
   If there is an improved service that **reduces** 15 min travel time, what **fare** are you willing to pay? Tk__
   If there is an improved service that **reduces** 20 min travel time, what **fare** are you willing to pay? Tk__

If there is an improved service that **reduces** 30 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 40 min travel time, what **fare** are you willing to pay? Tk__

10. Do you have a driver?
a. Yes b. No

11. The car you use is Your
a. Personal Car b. Family owned car c. Office/company owned car

12. What is the approximate cost incurred for your car trip per month (e.g. fuel, garage space, salary of the driver, regular maintenance, parking)? Tk___________________

Now we would like to ask some questions about you and your family so that we can better understand your responses.

13.How old are you? __________years

14. What is your employment status?
a. Student b. Full-time employed c. Part-time employed d. Housewife
e. Retired f. Self employed/Businessman g. Unemployed h. Other _______________

15. What is your highest educational degree?
a. Less than SSC b. SSC c. HSC d. Graduate (BSc/BA/BCom) e. Postgraduate (MSc/MA/MCom/PhD) f. Technical Education g.Other___________

16. What is the range of your monthly household income ?
a. Less than 5000 b. 5,000 to 10,000
c. 10,000 to 20,000 d. 20,000 to 30,000
e. 30,000 to 50,000 f. More than 50,000

17. You are Male/Female.

18. Are you interested to participate similar kind of surveys in the future?
a. Yes b.No

Thank you very much for you inputs. Have a safe trip !

B3: For non-bus users – car users (work trip)

Questionnaire on User Opinion on Improved Public Transport
Department of Civil Engineering
Bangladesh University of Engineering and Technology (BUET)

Work Trip

ID:

The Department of Civil Engineering at BUET in assistance with Japan International Cooperation Agency (JICA) is doing an independent evaluation of improved public transport options for Dhaka city. We would like to ask you some questions to know your opinion regarding this. Please take a moment to answer our questions.

First, we would like to ask you some questions about your **home to work** trip.

1. The address of your home is ____________________________
   (e.g. Azimpur, Dhanmondi Rd # 5, Uttara Sector #1 etc.)

2. The address of your office is ____________________________
   (e.g. Azimpur, Dhanmondi Rd # 5, Uttara Sector #1 etc.)

3. Do you usually go to office directly from your home?
a. Yes b. No

4. If not, how many intermediate stops do you make and for what reasons?

Number_________
Stop 1. a. drop children to school b. drop another family member to work c. pick co-worker
d. Other_________________
Stop 2. a. drop children to school b. drop another family member to work c. pick co-worker
d. Other_________________
Stop 3. a. drop children to school b. drop another family member to work c. pick co-worker
d. Other_________________

Now, please think about your home to work trip yesterday (or the last weekday).

5. Did you have any flexibility in your arrival time?
a. Yes +/- 30mins or more b. No

6. When did you start from your home in the morning? _______________

7. Was there any bus service (with reasonable walking distance and transfers) available for the trip?
a. Yes b. No c. Don't know

8. Why do you choose car for your home to office trip? (you can choose multiple answers)
   a. Have no other options b. Cheaper than other options c. Faster than other options
   d. Is more flexible (i.e. I can leave/return when I want, can do other tasks on my way etc.)
   e. Safer than other options f. Other _______________________________

9. If there is an improved public transport service in this route, are you willing to switch?
a. Yes b. No c. Maybe

10. Now we are going to mention some features/attributes of improved public transport service. Which of the these do you think are important for you to switch to public transport?

Better bus stops (fare will be higher than current bus service)	Important	Unimportant
More frequent service (fare will be higher than current bus service)	Important	Unimportant
More reliable and on-time service (fare will be higher than current bus service)	Important	Unimportant
Separate bus lanes (fare will be higher than current bus service)	Important	Unimportant
Cleaner and more comfortable buses (fare will be higher than current service)	Important	Unimportant
Reduced travel times (fare will be higher than current bus service)	Important	Unimportant
Direct service to destination (fare will be higher than current bus service)	Important	Unimportant
Rail based service (fare will be **much** higher than current bus service)	Important	Unimportant
Rail based underground metro service (fare will be **much** higher than current bus service)	Important	Unimportant

11. Approximately how long did it take you to reach office from home? _______________

12. If less than 15 mins, go to 13.
If 15-30 mins,
12a. If there is an improved service that **reduces** 5 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 10 min travel time, what **fare** are you willing to pay? Tk__

If 31 mins- 45mins,
12b. If there is an improved service that **reduces** 5 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 10 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 15 min travel time, what **fare** are you willing to pay? Tk__

If 46mins - 60 mins,
12c. If there is an improved service that **reduces** 5 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 10 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 15 min travel time, what **fare** are you willing to pay? Tk__

If there is an improved service that **reduces** 20 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 30 min travel time, what **fare** are you willing to pay? Tk__

If more than 60 mins,
12d. If there is an improved service that **reduces** 5 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 10 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 15 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 20 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 30 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 40 min travel time, what **fare** are you willing to pay? Tk__

13. Do you have a driver?
a. Yes b. No

14. The car U use is Your
a. Personal Car b. Family owned car c. Office/company owned car

15. What is the approximate cost incurred for your car trip per month (e.g. fuel, garage space, salary of the driver, regular maintenance, parking)? Tk___________ Don't Know

16. Suppose there is a free car pool system in your office, how much cost reduction do you expect, if you dc not use car for your office trip? Tk______

Now we would like to ask some questions about you and your family so that we can better understand your responses.

17.How old are you? __________years

18. What is your employment status?
a. Student b. Full-time employed c. Part-time employed d. Housewife
e. Retired f. Self employed/Businessman g. Unemployed h. Other _______________

19. What is your highest educational degree?
a. Less than SSC b. SSC c. HSC d. Graduate (BSc/BA/BCom) e. Postgraduate (MSc/MA/MCom/PhD) f. Technical Education g.Other___________

20. What is the number of your family members? _________________

21. How of them are below 16 years old? _______________

22. What is the range of your monthly household income ?
b. Less than 5000 b. 5,000 to 10,000
d. 10,000 to 20,000 d. 20,000 to 30,000
f. 30,000 to 50,000 f. More than 50,000

23. You are Male/Female.

24. Are you interested to participate similar kind of surveys in the future?
a. Yes b.No

Thank you very much for you inputs. Have a safe trip !

B4: For non-bus users - CNG/rickshaw/taxi (non-work trip)

Questionnaire on User Opinion on Improved Public Transport

Department of Civil Engineering
Bangladesh University of Engineering and Technology (BUET)

Non-Work trip
CNG/Rickshaw/Taxi

ID:

The Department of Civil Engineering at BUET in assistance with Japan International Cooperation Agency (JICA) is doing an independent evaluation of improved public transport options for Dhaka city. We would like to ask you some questions to know your opinion regarding this. Please take a moment to answer our questions.

First, we would like to ask you some questions about your **non-work** related trip (e.g. shopping, visiting friends/relatives etc.). Please think about the last such trip that you have made **by CNG/Rickshaw/Taxi**.

1. From where did you start the trip?
   a. Home b. Friend/ Relative's home d. School
   e. Store/ Shopping Mall f. Other ___________ (please mention)
   The address of which is ____________________________
   (e.g. Azimpur, Dhanmondi, Shyamoli etc.)

2. Where did your trip end?
   a. Home b. Friend/ Relative's home d. School
   e. Store/ Shopping Mall f. Other ___________ (please mention)
   The address of which is ____________________________
   (e.g. Azimpur, Dhanmondi, Shyamoli etc.)

3. When did you start? _______________

4. Was there any bus service (with reasonable walking distance and transfers) available for the trip?
a. Yes b. No c. Don't Know

5. Why do you choose CNG/Rickshaw/Taxi for the trip? (you can choose multiple answers)
   a. Have no other options b. Cheaper than other options c. Faster than other options
   d. Is more flexible (i.e. I can leave/return when I want, can do other tasks on my way etc.)
   e. Safer than other options f. Other ______________________________

6. If there is an improved public transport service in this route, are you willing to switch?
a. Yes b. No c. Maybe

7. Now we are going to mention some features/attributes of improved public transport service. Which of the these do you think are important for you to switch to public transport for the trip?

Better bus stops (fare will be higher than current bus service)	Important	Unimportant
More frequent service (fare will be higher than current bus service)	Important	Unimportant
More reliable and on-time service (fare will be higher than current bus service)	Important	Unimportant
Separate bus lanes (fare will be higher than current bus service)	Important	Unimportant
Cleaner and more comfortable buses (fare will be higher than current service)	Important	Unimportant
Reduced travel times (fare will be higher than current bus service)	Important	Unimportant
Direct service to destination (fare will be higher than current bus service)	Important	Unimportant
Rail based service (fare will be **much** higher than current bus service)	Important	Unimportant
Rail based underground metro service (fare will be **much** higher than current bus service)	Important	Unimportant

8. Approximatley how much fare did you pay for your trip? Tk________
9. Approximately how long did it take you to reach your destination? _______________

If less than 15 mins, go to question 10.
If 15-30 mins,

10a. If there is an improved service that **reduces** 5 min travel time, how much extra are you willing to pay? Tk__
If there is an improved service that **reduces** 10 min travel time, how much extra are you willing to pay? Tk__
If 31 mins- 45mins,
10b. If there is an improved service that **reduces** 5 min travel time, how much extra are you willing to pay? Tk__
If there is an improved service that **reduces** 10 min travel time, how much extra are you willing to pay? Tk__
If there is an improved service that **reduces** 15 min travel time, how much extra are you willing to pay? Tk__

If 46mins - 60 mins,
10c. If there is an improved service that **reduces** 5 min travel time, how much extra are you willing to pay? Tk__
If there is an improved service that **reduces** 10 min travel time, how much extra are you willing to pay? Tk__
If there is an improved service that **reduces** 15 min travel time, how much extra are you willing to pay? Tk__
If there is an improved service that **reduces** 20 min travel time, how much extra are you willing to pay? Tk__
If there is an improved service that **reduces** 30 min travel time, how much extra are you willing to pay? Tk__

If more than 60 mins,

10d. If there is an improved service that **reduces** 5 min travel time, how much extra are you willing to pay? Tk__

If there is an improved service that **reduces** 10 min travel time, how much extra are you willing to pay? Tk__

If there is an improved service that **reduces** 15 min travel time, how much extra are you willing to pay? Tk__

If there is an improved service that **reduces** 20 min travel time, how much extra are you willing to pay? Tk__

If there is an improved service that **reduces** 30 min travel time, how much extra are you willing to pay? Tk__

If there is an improved service that **reduces** 40 min travel time, how much extra are you willing to pay? Tk

11. Do you have access to a car?

a. Yes b. No

12.If yes, the car you have access to is your

a. Personal Car b. Family owned car c. Office/company owned car

Now we would like to ask some questions about you and your family so that we can better understand your responses.

13.How old are you? __________years

14. What is your employment status?

a. Student b. Full-time employed c. Part-time employed d. Housewife

e. Retired f. Self employed/Businessman g. Unemployed h. Other _______________

15. What is your highest educational degree?

a. Less than SSC b. SSC c. HSC d. Graduate (BSc/BA/BCom) e. Postgraduate (MSc/MA/MCom/PhD) f. Technical Education g.Other

16. What is the range of your monthly household income ?

c. Less than 5000 b. 5,000 to 10,000

e. 10,000 to 20,000 d. 20,000 to 30,000

g. 30,000 to 50,000 f. More than 50,000

17. You are Male/Female.

18. Are you interested to participate similar kind of surveys in the future?

a. Yes b.No

19. If yes, please provide your phone number:______________________

Thank you very much for you inputs. Have a safe trip !

B5: For non-bus users – CNG/rickshaw/taxi (work trip)

If 46mins - 60 mins,

13c. If there is an improved service that **reduces** 5 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 10 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 15 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 20 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 30 min travel time, what **fare** are you willing to pay? Tk__

If more than 60 mins,

13d. If there is an improved service that **reduces** 5 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 10 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 15 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 20 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 30 min travel time, what **fare** are you willing to pay? Tk__
If there is an improved service that **reduces** 40 min travel time, what **fare** are you willing to pay? Tk__

14. Do you have access to a car?
a. Yes b. No

15.If yes, the car you have access to is your
a. Personal Car b. Family owned car c. Office/company owned car

Now we would like to ask some questions about you and your family so that we can better understand your responses.

16.How old are you? __________years

17. What is your employment status?
a. Student b. Full-time employed c. Part-time employed d. Housewife
e. Retired f. Self employed/Businessman g. Unemployed h. Other _______________

18. What is your highest educational degree?
a. Less than SSC b. SSC c. HSC d. Graduate (BSc/BA/BCom) e. Postgraduate (MSc/MA/MCom/PhD) f. Technical Education g.Other___________

19. What is the range of your monthly household income ?
d. Less than 5000 b. 5,000 to 10,000
f. 10,000 to 20,000 d. 20,000 to 30,000
h. 30,000 to 50,000 f. More than 50,000

20. You are Male/Female.

21. Are you interested to participate similar kind of surveys in the future?
a. Yes b.No

22. If yes, please provide your phone number:______________________

Thank you very much for you inputs. Have a safe trip !

Appendix C

SP Survey Sample Questionnaire

C1: For bus/tempo users

METRO
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উন্নত পরিবহন ব্যবস্থা সম্পর্কে আপনার মতামত

পুরকৌশল বিভাগ, বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়, ঢাকা

বাস স্টপের নাম ঃ ______________________________

সময় ঃ ______________________________

AC	non-AC	BOTH

আপনি হয়তো শুনেছেন ঢাকায় উন্নত বাস সার্ভিস বা Metro Train সার্ভিস শুরু হতে পারে। বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়ের পুরকৌশল বিভাগ Japan International Co-operation Agency (JICA) এর সহায়তায় এর একটি নিরপেক্ষ মূল্যায়ন করছে। আপনি নীচের প্রশ্নগুলোর উত্তর দিলে উপকৃত হব।

প্রথমে আমরা আপনাকে আপনার এখনকার ভ্রমন নিয়ে কিছু প্রশ্ন করব।

১। আপনি কোথা থেকে রওনা হয়েছেন? (Main Origin)

ক. নিজের বাসা খ. বন্ধু/আত্মীয়ের বাসা গ. অফিস
ঘ. স্কুল/কলেজ/বিশ্ববিদ্যালয় ঙ. দোকান/বাজার/শপিং মল চ. অন্যান্য __________

যার ঠিকানা হলোঃ ____

(যেমন, আজিমুপর, ধানমন্ডি, উত্তরা ইত্যাদি)

২। আপনি কোথায় যাবেন? (Final Destination)

ক. নিজের বাসা খ. বন্ধু/আত্মীয়ের বাসা গ. অফিস
ঘ. স্কুল/কলেজ/বিশ্ববিদ্যালয় ঙ. দোকান/বাজার/শপিং মল চ. অন্যান্য __________

যার ঠিকানা হলোঃ ____

(যেমন, আজিমুপর, শ্যামলী, উত্তরা ইত্যাদি)

৩। বাসে ওঠার পরে, আপনার গন্তব্যের **বাস স্টপে** পৌছাতে কত সময় লাগবে বলে মনে করেন? _____ ঘণ্টা _____ মিনিট

৪। আপনি আজকে কতক্ষণ ধরে বাসের জন্য অপেক্ষা করছেন? __________________ মিনিট

৫। আপনাকে এই যাত্রায় (one way) কত টাকা **বাস** ভাড়া দিতে হবে বলে মনে করছেন? __________________

৬। আপনি আজকে নিম্নের কোন ধরণের বাস ব্যবহার করবেন?

(ক) এসি বাস (খ) নন-এসি বাস (গ) যে ধরনের বাস আগে আসে

৭। এই যাত্রার জন্য আপনার কি আর কোন যানবাহন ব্যবহারের সুযোগ ছিল? (একাধিক উত্তর হতে পারে)

(ক) নিজের গাড়ি (খ) ট্যাক্সি (গ) সিএনজি (ঘ) রিক্সা (ঙ) টেম্পু (চ) জানা নেই

৮। আপনি আজকের যাত্রার জন্য বাস ব্যবহার করছেন কেন? (একাধিক উত্তর হতে পারে)

(ক) এ ছাড়া আর কোন সুযোগ নেই (খ) অন্য যানবাহানের তুলনায় ভাড়া কম
(গ) অন্য যানবাহনের চেয়ে দ্রুতগামী (ঘ) সরাসরি গন্তব্যে পৌছায় (ঙ) অন্য যানবাহনের চেয়ে নিরাপদ
(চ) অন্যান্য ____________

৯। এই রুটে আপনি কত ঘন ঘন যাতায়াত করেন? (সম্পূর্ণ রুট অথবা এর কম পক্ষে ৫ কিমি)

ক. প্রতিদিন খ. সাপ্তাহিক ছুটির দিন ছাড়া প্রতিদিন গ. সপ্তাহে ১-৪ দিন
ঘ. মাসে ২/৩ দিন ঙ. মাসে ১ দিনের চাইতে কম চ. আগে কখনো যাতায়াত করিনি

আপনি হয়তো ঢাকার জন্য প্রস্তাবিত বিভিন্ন ধরনের উন্নত পরিবহন ব্যবস্থা সম্পর্কে শুনেছেন। প্রস্তাবিত ব্যবস্থাগুলোর মধ্যে মেট্রো ট্রেন এবং BRT ব্যবস্থা অন্যতম। আমরা এখন এই দুইটির বিষয়ে আপনার মতামত সম্পর্কে জানতে চাইব।

মেট্রো ট্রেন ব্যবস্থায় রাস্তা দিয়ে, রাস্তার নীচ দিয়ে বা ফ্লাইওভারের মত ব্রিজ দিয়ে ট্রেন চলাচলের ব্যবস্থা করা হবে এবং এর ফলে যাতায়াতের সময় কমে যেতে পারে। এই ট্রেন সার্ভিসে ঘন ঘন ট্রেনের ব্যবস্থা থাকবে এবং সেগুলো নির্দিষ্ট সময়সূচী মেনে চলবে। স্টেশনগুলোকে পরিষ্কার এবং আরামদায়ক করে তৈরী করা হবে এবং স্টেশনে ট্রেনের সময়সূচী প্রদর্শনেরও ব্যবস্থা থাকবে। কিন্তু এই সার্ভিসের ভাড়া প্রচলিত বাস সার্ভিস এবং BRT-র তুলনায় বেশী হতে পারে।

এখন মনে করেন আপনার আজকের এই যাত্রার জন্য প্রচলিত বাস সার্ভিসের পাশাপাশি মেট্রো ট্রেন ব্যবহারের সুযোগ আছে।

আমি এখন আপনাকে মেট্রো ট্রেন ব্যবস্থার বর্ণনা দিচ্ছি।

মেট্রোতে ট্রেনগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং ট্রেনগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি _________ একটি ট্রেন পাওয়া যাবে অর্থাৎ আপনাকে ট্রেনের জন্য __________ পর্যন্ত অপেক্ষা করতে হতে পারে , ট্রেন ছাড়ার পরে __________ সময় কম লাগবে এবং ভাড়া ____________ বেশী লাগবে।

	Metro:(15-30 min)	Metro:(31-45 min)	Metro:(46-60min)	Metro:(61-90min)	Metro:(>90min)
Waiting	20	20	20	20	20
time	- 10	- 20	- 25	- 30	- 50
cost	+ 10	+ 12	+ 15	+20	+20

সেক্ষেত্রে আপনি কোন সার্ভিসটি ব্যবহার করবেন উল্লেখ করুন। | Bus | Metro |

যদি মেট্রো বলে থাকেন, আপনি কোনটি পছন্দ করবেন? | মাটির নীচে | Flyover/bridge দিয়ে | মাটির বরাবর |

এখন মনে করেন আপনার আজকের যাত্রার জন্য প্রচলিত বাস সার্ভিস/ মেট্রোট্রেনের পাশাপাশি BRT ব্যবহারের সুযোগ আছে।

BRT একটি নতুন ধরনের পরিবহন ব্যবস্থা যা বিগত কয়েক বছরে আমেরিকা, জার্মানী, অস্ট্রেলিয়া এবং ভারতসহ বিশ্বের বিভিন্ন বড় বড় শহর গুলোতে চালু করা হয়েছে। এটি আমাদের দেশে বর্তমানে প্রচলিত বাস পরিবহন ব্যবস্থা থেকে সম্পূর্ণ ভিন্ন। এই উন্নত বাস পরিবহন ব্যবস্থায় এক/একাধিক বগি বিশিষ্ট বড় বাস চালু করা হবে। এই বাসগুলো রাস্তার এক পাশ দিয়ে চলবে (যেখানে অন্য কোন যানবাহন চলবে না) এবং এর ফলে যাতায়াতের সময় অনেক কমে যাবে। এই বাসগুলো সুনির্দিষ্ট সময়ে বাস স্টপ থেকে ছেড়ে যাবে এবং দুইটি বাস ছাড়ার মাঝের সময়ও অনেক কমে যাবে (অর্থাৎ ঘন ঘন বাস চালু করা হবে)। এই ব্যবস্থায় বাস স্টপগুলি পরিষ্কার এবং আরামদায়ক করে তৈরী করা হবে এবং বাস স্টপে বাসের সময়সূচী প্রদর্শনেরও ব্যবস্থা করা হবে। কিন্তু এই নতুন সার্ভিসের ভাড়া প্রচলিত বাস সার্ভিসের চেয়ে বেশী হবে।

আমি এখন আপনাকে BRT ব্যবস্থার বর্ণনা দিচ্ছি।

BRT তে বাসগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং বাসগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি ______ একটি বাস পাওয়া যাবে,অর্থাৎ আপনাকে বাসের জন্য ___________ পর্যন্ত অপেক্ষা করতে হতে পারে , বাস ছাড়ার পরে ______ সময় কম লাগবে এবং ভাড়া ______ বেশী লাগবে।

	BRT:(15-30 min)	BRT:(31-45 min)	BRT:(46-60min)	BRT:(61-90min)	BRT:(>90min)
Waiting	10	10	10	10	10
time	- 5	- 15	- 20	- 25	- 30
cost	+ 3	+ 5	+ 7	+ 7	+ 7

মেট্রোতে ট্রেনগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং ট্রেনগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি _________ একটি ট্রেন পাওয়া যাবে অর্থাৎ আপনাকে ট্রেনের জন্য __________ পর্যন্ত অপেক্ষা করতে হতে পারে , ট্রেন ছাড়ার পরে __________ সময় কম লাগবে এবং ভাড়া ____________ বেশী লাগবে।

অথবা

প্রচলিত বাস সার্ভিসে সব কিছু এখনকার মতই থাকবে।

সেক্ষেত্রে আপনি কোন সার্ভিসটি ব্যবহার করবেন উল্লেখ করুন। | Bus | METRO | BRT |

এক্ষেত্রে যানবাহন পছন্দ করার সময় এর কোন বৈশিষ্ট্যগুলো আপনার কাছে বেশি গুরুত্বপূর্ণ বলে মনে হয়েছে? (একাধিক উত্তর হতে পারে)

ক. সময় **খ. ভাড়া** **গ. অপেক্ষার সময়** **গ. অন্যান্য ________________**

আমরা এখন আপনার সম্পর্কে কিছু জানতে চাই যেন আমরা ভালভাবে প্রতিবেদন তৈরী করতে পারি।

১০। আপনার বয়স কত? ক. <১৮ খ.১৮-২৫ গ. ২৫-৪০ ঘ. ৪০-৬০ ঙ.> ৬০

১১। আপনি কি করেন?
ক. ছাত্র খ. নিয়মিত (ফুলটাইম) চাকরী গ. খন্ডকালীন (পার্ট টাইম) চাকরী ঘ. গৃহিনী ঙ. অবসরপ্রাপ্ত
চ. ব্যবসায়ী ছ. বেকার জ. অন্যান্য

১২। আপনি কতদূর লেখাপড়া করেছেন?
ক. মাধ্যমিকের কম (এসএসসি) খ. মাধ্যমিক (এসএসসি) গ. উচ্চ মাধ্যমিক (এইচএসসি)
ঘ. বিএসসি/বিএ/বিকম ঙ. উচ্চতর চ. অন্যান্য

১৩। আপনার পরিবারের মাসিক আয় কত?
ক. ১,৫০০ টাকার কম খ. ১,৫০০-৫ হাজার টাকা গ. ৫-১০ হাজার টাকা
ঘ. ১০-২০ হাজার টাকা ঙ. ২০-৩০ হাজার টাকা চ. ৩০-৪০ হাজার টাকা
ছ. ৪০-৫০ হাজার টাকা জ. ৫০ হাজার টাকার বেশী

১৪। আপনার কি নিজস্ব মটরসাইকেল/গাড়ী ব্যবহারের সুযোগ আছে?
উত্তর হ্যাঁ হলে- মটরসাইকেল/গাড়ীটি কি আপনার ক. নিজস্ব খ. পরিবারের গ. অফিসের

১৫। আপনার পরিবারের সদস্য সংখ্যা কতজন? ____________

১৬। আপনার পরিবারে ১৬ বছরের কম শিশুর সংখ্যা কতজন? ____________

১৭। ক. আপনি পুরুষ খ. আপনি মহিলা

১৮। আপনি কি BRT বা মেট্রোর বর্ণনা ঠিকমত বুঝতে পেরেছেন? (ক) হ্যাঁ (খ) না

আপনাকে প্রশ্নগুলোর উত্তর দেয়ার জন্য অসংখ্য ধন্যবাদ। আপনার ভ্রমন আনন্দময় হোক।

C2: For car users

METRO	উন্নত পরিবহন ব্যবস্থা সম্পর্কে আপনার মতামত	Section B
87	পুরকৌশল বিভাগ, বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়, ঢাকা	CAR

সময় ঃ ______________________________

আপনি হয়তো শুনেছেন ঢাকায় উন্নত বাস সার্ভিস বা Metro Train সার্ভিস শুরু হতে পারে। বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়ের পুরকৌশল বিভাগ Japan International Co-operation Agency (JICA) এর সহায়তায় এর একটি নিরপেক্ষ মূল্যায়ন করছে। আপনি নীচের প্রশ্নগুলোর উত্তর দিলে উপকৃত হব।

প্রথমে আমরা আপনাকে আপনার এখনকার ভ্রমন নিয়ে কিছু প্রশ্ন করব।

১। আপনি এই যাত্রার জন্য কোনটি ব্যবহার করেছেন?
ক. নিজের গাড়ি খ. সিএনজি/ট্যাক্সি গ. রিক্সা ঘ. বাস

২। আপনি কোথা থেকে রওনা হয়েছেন? (Main Origin)
ক. নিজের বাসা খ. বন্ধু/আত্মীয়ের বাসা গ. অফিস
ঘ. স্কুল/কলেজ/বিশ্ববিদ্যালয় ঙ. দোকান/বাজার/শপিং মল চ. অন্যান্য ___________

যার ঠিকানা হলোঃ ____
(যেমন, আজিমুপর, ধানমন্ডি, উত্তরা ইত্যাদি)

৩। আপনি কোথায় যাবেন? (Final Destination)
ক. নিজের বাসা খ. বন্ধু/আত্মীয়ের বাসা গ. অফিস
ঘ. স্কুল/কলেজ/বিশ্ববিদ্যালয় ঙ. দোকান/বাজার/শপিং মল চ. অন্যান্য ___________

যার ঠিকানা হলোঃ ____
(যেমন, আজিমুপর, শ্যামলী, উত্তরা ইত্যাদি)

৪। এই যাত্রার জন্য আপনার কি আর কোন যানবাহন ব্যবহারের সুযোগ ছিল? (একাধিক উত্তর হতে পারে)
(ক) সিএনজি/ট্যাক্সি (খ) বাস (ঘ) রিক্সা (ঙ) টেম্পু (চ) জানা নেই

৫। আপনি আজকের যাত্রার জন্য গাড়ি ব্যবহার করছেন কেন? (একাধিক উত্তর হতে পারে)
(ক) এ ছাড়া আর কোন সুযোগ নেই (খ) অন্য যানবাহানের তুলনায় ভাড়া কম
(গ) অন্য যানবাহনের চেয়ে দ্রুতগামী (ঘ) সরাসরি গন্তব্যে পৌছায় (ঙ) অন্য যানবাহনের চেয়ে নিরাপদ
(চ) অন্যান্য _____________

৬। আজকে আপনার গন্তব্যে পৌছাতে কত সময় লেগেছে ? _____ ঘণ্টা _____ মিনিট

৭। এই রুটে আপনি কত ঘন ঘন যাতায়াত করেন? (সম্পূর্ণ রুট অথবা এর কম পক্ষে ৫ কিমি)
ক. প্রতিদিন খ. সাপ্তাহিক ছুটির দিন ছাড়া প্রতিদিন গ. সপ্তাহে ১-৪ দিন
ঘ. মাসে ২/৩ দিন ঙ. মাসে ১ দিনের চাইতে কম চ. আগে কখনো যাতায়াত করিনি

আপনি হয়তো ঢাকার জন্য প্রস্তাবিত বিভিন্ন ধরনের উন্নত পরিবহন ব্যবস্থা সম্পর্কে শুনেছেন। প্রস্তাবিত ব্যবস্থাগুলোর মধ্যে মেট্রো ট্রেন এবং BRT ব্যবস্থা অন্যতম। আমরা এখন এই দুইটির বিষয়ে আপনার মতামত সম্পর্কে জানতে চাইব।

মেট্রো ট্রেন ব্যবস্থায় রাস্তা দিয়ে, রাস্তার নীচ দিয়ে বা ফ্লাইওভারের মত ব্রিজ দিয়ে ট্রেন চলাচলের ব্যবস্থা করা হবে এবং এর ফলে যাতায়াতের সময় কমে যেতে পারে। এই ট্রেন সার্ভিসে ঘন ঘন ট্রেনের ব্যবস্থা থাকবে এবং সেগুলো নির্দিষ্ট সময়সূচী মেনে চলবে। স্টেশনগুলোকে পরিষ্কার এবং আরামদায়ক করে তৈরী করা হবে এবং স্টেশনে ট্রেনের সময়সূচী প্রদর্শনেরও ব্যবস্থা থাকবে। কিন্তু এই সার্ভিসের ভাড়া প্রচলিত বাস সার্ভিস এবং BRT-র তুলনায় বেশী হতে পারে।

এখন মনে করেন আপনার আজকের এই যাত্রার জন্য গাড়ির পাশাপাশি মেট্রো ট্রেন ব্যবহারের সুযোগ আছে।

আমি এখন আপনাকে মেট্রো ট্রেন ব্যবস্থার বর্ণনা দিচ্ছি।

মেট্রোতে ট্রেনগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং ট্রেনগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি _________ একটি ট্রেন পাওয়া যাবে অর্থাৎ আপনাকে ট্রেনের জন্য __________ পর্যন্ত অপেক্ষা করতে হতে পারে , ট্রেন ছাড়ার পরে __________ সময় কম লাগবে এবং ভাড়া ____________ লাগবে।

	Metro:(15-30 min)	Metro:(31-45 min)	Metro:(46-60min)	Metro:(61-90min)	Metro:(>90min)
Waiting	7	7	7	7	7
time	-5	-5	-10	-15	-20
cost	20	25	33	38	47

সেক্ষেত্রে আপনি কোন সার্ভিসটি ব্যবহার করবেন উল্লেখ করুন। | CAR | Metro |

যদি মেট্রো বলে থাকেন, আপনি কোনটি পছন্দ করবেন?	মাটির নীচে	Flyover/bridge দিয়ে	মাটির বরাবর

এখন মনে করেন আপনার আজকের যাত্রার জন্য গাড়ি/ মেট্রোট্রেনের পাশাপাশি BRT ব্যবহারের সুযোগ আছে।

BRT একটি নতুন ধরনের পরিবহন ব্যবস্থা যা বিগত কয়েক বছরে আমেরিকা, জার্মানী, অষ্ট্রেলিয়া এবং ভারতসহ বিশ্বের বিভিন্ন বড় বড় শহর গুলোতে চালু করা হয়েছে। এটি আমাদের দেশে বর্তমানে প্রচলিত বাস পরিবহন ব্যবস্থা থেকে সম্পূর্ণ ভিন্ন। এই উন্নত বাস পরিবহন ব্যবস্থায় এক/একাধিক বগি বিশিষ্ট বড় বাস চালু করা হবে। এই বাসগুলো রাস্তার এক পাশ দিয়ে চলবে (যেখানে অন্য কোন যানবাহন চলবে না) এবং এর ফলে যাতায়াতের সময় অনেক কমে যাবে। এই বাসগুলো সুনির্দিষ্ট সময়ে বাস স্টপ থেকে ছেড়ে যাবে এবং দুইটি বাস ছাড়ার মাঝের সময়ও অনেক কমে যাবে (অর্থাৎ ঘন ঘন বাস চালু করা হবে)। এই ব্যবস্থায় বাস স্টপগুলি পরিষ্কার এবং আরামদায়ক করে তৈরী করা হবে এবং বাস স্টপে বাসের সময়সূচী প্রদর্শনেরও ব্যবস্থা করা হবে। কিন্তু এই নতুন সার্ভিসের ভাড়া প্রচলিত বাস সার্ভিসের চেয়ে বেশী হবে।

আমি এখন আপনাকে BRT ব্যবস্থার বর্ণনা দিচ্ছি।

BRT তে বাসগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং বাসগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি ______ একটি বাস পাওয়া যাবে,অর্থাৎ আপনাকে বাসের জন্য ___________ পর্যন্ত অপেক্ষা করতে হতে পারে , বাস ছাড়ার পরে ______ সময় কম লাগবে এবং ভাড়া ______ লাগবে।

	BRT:(15-30 min)	BRT:(31-45 min)	BRT:(46-60min)	BRT:(61-90min)	BRT:(>90min)
Waiting	7	7	7	7	7
time	-5	-5	-10	-15	-20
cost	17	22	29	34	41

মেট্রোতে ট্রেনগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং ট্রেনগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি _________ একটি ট্রেন পাওয়া যাবে অর্থাৎ আপনাকে ট্রেনের জন্য __________ পর্যন্ত অপেক্ষা করতে হতে পারে , ট্রেন ছাড়ার পরে __________ সময় কম লাগবে এবং ভাড়া ____________লাগবে।

অথবা

গাড়িতে সব কিছু এখনকার মতই থাকবে।

সেক্ষেত্রে আপনি কোন সার্ভিসটি ব্যবহার করবেন উল্লেখ করুন।	CAR	METRO	BRT

এক্ষেত্রে যানবাহন পছন্দ করার সময় এর কোন বৈশিষ্ট্যগুলো আপনার কাছে বেশি গুরুত্বপূর্ণ বলে মনে হয়েছে? (একাধিক উত্তর হতে পারে)

ক. সময় **খ. ভাড়া** **গ. অপেক্ষার সময়** **গ. অন্যান্য ________________**

মহিলা যাত্রীদের জন্য আলাদা জায়গা (কামরা/সিটের) ব্যবস্থা থাকাটা জরুরি বলে মনে করেন কি?

ক. অবশ্যই থাকা উচিত **খ. থাকলে ভাল হয়** **গ. না থাকলেও হয়**

আমরা এখন আপনার সম্পর্কে কিছু জানতে চাই যেন আমরা ভালভাবে প্রতিবেদন তৈরী করতে পারি।

৮। আপনার বয়স কত? ক. <১৮ খ.১৮-২৫ গ. ২৫-৪০ ঘ. ৪০-৬০ ঙ.> ৬০

৯। আপনি কি করেন?
ক. ছাত্র খ. নিয়মিত (ফুলটাইম) চাকরী গ. খন্ডকালীন (পার্ট টাইম) চাকরী ঘ. গৃহিনী ঙ. অবসরপ্রাপ্ত
চ. ব্যবসায়ী ছ. বেকার জ. অন্যান্য

১০। আপনি কতদূর লেখাপড়া করেছেন?
ক. মাধ্যমিকের কম (এসএসসি) খ. মাধ্যমিক (এসএসসি) গ. উচ্চ মাধ্যমিক (এইচএসসি)
ঘ. বিএসসি/বিএ/বিকম ঙ. উচ্চতর চ. অন্যান্য

১১। আপনার পরিবারের মাসিক আয় কত?
ক. ১,৫০০ টাকার কম খ. ১,৫০০-৫ হাজার টাকা গ. ৫-১০ হাজার টাকা
ঘ. ১০-২০ হাজার টাকা ঙ. ২০-৩০ হাজার টাকা চ. ৩০-৪০ হাজার টাকা
ছ. ৪০-৫০ হাজার টাকা জ. ৫০ হাজার টাকার বেশী

১২। গাড়ীটি কি আপনার ক. নিজস্ব খ. পরিবারের গ. অফিসের

১৩। আপনার কি ড্রাইভার আছে? ক. হ্যাঁ খ. না

১৪। গাড়ির জন্য আপনার প্রতি মাসে কত টাকা (গ্যাস/পেট্রোল,গ্যারেজ ভাড়া,ড্রাইভারের বেতন, গাড়ির রক্ষণাবেক্ষণ,পার্কিং বাবদ) খরচ হয়? -------------------- টাকা

১৫। অফিসে যাতায়াতের জন্য অফিসের গাড়ি ব্যবহার করলে আপনার গাড়ির মাসিক খরচ কত টাকা কমে যাবে বলে মনে করেন? _____________ টাকা

১৬। আপনার পরিবারের সদস্য সংখ্যা কতজন? _____________

১৭। আপনার পরিবারে ১৬ বছরের কম শিশুর সংখ্যা কতজন? _____________

১৮। ক. আপনি পুরুষ খ. আপনি মহিলা

১৯। আপনি কি BRT বা মেট্রোর বর্ণনা ঠিকমত বুঝতে পেরেছেন? (ক) হ্যাঁ (খ) না

আপনাকে প্রশ্নগুলোর উত্তর দেয়ার জন্য অসংখ্য ধন্যবাদ। আপনার ভ্রমন আনন্দময় হোক।

C3: For CNG/taxi users

METRO
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উন্নত পরিবহন ব্যবস্থা সম্পর্কে আপনার মতামত

পুরকৌশল বিভাগ, বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়, ঢাকা

Section A
CNG/TAXI

সময় ঃ ____________________________

আপনি হয়তো শুনেছেন ঢাকায় উন্নত বাস সার্ভিস বা Metro Train সার্ভিস শুরু হতে পারে। বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়ের পুরকৌশল বিভাগ Japan International Co-operation Agency (JICA) এর সহায়তায় এর একটি নিরপেক্ষ মূল্যায়ন করছে। আপনি নীচের প্রশ্নগুলোর উত্তর দিলে উপকৃত হব।

প্রথমে আমরা আপনাকে আপনার এখনকার ভ্রমন নিয়ে কিছু প্রশ্ন করব।

১। আপনি এই যাত্রার জন্য কোনটি ব্যবহার করেছেন?
ক. নিজের গাড়ি খ. সিএনজি/ট্যাক্সি গ. রিক্সা ঘ. বাস

২। আপনি কোথা থেকে রওনা হয়েছেন? (Main Origin)
ক. নিজের বাসা খ. বন্ধু/আত্মীয়ের বাসা গ. অফিস
ঘ. স্কুল/কলেজ/বিশ্ববিদ্যালয় ঙ. দোকান/বাজার/শপিং মল চ. অন্যান্য __________
যার ঠিকানা হলোঃ ________________________________
(যেমন, আজিমুপর, ধানমন্ডি, উত্তরা ইত্যাদি)

৩। আপনি কোথায় যাবেন? (Final Destination)
ক. নিজের বাসা খ. বন্ধু/আত্মীয়ের বাসা গ. অফিস
ঘ. স্কুল/কলেজ/বিশ্ববিদ্যালয় ঙ. দোকান/বাজার/শপিং মল চ. অন্যান্য __________
যার ঠিকানা হলোঃ ________________________________
(যেমন, আজিমুপর, শ্যামলী, উত্তরা ইত্যাদি)

৪। এই যাত্রার জন্য আপনার কি আর কোন যানবাহন ব্যবহারের সুযোগ ছিল? (একাধিক উত্তর হতে পারে)
(ক) নিজের গাড়ি (খ) বাস (গ) রিক্সা (ঘ) টেম্পু (ঙ) জানা নেই

৫। আপনি আজকের যাত্রার জন্য সিএনজি/ট্যাক্সি ব্যবহার করছেন কেন? (একাধিক উত্তর হতে পারে)
(ক) এ ছাড়া আর কোন সুযোগ নেই (খ) অন্য যানবাহানের তুলনায় ভাড়া কম
(গ) অন্য যানবাহনের চেয়ে দ্রুতগামী (ঘ) সরাসরি গন্তব্যে পৌছায় (ঙ) অন্য যানবাহনের চেয়ে নিরাপদ
(চ) অন্যান্য __________

৬। আপনি আজকে কতক্ষণ ধরে সিএনজি/ট্যাক্সির জন্য অপেক্ষা করেছেন? ______________ মিনিট

৭। আজকে আপনার গন্তব্যে পৌছাতে কত সময় লেগেছে ? ____ ঘণ্টা ____ মিনিট

এই যাত্রায় আপনার কি কোন সহযাত্রী ছিল? উত্তর হ্যাঁ হলে কতজন? __________ জন

৮। আপনার আজকের এই যাত্রার (one way) ভাড়া কত টাকা ছিল? ______________

৯। এই রুটে আপনি কত ঘন ঘন যাতায়াত করেন? (সম্পূর্ণ রুট অথবা এর কম পক্ষে ৫ কিমি)
ক. প্রতিদিন খ. সাপ্তাহিক ছুটির দিন ছাড়া প্রতিদিন গ. সপ্তাহে ১-৪ দিন
ঘ. মাসে ২/৩ দিন ঙ. মাসে ১ দিনের চাইতে কম চ. আগে কখনো যাতায়াত করিনি

আপনি হয়তো ঢাকার জন্য প্রস্তাবিত বিভিন্ন ধরনের উন্নত পরিবহন ব্যবস্থা সম্পর্কে শুনেছেন। প্রস্তাবিত ব্যবস্থাগুলোর মধ্যে মেট্রো ট্রেন এবং BRT ব্যবস্থা অন্যতম। আমরা এখন এই দুইটির বিষয়ে আপনার মতামত সম্পর্কে জানতে চাইব।

মেট্রো ট্রেন ব্যবস্থায় রাস্তা দিয়ে, রাস্তার নীচ দিয়ে বা ফ্লাইওভারের মত ব্রিজ দিয়ে ট্রেন চলাচলের ব্যবস্থা করা হবে এবং এর ফলে যাতায়াতের সময় কমে যেতে পারে। এই ট্রেন সার্ভিসে ঘন ঘন ট্রেনের ব্যবস্থা থাকবে এবং সেগুলো নির্দিষ্ট সময়সূচী মেনে চলবে। স্টেশনগুলোকে পরিস্কার এবং আরামদায়ক করে তৈরী করা হবে এবং স্টেশনে ট্রেনের সময়সূচী প্রদর্শনেরও ব্যবস্থা থাকবে। কিন্তু এই সার্ভিসের ভাড়া প্রচলিত বাস সার্ভিস এবং BRT-র তুলনায় বেশী হতে পারে।

এখন মনে করেন আপনার আজকের এই যাত্রার জন্য সিএনজি/ট্যাক্সির পাশাপাশি মেট্রো ট্রেন ব্যবহারের সুযোগ আছে।

আমি এখন আপনাকে মেট্রো ট্রেন ব্যবস্থার বর্ণনা দিচ্ছি।

মেট্রোতে ট্রেনগুলো পরিস্কার পরিচ্ছন্ন থাকবে এবং ট্রেনগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি ________ একটি ট্রেন পাওয়া যাবে অর্থাৎ আপনাকে ট্রেনের জন্য ________ পর্যন্ত অপেক্ষা করতে হতে পারে , ট্রেন ছাড়ার পরে ________ সময় কম লাগবে এবং ভাড়া __________ লাগবে।

	Metro:(15-30 min)	Metro:(31-45 min)	Metro:(46-60min)	Metro:(61-90min)	Metro:(>90min)
Waiting	7	7	7	7	7
time	-10	-10	-20	-25	-30
cost	59	73	84	119	159

সেক্ষেত্রে আপনি কোন সার্ভিসটি ব্যবহার করবেন উল্লেখ করুন।

cng/taxi	Metro

যদি মেট্রো বলে থাকেন, আপনি কোনটি পছন্দ করবেন?

মাটির নীচে	Flyover/bridge দিয়ে	মাটির বরাবর

এখন মনে করেন আপনার আজকের যাত্রার জন্য সিএনজি/ট্যাক্সি/ মেট্রোট্রেনের পাশাপাশি BRT ব্যবহারের সুযোগ আছে।

BRT একটি নতুন ধরনের পরিবহন ব্যবস্থা যা বিগত কয়েক বছরে আমেরিকা, জার্মানী, অষ্ট্রেলিয়া এবং ভারতসহ বিশ্বের বিভিন্ন বড় বড় শহর গুলোতে চালু করা হয়েছে। এটি আমাদের দেশে বর্তমানে প্রচলিত বাস পরিবহন ব্যবস্থা থেকে সম্পূর্ণ ভিন্ন। এই উন্নত বাস পরিবহন ব্যবস্থায় এক/একাধিক বগি বিশিষ্ট বড় বাস চালু করা হবে। এই বাসগুলো রাস্তার এক পাশ দিয়ে চলবে (যেখানে অন্য কোন যানবাহন চলবে না) এবং এর ফলে যাতায়াতের সময় অনেক কমে যাবে। এই বাসগুলো সুনির্দিষ্ট সময়ে বাস স্টপ থেকে ছেড়ে যাবে এবং দুইটি বাস ছাড়ার মাঝের সময়ও অনেক কমে যাবে (অর্থাৎ ঘন ঘন বাস চালু করা হবে)। এই ব্যবস্থায় বাস স্টপগুলি পরিষ্কার এবং আরামদায়ক করে তৈরী করা হবে এবং বাস স্টপে বাসের সময়সূচী প্রদর্শনেরও ব্যবস্থা করা হবে। কিন্তু এই নতুন সার্ভিসের ভাড়া প্রচলিত বাস সার্ভিসের চেয়ে বেশী হবে।

আমি এখন আপনাকে BRT ব্যবস্থার বর্ণনা দিচ্ছি।

BRT তে বাসগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং বাসগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি ______ একটি বাস পাওয়া যাবে,অর্থাৎ আপনাকে বাসের জন্য ___________ পর্যন্ত অপেক্ষা করতে হতে পারে , বাস ছাড়ার পরে ______ সময় কম লাগবে এবং ভাড়া ______ লাগবে।

	BRT:(15-30 min)	BRT:(31-45 min)	BRT:(46-60min)	BRT:(61-90min)	BRT:(>90min)
Waiting	5	5	5	5	5
time	-5	-5	-15	-20	-25
cost	53	65	77	107	147

মেট্রোতে ট্রেনগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং ট্রেনগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি __________ একটি ট্রেন পাওয়া যাবে অর্থাৎ আপনাকে ট্রেনের জন্য ___________ পর্যন্ত অপেক্ষা করতে হতে পারে , ট্রেন ছাড়ার পরে ___________ সময় কম লাগবে এবং ভাড়া ______________ লাগবে।

অথবা

সিএনজি/ট্যাক্সি সার্ভিসে সব কিছু এখনকার মতই থাকবে।

সেক্ষেত্রে আপনি কোন সার্ভিসটি ব্যবহার করবেন উল্লেখ করুন।

cng/taxi	METRO	BRT

এক্ষেত্রে যানবাহন পছন্দ করার সময় এর কোন বৈশিষ্ট্যগুলো আপনার কাছে বেশি গুরুত্বপূর্ণ বলে মনে হয়েছে? (একাধিক উত্তর হতে পারে)

ক, সময় খ, ভাড়া গ, অপেক্ষার সময় গ, অন্যান্য ____________________

মহিলা যাত্রীদের জন্য আলাদা জায়গা (কামরা/সিটের) ব্যবস্থা থাকাটা জরুরি বলে মনে করেন কি?

ক. অবশ্যই থাকা উচিত খ. থাকলে ভাল হয় গ. না থাকলেও হয়

আমরা এখন আপনার সম্পর্কে কিছু জানতে চাই যেন আমরা ভালভাবে প্রতিবেদন তৈরী করতে পারি।

১০। আপনার বয়স কত? ক. <১৮ খ.১৮-২৫ গ. ২৫-৪০ ঘ. ৪০-৬০ ঙ.> ৬০

১১। আপনি কি করেন?
ক. ছাত্র খ. নিয়মিত (ফুলটাইম) চাকরী গ. খন্ডকালীন (পার্ট টাইম) চাকরী ঘ. গৃহিনী ঙ. অবসরপ্রাপ্ত
চ. ব্যবসায়ী ছ. বেকার জ. অন্যান্য

১২। আপনি কতদূর লেখাপড়া করেছেন?
ক. মাধ্যমিকের কম (এসএসসি) খ. মাধ্যমিক (এসএসসি) গ. উচ্চ মাধ্যমিক (এইচএসসি)
ঘ. বিএসসি/বিএ/বিকম ঙ. উচ্চতর চ. অন্যান্য

১৩। আপনার পরিবারের মাসিক আয় কত?
ক. ১,৫০০ টাকার কম খ. ১,৫০০-৫ হাজার টাকা গ. ৫-১০ হাজার টাকা
ঘ. ১০-২০ হাজার টাকা ঙ. ২০-৩০ হাজার টাকা চ. ৩০-৪০ হাজার টাকা
ছ. ৪০-৫০ হাজার টাকা জ. ৫০ হাজার টাকার বেশী

১৪। আপনার কি নিজস্ব মটরসাইকেল/গাড়ী ব্যবহারের সুযোগ আছে?
উত্তর হ্যাঁ হলে- মটরসাইকেল/গাড়ীটি কি আপনার ক. নিজস্ব খ. পরিবারের গ. অফিসের

১৫। আপনার পরিবারের সদস্য সংখ্যা কতজন? ______________

১৬। আপনার পরিবারে ১৬ বছরের কম শিশুর সংখ্যা কতজন? ______________

১৭। ক. আপনি পুরুষ খ. আপনি মহিলা

১৮। আপনি কি BRT বা মেট্রোর বর্ণনা ঠিকমত বুঝতে পেরেছেন? (ক) হ্যাঁ (খ) না

আপনাকে প্রশ্নগুলোর উত্তর দেয়ার জন্য অসংখ্য ধন্যবাদ। আপনার ভ্রমন আনন্দময় হোক।

C4: For rickshaw users

BRT	উন্নত পরিবহন ব্যবস্থা সম্পর্কে আপনার মতামত	Section C
216	পুরকৌশল বিভাগ, বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়, ঢাকা	RICKSHAW

সময় ঃ ______________________________

আপনি হয়তো শুনেছেন ঢাকায় উন্নত বাস সার্ভিস বা Metro Train সার্ভিস শুরু হতে পারে। বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়ের পুরকৌশল বিভাগ Japan International Co-operation Agency (JICA) এর সহায়তায় এর একটি নিরপেক্ষ মূল্যায়ন করছে। আপনি নীচের প্রশ্নগুলোর উত্তর দিলে উপকৃত হব।

প্রথমে আমরা আপনাকে আপনার এখনকার ভ্রমন নিয়ে কিছু প্রশ্ন করব।

১। আপনি এই যাত্রার জন্য কোনটি ব্যবহার করেছেন?
ক. নিজের গাড়ি খ. সিএনজি/ট্যাক্সি গ. রিক্সা ঘ. বাস

২। আপনি কোথা থেকে রওনা হয়েছেন? (Main Origin)
ক. নিজের বাসা খ. বন্ধু/আত্মীয়ের বাসা গ. অফিস
ঘ. স্কুল/কলেজ/বিশ্ববিদ্যালয় ঙ. দোকান/বাজার/শপিং মল চ. অন্যান্য ___________
যার ঠিকানা হলোঃ ____
(যেমন, আজিমুপর, ধানমন্ডি, উত্তরা ইত্যাদি)

৩। আপনি কোথায় যাবেন? (Final Destination)
ক. নিজের বাসা খ. বন্ধু/আত্মীয়ের বাসা গ. অফিস
ঘ. স্কুল/কলেজ/বিশ্ববিদ্যালয় ঙ. দোকান/বাজার/শপিং মল চ. অন্যান্য ___________
যার ঠিকানা হলোঃ ____
(যেমন, আজিমুপর, শ্যামলী, উত্তরা ইত্যাদি)

৪। এই যাত্রার জন্য আপনার কি আর কোন যানবাহন ব্যবহারের সুযোগ ছিল? (একাধিক উত্তর হতে পারে)
(ক) নিজের গাড়ি (খ) বাস (ঘ) সিএনজি/ট্যাক্সি (ঙ) টেম্পু (চ) জানা নেই

৫। আপনি আজকের যাত্রার জন্য রিক্সা ব্যবহার করছেন কেন? (একাধিক উত্তর হতে পারে)
(ক) এ ছাড়া আর কোন সুযোগ নেই (খ) অন্য যানবাহানের তুলনায় ভাড়া কম
(গ) অন্য যানবাহনের চেয়ে দ্রুতগামী (ঘ) সরাসরি গন্তব্যে পৌছায় (ঙ) অন্য যানবাহনের চেয়ে নিরাপদ
(চ) অন্যান্য ______________

৬। আপনি আজকে কতক্ষণ ধরে রিক্সার জন্য অপেক্ষা করেছেন? __________________ মিনিট

৭। আজকে আপনার গন্তব্যে পৌছাতে কত সময় লেগেছে ? _____ ঘণ্টা _____ মিনিট

৮। আপনার আজকের এই যাত্রার (one way) ভাড়া কত টাকা ছিল? ___________________

এই যাত্রায় আপনার কি কোন সহযাত্রী ছিল? উত্তর হ্যাঁ হলে কতজন? _____________ জন

৯। এই রুটে আপনি কত ঘন ঘন যাতায়াত করেন? (সম্পূর্ণ রুট অথবা এর কম পক্ষে ৫ কিমি)
ক. প্রতিদিন খ. সাপ্তাহিক ছুটির দিন ছাড়া প্রতিদিন গ. সপ্তাহে ১-৪ দিন
ঘ. মাসে ২/৩ দিন ঙ. মাসে ১ দিনের চাইতে কম চ. আগে কখনো যাতায়াত করিনি

আপনি হয়তো ঢাকার জন্য প্রস্তাবিত বিভিন্ন ধরনের উন্নত পরিবহন ব্যবস্থা সম্পর্কে শুনেছেন। প্রস্তাবিত ব্যবস্থাগুলোর মধ্যে BRT এবং মেট্রো ট্রেন ব্যবস্থা অন্যতম। আমরা এখন এই দুইটির বিষয়ে আপনার মতামত সম্পর্কে জানতে চাইব।

BRT একটি নতুন ধরনের পরিবহন ব্যবস্থা যা বিগত কয়েক বছরে আমেরিকা, জার্মানী, অষ্ট্রেলিয়া এবং ভারতসহ বিশ্বের বিভিন্ন বড় বড় শহর গুলোতে চালু করা হয়েছে। এটি আমাদের দেশে বর্তমানে প্রচলিত বাস পরিবহন ব্যবস্থা থেকে সম্পূর্ণ ভিন্ন। এই উন্নত বাস পরিবহন ব্যবস্থায় এক/একাধিক বগি বিশিষ্ট বড় বাস চালু করা হবে। এই বাসগুলো রাস্তার এক পাশ দিয়ে চলবে (যেখানে অন্য কোন যানবাহন চলবে না) এবং এর ফলে যাতায়াতের সময় অনেক কমে যাবে। এই বাসগুলো সুনির্দিষ্ট সময়ে বাস স্টপ থেকে ছেড়ে যাবে এবং দুইটি বাস ছাড়ার মাঝের সময়ও অনেক কমে যাবে (অর্থাৎ ঘন ঘন বাস চালু করা হবে)। এই ব্যবস্থায় বাস স্টপগুলি পরিষ্কার এবং আরামদায়ক করে তৈরী করা হবে এবং বাস স্টপে বাসের সময়সূচী প্রদর্শনেরও ব্যবস্থা করা হবে। কিন্তু এই নতুন সার্ভিসের ভাড়া প্রচলিত বাস সার্ভিসের চেয়ে বেশী হবে।

এখন মনে করেন আপনার আজকের এই যাত্রার জন্য রিক্সার পাশাপাশি BRT ব্যবহারের সুযোগ আছে।

আমি এখন আপনাকে **BRT** ব্যবস্থার বর্ণনা দিচ্ছি।

BRT তে বাসগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং বাসগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি ______ একটি বাস পাওয়া যাবে,অর্থাৎ আপনাকে বাসের জন্য __________ পর্যন্ত অপেক্ষা করতে হতে পারে , বাস ছাড়ার পরে ______ সময় কম লাগবে এবং ভাড়া ______ লাগবে।

	BRT:(10-20 min)	BRT:(21-30 min)	BRT:(31-45 min)	BRT:(46-60min)
waiting	5	5	5	5
time	-7	-15	-25	-30
cost	23	29	37	46

সেক্ষেত্রে আপনি কোন সার্ভিসটি ব্যবহার করবেন উল্লেখ করুন।

rickshaw	BRT

এখন মনে করেন আপনার আজকের যাত্রার জন্য রিক্সা/ BRT-র পাশাপাশি মেট্রো ট্রেন ব্যবহারের সুযোগ আছে।

মেট্রো ট্রেন ব্যবস্থায় রাস্তা দিয়ে, রাস্তার নীচ দিয়ে বা ফ্লাইওভারের মত ব্রিজ দিয়ে ট্রেন চলাচলের ব্যবস্থা করা হবে এবং এর ফলে যাতায়াতের সময় কমে যেতে পারে। এই ট্রেন সার্ভিসে ঘন ঘন ট্রেনের ব্যবস্থা থাকবে এবং সেগুলো নির্দিষ্ট সময়সূচী মেনে চলবে। স্টেশনগুলোকে পরিষ্কার এবং আরামদায়ক করে তৈরী করা হবে এবং স্টেশনে ট্রেনের সময়সূচী প্রদর্শনেরও ব্যবস্থা থাকবে। কিন্তু এই সার্ভিসের ভাড়া প্রচলিত বাস সার্ভিস এবং BRT-র তুলনায় বেশী হতে পারে।

আমি এখন আপনাকে মেট্রো ট্রেন ব্যবস্থার বর্ণনা দিচ্ছি।

মেট্রোতে ট্রেনগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং ট্রেনগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি _________ একটি ট্রেন পাওয়া যাবে অর্থাৎ আপনাকে ট্রেনের জন্য __________ পর্যন্ত অপেক্ষা করতে হতে পারে , ট্রেন ছাড়ার পরে __________ সময় কম লাগবে এবং ভাড়া ____________ লাগবে।

	Metro:(10-20 min)	Metro:(21-30 min)	Metro:(31-45 min)	Metro:(46-60min)
waiting	10	10	10	10
time	-7	-18	-25	-35
cost	29	36	47	54

BRT তে বাসগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং বাসগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি _____ একটি বাস পাওয়া যাবে,অর্থাৎ আপনাকে বাসের জন্য __________ পর্যন্ত অপেক্ষা করতে হতে পারে , বাস ছাড়ার পরে _____ সময় কম লাগবে এবং ভাড়া _____ লাগবে।

অথবা

রিক্সাতে সব কিছু এখনকার মতই থাকবে।

সেক্ষেত্রে আপনি কোন সার্ভিসটি ব্যবহার করবেন উল্লেখ করুন।

rickshaw	BRT	METRO

যদি মেট্রো বলে থাকেন, আপনি কোনটি পছন্দ করবেন?

মাটির নীচে	Flyover/bridge দিয়ে	মাটির বরাবর

এক্ষেত্রে যানবাহন পছন্দ করার সময় এর কোন বৈশিষ্ট্যগুলো আপনার কাছে বেশি গুরুত্বপূর্ণ বলে মনে হয়েছে? (একাধিক উত্তর হতে পারে)

ক. সময় **খ. ভাড়া** **গ. অপেক্ষার সময়** **গ. অন্যান্য** _________________

মহিলা যাত্রীদের জন্য আলাদা জায়গা (কামরা/সিটের) ব্যবস্থা থাকাটা জরুরি বলে মনে করেন কি?

ক. অবশ্যই থাকা উচিত **খ. থাকলে ভাল হয়** **গ. না থাকলেও হয়**

আমরা এখন আপনার সম্পর্কে কিছু জানতে চাই যেন আমরা ভালভাবে প্রতিবেদন তৈরী করতে পারি।

১০। আপনার বয়স কত? ক. <১৮ খ.১৮-২৫ গ. ২৫-৪০ ঘ. ৪০-৬০ ঙ.> ৬০

১১। আপনি কি করেন?
ক. ছাত্র খ. নিয়মিত (ফুলটাইম) চাকরী গ. খন্ডকালীন (পার্ট টাইম) চাকরী ঘ. গৃহিনী ঙ. অবসরপ্রাপ্ত
চ. ব্যবসায়ী ছ. বেকার জ. অন্যান্য

১২। আপনি কতদূর লেখাপড়া করেছেন?
ক. মাধ্যমিকের কম (এসএসসি) খ. মাধ্যমিক (এসএসসি) গ. উচ্চ মাধ্যমিক (এইচএসসি)
ঘ. বিএসসি/বিএ/বিকম ঙ. উচ্চতর চ. অন্যান্য

১৩। আপনার পরিবারের মাসিক আয় কত?
ক. ১,৫০০ টাকার কম খ. ১,৫০০-৫ হাজার টাকা গ. ৫-১০ হাজার টাকা
ঘ. ১০-২০ হাজার টাকা ঙ. ২০-৩০ হাজার টাকা চ. ৩০-৪০ হাজার টাকা
ছ. ৪০-৫০ হাজার টাকা জ. ৫০ হাজার টাকার বেশী

১৪। আপনার কি নিজস্ব মটরসাইকেল/গাড়ী ব্যবহারের সুযোগ আছে?
উত্তর হ্যাঁ হলে- মটরসাইকেল/গাড়ীটি কি আপনার ক. নিজস্ব খ. পরিবারের গ. অফিসের

১৫। আপনার পরিবারের সদস্য সংখ্যা কতজন? ____________

১৬। আপনার পরিবারে ১৬ বছরের কম শিশুর সংখ্যা কতজন? ____________

১৭। ক. আপনি পুরুষ খ. আপনি মহিলা

১৮। আপনি কি BRT বা মেট্রোর বর্ণনা ঠিকমত বুঝতে পেরেছেন? (ক) হ্যাঁ (খ) না

আপনাকে প্রশ্নগুলোর উত্তর দেয়ার জন্য অসংখ্য ধন্যবাদ। আপনার ভ্রমন আনন্দময় হোক।

Appendix D

Attribute Table for Pilot Survey

Table D1: For bus users

Factors	Levels	For BRT				For Metro			
		Short	Medium	Long	Very long	Short	Medium	Long	Very long
Travel time (min)	1	-5	-10	-15	-20	-5	-10	-15	-20
	2	-5	-15	-20	-25	-7	-15	-20	-25
	3	-7	-18	-25	-30	-10	-20	-25	-30
	4	-10	-20	-30	-40	-12	-25	-30	-45
Travel cost (Taka)	1	+3	+5	+7	+7	+5	+7	+10	+10
	2	+5	+7	+10	+10	+7	+10	+12	+15
	3	+7	+10	+12	+15	+10	+12	+15	+20
	4	+10	+12	+15	+20	+12	+15	+20	+25
Frequency (min)	1	10	10	10	10	5	5	5	5
	2	12	12	12	12	7	7	7	7
	3	15	15	15	15	10	10	10	10
	4	20	20	20	20	15	15	15	15
	5	30	30	30	30	20	20	20	20

Table D2: For car users

Factors	Levels	For BRT					For Metro				
		Short	Medium	Long	Very long	VV long	Short	Medium	Long	Very long	VV long
Travel time (min)	1	-5	-5	-10	-15	-20	-5	-5	-10	-15	-20
	2	-5	-5	-15	-20	-25	-7	-7	-15	-20	-25
	3	-7	-7	-18	-25	-30	-10	-10	-20	-25	-30
	4	-7	-10	-20	-30	-40	-10	-12	-25	-30	-45
Travel cost (Taka)	1	+3	+5	+7	+7	+7	+5	+7	+10	+10	+12
	2	+5	+7	+10	+10	+10	+7	+10	+12	+15	+15
	3	+7	+10	+12	+15	+15	+10	+12	+15	+20	+20
	4	+10	+12	+15	+20	+22	+12	+15	+20	+22	+25
Frequency (min)	1	10	10	10	10	10	5	5	5	5	5
	2	12	12	12	12	12	7	7	7	7	7
	3	15	15	15	15	15	10	10	10	10	10
	4	20	20	20	20	20	15	15	15	15	15
	5	30	30	30	30	30	20	20	20	20	20
Absolute cost (Taka)	Mean	14	17	22	27	34	14	17	22	27	34
	1	17	22	29	34	41	19	24	32	37	46
	2	19	24	32	37	44	21	27	34	42	49
	3	21	27	34	42	49	24	29	37	47	54
	4	24	29	37	47	56	26	32	42	49	59

Table D3: For CNG/taxi users

Factors	Levels	For BRT					For Metro				
		Short	Medium	Long	Very long	VV long	Short	Medium	Long	Very long	VV long
Travel time (min)	1	-5	-5	-10	-15	-20	-5	-5	-10	-15	-20
	2	-5	-5	-15	-20	-25	-7	-7	-15	-20	-25
	3	-7	-7	-18	-25	-30	-10	-10	-20	-25	-30
	4	-7	-10	-20	-30	-40	-10	-12	-25	-30	-45
Travel cost (Taka)	1	+3	+5	+7	+7	+7	+5	+7	+10	+10	+12
	2	+5	+7	+10	+10	+10	+7	+10	+12	+15	+15
	3	+7	+10	+12	+15	+15	+10	+12	+15	+20	+20
	4	+10	+12	+15	+20	+22	+12	+15	+20	+22	+25
Frequency (min)	1	10	10	10	10	10	5	5	5	5	5
	2	12	12	12	12	12	7	7	7	7	7
	3	15	15	15	15	15	10	10	10	10	10
	4	20	20	20	20	20	15	15	15	15	15
	5	30	30	30	30	30	20	20	20	20	20
Absolute cost (Taka)	Mean	23	28	36	45	56	23	28	36	45	56
	1	26	33	43	52	63	28	35	46	55	68
	2	28	35	46	55	66	30	38	48	60	71
	3	30	38	48	60	71	33	40	51	65	76
	4	33	40	51	65	78	35	43	56	67	81

Table D4: For Rickshaw users

Factors	Levels	For BRT				For Metro			
		Short	Medium	Long	Very long	Short	Medium	Long	Very long
Travel time (min)	1	-5	-7	-10	-15	-5	-10	-15	-20
	2	-5	-10	-15	-20	-5	-12	-20	-25
	3	-7	-12	-20	-25	-7	-15	-22	-30
	4	-7	-15	-25	-30	-7	-18	-25	-35
Travel cost (Taka)	1	+3	+5	+7	+7	+5	+7	+10	+10
	2	+5	+7	+10	+10	+7	+10	+12	+15
	3	+7	+10	+12	+15	+10	+12	+15	+20
	4	+10	+12	+15	+20	+12	+15	+20	+22
Frequency (min)	1	10	10	10	10	5	5	5	5
	2	12	12	12	12	7	7	7	7
	3	15	15	15	15	10	10	10	10
	4	20	20	20	20	15	15	15	15
	5	30	30	30	30	20	20	20	20
Absolute cost (Taka)	Mean	16	19	25	31	16	19	25	31
	1	19	24	32	38	21	26	35	41
	2	21	26	35	41	23	29	37	46
	3	23	29	37	46	26	31	40	51
	4	26	31	40	51	28	34	45	53

Appendix E

Pilot Survey Estimation Results

E1: For bus users

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Utility Functions

V_brt	ASC_brt + BETA_tt * brt_tt + BETA_fare * brt_fare + BETA_wtime * brt_freq
V_bus	ASC_bus + BETA_tt * bus_tt + BETA_fare * bus_fare + BETA_wtime * bus_wt
V_metro	ASC_metro + BETA_tt * metro_tt + BETA_fare * metro_fare + BETA_wtime * metro_freq

Parameters estimates

Parameter name	Value	t-stat
ASC_brt	2.40	2.66
ASC_bus	0.00	-
ASC_metro	2.94	2.84
BETA_fare	-0.121	-2.18
BETA_wtime	0.00245	0.11
BETA_tt	-0.0342	-0.89

E2: For bus users

Utility functions

V_brt	ASC_brt + BETA_tt * brt_tt + BETA_fare * brt_fare + BETA_wtime * brt_freq
V_bus	ASC_bus + BETA_tt * bus_tt + BETA_fare * bus_fare + BETA_wtime * bus_wt
V_metro	ASC_metro + BETA_tt * metro_tt + BETA_fare * metro_fare + BETA_wtime * metro_freq

Parameters estimates

Parameter name	Value	t-stat
ASC_brt	3.96	3.92
ASC_bus	0.00	
ASC_metro	3.80	3.27
BETA_fare	-0.104	-1.74
BETA_wtime	-0.108	-3.31
BETA_tt	-0.0375	-1.07

E3: For car users

Utility functions

V_brt	ASC_brt + BETA_tt * brt_tt + BETA_fare * brt_fare + BETA_wtime * brt_freq
V_car	ASC_car + BETA_tt * car_tt
V_metro	ASC_metro + BETA_tt * metro_tt + BETA_fare * metro_fare + BETA_wtime* metro_freq

Parameters estimates

Parameter name	Value	t-stat
ASC_brt	-0.455	-0.31
ASC_car	0.00	-
ASC_metro	0.142	0.09
BETA_fare	-0.0209	-0.36
BETA_wtime	0.00228	0.05
BETA_tt	-0.0556	-0.70

E4: For CNG/taxi users

Utility functions

V_brt	ASC_brt + BETA_tt * brt_tt + BETA_fare * brt_fare + BETA_wtime * brt_freq
V_CNG	ASC_cng + BETA_tt * cng_tt + BETA_fare * cng_fare + BETA_freq * cng_wtime
V_metro	ASC_metro + BETA_tt * metro_tt + BETA_fare * metro_fare + BETA_wtime * metro_freq

Parameter estimates

Parameter name	Value	t-stat
ASC_brt	0.524	0..38
ASC_cng	0.00	-
ASC_metro	0.818	0.65
BETA_fare	-0.00974	-0.56
BETA_wtime	-0.00421	-0.17
BETA_tt	-0.0329	-0.54

E5: For rickshaw users

Utility functions

V_brt	ASC_brt + BETA_tt * brt_tt + BETA_fare * brt_fare + BETA_wtime * brt_freq
V_rickshaw	ASC_rickshaw + BETA_tt * rickshaw_tt + BETA_fare * rickshaw_fare + BETA_wtime * rickshaw_wt
V_metro	ASC_metro + BETA_tt * metro_tt + BETA_fare * metro_fare + BETA_wtime * metro_freq

Utility parameters

Parameter name	Value	t-stat
ASC_brt	-1.54	-2.00
ASC_rickshaw	0.00	
ASC_metro	-1.80	-2.09
BETA_fare	-0.0657	-1.50
BETA_wtime	-0.0486	-1.71
BETA_tt	-0.254	-3.12

Appendix F

Modified Attributes for Final Survey

Table F1: For bus users

Factors	Levels	For BRT					For Metro				
		Short	Medium	Long	Very long	VV long	Short	Medium	Long	Very long	VV long
Travel time (min)	1	-5	-10	-15	-20	-25	-5	-10	-15	-20	-30
	2	-5	-15	-20	-25	-30	-7	-15	-20	-25	-40
	3	-7	-18	-25	-30	-40	-10	-20	-25	-30	-50
	4	-10	-20	-30	-40	-45	-12	-25	-30	-45	-60
Travel cost (Taka)	1	+3	+5	+7	+7	+7	+5	+7	+10	+10	+12
	2	+5	+7	+10	+10	+10	+7	+10	+12	+15	+15
	3	+7	+10	+12	+15	+15	+10	+12	+15	+20	+20
	4	+10	+12	+15	+20	+22	+12	+15	+20	+22	+25
Frequency (min)	1	10	10	10	10	10	5	5	5	5	5
	2	12	12	12	12	12	7	7	7	7	7
	3	15	15	15	15	15	10	10	10	10	10
	4	20	20	20	20	20	15	15	15	15	15
	5	30	30	30	30	30	20	20	20	20	20

Table F2: For car users for metro cards (Travel Cost)

Absolute cost (Taka)	Short	Medium	Long	Very long	VV long
1	20	25	33	38	47
2	22	28	35	43	50
3	25	30	38	48	55
4	27	33	43	50	60

Table F3: For CNG/taxi users (Travel cost)

Factors	Levels	For BRT					For Metro				
		Short	Medium	Long	Very long	VV long	Short	Medium	Long	Very long	VV long
Absolute cost (Taka)	Mean	50	60	70	100	140	50	60	70	100	140
	1	53	65	77	107	147	57	69	83	113	156
	2	55	67	80	110	150	59	73	84	119	159
	3	57	70	82	115	155	63	74	88	124	164
	4	60	72	85	120	162	64	78	94	124	168

Table F4: For rickshaw users for metro cards (Travel Cost)

Absolute cost (Taka)	Short	Medium	Long	Very long	VV long
1	22	27	37	38	43
2	24	31	38	43	48
3	28	32	42	48	53
4	29	36	47	50	54

Table F5: For all modes (Frequency)

Frequency Levels (min)	For BRT	For metro
1	5	3
2	7	5
3	10	7
4	12	10
5	15	12

Appendix G

Table G1: Correlation matrix between choice sets and socio economic variables

Variables	Correlation value with choice set
Time of day	0.056873812
Trip purpose1*	-0.096859568
Trip purpose2*	0.04649647
Travel time	-0.184827578
Age	0.017937812
Occupation	0.023462797
Education	0.210162009
Monthly household income	0.476108247
Member	-0.008426684
Gender	0.262092973
Child	-0.064812932

*Here trip purpose 1 categorize the trips on the basis of home based or non-home based trip and trip purpose 2 categorizes on the basis of educational or work trip, social trip, shopping trip and other trips.