APPENDIX 6: STUDY ON EXPANSION OF COMMUTER SERVICES OF BANGLADESH RAILWAY

6.1 INTRODUCTION

6.1.1 Purpose of the study

Dhaka, the capital of the country, being most industrialized, is the administrative, financial, commercial and cultural center of the nation. The transportation system of this city, having a population of 10.7 million, heavily relies on road. This has resulted in serious traffic congestion, aggravated health hazard by traffic population including air pollution casting heavy toll on the business, economy, and administration and over all life of its inhabitants.

In consideration to this situation, the Government of Bangladesh formulated a "Strategic Transportation Plan (STP)" with the cooperation of World Bank in 2005. The STP compiles a policy as "Urban Transport Policy", identified priority issues and recommended implementation of mass transit system and urban expressway in the city. The plan has received official node of the government of Bangladesh. Therefore it is expected that donors will come forward to assist improvement of the traffic situation and urban environment on the basis of STP.

In this context a JICA study team is now conducting a study with the aim of formulating basic concept of urban development and formulating development projects for JICA assistance. During the study process, while confirming the rationale and necessity for introduction of a mass transit system it is felt essential to expand rail based commuter services in and around Dhaka and integrate it with mass transit system.

Bangladesh Railway (BR) concentrate its services aiming long haul passenger and goods but not responding to the transport services required for the densely populated country, particularly nearby areas of cities like Dhaka. However, BR has now started appreciate the requirement and started operation of commuter services on a limited scale with their available rolling stocks not suitable for commuter services.

This study therefore aims to find how rail base Commuter Services in the greater Dhaka and its periphery can be expanded, made efficient and also integrate with the mass transit system of Dhaka.

6.1.2 Scope of Works

The main goal of the study is to expand the rail based commuter services in greater Dhaka, its periphery and integrate it with mass transport system of Dhaka. The present condition of Commuter Services on Bangladesh Railway, current condition of its infrastructure including rolling stock, signaling equipment and communication system is required to be examined to prepare a development plan for the goal. BR's development plan and measure to this end are also to be considered while envisaging an expended commuter service development plan.

The structure of this study is therefore organized in section 2, current condition of commuter services, its routs; number of trains, train schedule and number of passengers are provided. Section 3, describes the current condition of railway infrastructure and rolling stock and also describes available passenger amenities. Section 4, discusses concerning issues of Bangladesh Railway for expansion of commuter services. While section 5 suggests improvement plan in respect of policy, infrastructure, rolling stocks and advices target of passenger. Finally it gives indicative investment cost for the commuter service expansion and development.

6.1.3 Study Area

B R is presently operating commuter trains mostly around Dhaka and a few in other area. Rail based commuter services are essential for the city like Dhaka and such trains are also needed for its surrounding areas. Therefore, the study area has been selected in and around Dhaka and up to the nearest district head quarter connected by railways.

The selected routs are

- Dhaka- Narayanganj (A route map is to be inserted)
- Dhaka- Joydevpur
- Dhaka- Narshindhi

The railway line which serves Dhaka, passes through the centre of the city, down from central railway station Dhaka (kamlapur) to Narayanganj in the south and to wards north up to Tongi where it bifurcates into two. One of these lines goes towards Chittagong/ Sylhet, connecting Narsindi and the other to Joydevpur (Gazipur) railway junction. Where this line bifurcates again, one goes towards Mymensing and the other towards Jamuna Multipurpose Bridge. These three directional lines connect whole railway system of the country.

6.2 CURRENT CONDITION OF COMMUTER SERVICES

6.2.1 Current Operation of Commuter Services

Bangladesh Railway presently operating **nineteen pair of** Commuter Trains mainly on the following three routs:

(a) Dhaka (Kamlapur) - Narayanganj,

(b) Dhaka (Kamlapur) - Tongi-Joydevpur,

(c) Chittagong - Chittagong University route.

Except on these routs, it also operates **seven** more trains in the name 'Commuter Train' but these are virtually medium distance local trains. Detail may be seen at Annex- 2.1

(1) Dhaka - Narayanganj route:

Ten pair of commuter trains runs per day on this section.

The sixteen kilometer stretch meter gauge (MG) single line section passes mostly through densely populated area of Dhaka and Naryanganj city. There are three intermediate railway stations in between, namely Gandaria, Fatullah, Chashara and one halt in a business center of Dhaka named Postugola on the route.

The trains are composed of conventional Locomotive and five passenger carriages with all second class accommodation, which has a capacity of about 300 passengers. But the trains are caring more than double of its capacity. Two such sets (Rakes) of composition ply to cover the ten pair of trains which is presently caring more than 8,000 passengers per day per direction. The carriages of these trains are in bad condition and the locomotives used are also over aged. The journey time of the trains for the sixteen kilometer distance is 42 minutes; the average speed stands 23 KMPH which is considered to be too low as against average speed of 40+ KMPH of normal commuter services in neighboring countries. The main reasons of low average speed of the trains are the bad condition of the track; tracks are occupied by temporary kitchen markets, poor old signaling system, and pedestrian walks along and across the railway track, too many rail-road crossings on the route, on and above the rolling stocks are not proper for Commuter trains.

Railway operates all the trains on the route, maintains the infrastructure and the rolling stocks on the section. Revenue collection is managed by licensing it out to private management on lease basis. This has improved revenue collection of the trains.

The schedules of the trains on this route are as follows:

Table 6.2-1 Time Table of Dhaka- Narayanganj Route

Sl.No.	Train No	Dhaka		Narayanganj	
		Departure	Arrival	Departure	Arrival
1	222	0550			0632
2	221		0743	0655	
3	226	0810			0900
4	225		1021	0930	
5	230	1230			1312
6	229		1501	1410	
7	234	1620			1708
8	233		1833	1745	
9	238	1930			2012
10	237		2153	2105	
11	224	0650			0732
12	223		0837	0755	
13	228	1000			1042
14	227		1251	1200	
15	232	1440			1522
16	231		1717	1635	
17	236	1740			1822
18	235		1951	1900	
19	240	2100			2142
20	239		2242	2200	

Source; BR Time Table- 45

(2) Dhaka-Joydevpur Route:

Two pair of commuter trains is operated per day on this section but it is named as 'Turag Express'.

The 32Km section has six intermediate stations, namely Tejgaon, Banani, Dhaka Cantonment, Biman Bandar and Tongi Junction. The route passes through centre of the Dhaka city and densely populated residential cum commercial area like Banani, Uttara to Tongi and then goes to joydevpur / Gazipur through an area not densely populated but it has a suburb characteristic. On this route Tongi is a major traffic generating area.

The trains are composed of conventional Locomotive and 5 passenger carriages which has a capacity to accommodate 300 passengers. One such set (Rakes) of composition ply to cover the two pair of trains which presently caring more than 2,000 passengers per day is. The carriages of these trains are in bad condition and the locomotives used are also over aged. The journey time for the 34 kilometer distance is 1hr.15 min but for one train it is 2hr 25 min. due to congestion of path. The main reasons of low average speed of the trains are, speed restrictions; tracks are occupied by temporary kitchen markets, pedestrian walks along and across the railway line, old signaling system, too many rail-road crossings on the route, on and above the rolling stocks are not also proper for commuter trains.

The schedules of the commuter trains on this route are as follows:

Table 6.2-2 Dhaka-Joydevpur Route

Sl.No.	Train No	Dhaka		Joydevpur	
		Departure	Arrival	Departure	Arrival
1	Turag-1	0510			0625
2	Turag-2		0850	0735	
3	Turag-3	1715			1835
4	Turag-4		2235		

Source; BR Time Table-45

Chittagong - Chittagong University route:

Commuter services on this route are operated mainly for the university students of Chittagong University named as 'University Shuttle'. However, this train does not exist in the DMA. Therefore, this isn't described here.

6.2.2 Passenger traffic of commuter Services

Bangladesh Railway publishes information on Passenger traffic services which includes year wise total Passenger Traffic, Gauge wise Passenger Traffic, Class wise Passenger Traffic and also service wise but not for commuter service separately. Therefore, it could not be made possible to get passenger data on commuter services exclusively.

Sales of tickets from railway stations in the study area were collected from BR commercial office at Dhaka (Annex.2.2a). This gives the number of out going passenger and it is assumed that similar numbers of passengers are coming in. On this assumption the average number of passenger **per month** at different stations calculated as under:

Section	Dhaka	Tejgaon	Banani	Da. Cant	Dahaka B. Bandar	Tongi		Total Section
Dhaka-Tongi	497,300	16,000	3,000	15,700	169,783	9,600		**917,832**
	Tongi	Dhira shram	Joydevpur	Gazi pur				
Tongi-Gazipur		2,266	69,100	2,634				**74,200**
	Tongi	Pubail	Arikhola	Ghorashal F	Ghorashal p	Jinardi	Narshindhi	
Tongi-Narshindi		1,500	5,924	6,462	366	4,216	45,550	**64,018**
G total								**1,056,050**

Daily average passenger of the three sections stands: **35,200**. This figure shows fare paying passengers only but lot of passengers are using railway without paying fare.

BR conducted a passenger survey on Commuter trains of Dhaka-Narayanganj route, in May 08, which shows that on an average 8,720 passengers per day are travelling by 10 pair of trains on the section. The trains are over crowded; many passengers are travelling on the carriage roof even at midday lean period. Consultant, after a ride on the train on this section, estimates that the ridership has farther increased and it has exceeded **10,000** passengers per direction per day (PPDPD).

Present study encompasses nearest district headquarters (HQ) Narayanganj, Joydevpur(Gazipur) and Narshindhi, connected by railway from Dhaka. The district headquarters are also well connected with Dhaka by regional and national highways. Passenger flows by road from and to these places are not readily available. However 'Annual Average Daily Traffic (AADT)' maintained by Roads and Highways Department (RHD) gives data for vehicle movement along the roads connecting Dhaka from Narayanganj, Joydevpur (Gazipur) and Narshindi. The relevant extract of AADT-2007 may be seen in detail at Annex.2.2b. In the study area Tongi is a major traffic generating point. Traffic flow from this point can be derived from the 'Cordon Line Survey', August. 2009, conducted under 'Dhaka Urban Transport Study' (DHUTS). The relevant extract is at Annex-2.2c

Narayanganj is connected with Dhaka by three regional roads, R110, R111 and R801.The AADT shows that on an average about 1,500 Large, 2,000 Medium and 2,500 Micro busses are plying daily on these three roads. Except these, large number of utility vehicle, auto-rickshaws and motor cycles are also moving on these roads. Considering average occupancy of Large, Medium and Mini Busses as 4,735 and 7 passengers respectably, daily passenger traffic on these three roads by busses only, stands 158,500 (1500x47+2000x35+2500x7). This shows that there are huge number of commuter passenger between Dhaka and Narayanganj. The roads are congested and scope for farther expansion is very limited.

On Dhaka–Narayanganj railway route, the railway stations, Gandaria, Fatullah, Chashara and the Halt at Pagla are all traffic generating points. Except these, there are other traffic generating points such as Saydabad, WASA gate etc. but presently trains do not serve these points.

Gazipur is connected with Dhaka by two regional roads R311 and R310, linking to national high way N3 and there after by R803. The AADT shows that on an average 274 Large, 393 Medium and 345 Mini Busses are moving on the road R311. The traffic on road R310 is 770 Large, 2088 Medium and 1,772 Mini Busses. Except these, large number of utility vehicle, auto-rickshaws and motor cycles are also moving on these roads. Daily passenger traffic on the road R310 by busses alone stands 123,000. It is very likely that many of them are destined to Dhaka. This shows huge number of potential commuter passenger from Joidevpur (Gazipur) area to Dhaka.

On Joidebpur (Gazipr)–Dhaka railway route all the six intermediate railway. Stations are traffic generating points and few more traffic generating points may be located after conducting the survey.

Narshindi is connected with Dhaka by regional road R210 through national high way N2. From the ADT of R210, it is observed that 112 Large, 1,148 Medium and 279 Mimi Busses are moving on this road. Except these, numbers of utility vehicle, auto-rickshaws and motor cycles are also moving. Daily passenger traffic on this road by busses alone stands 94,000. It is likely that many of these are destined to Dhaka.

On railway route Narshindi – Tongi, all the six intermediate stations are traffic generating points. Ghorashal industrial area is the most prominent area among those six intermediate stations.

Tongi is the largest industrial area near Dhaka and connected by national highway N3. It generates very high Commuter passenger traffic for Dhaka. A Cordon Line Survey (Traffic & OD) conducted in May 2009 for Dhaka Urban Transport Study (DHUTS) shows that on an average 179 Large, 490 Mini and 702 Micro Busses are moving on the road during 6.00 – 21.00 hrs. per day. The traffic volume near Rail Crossing stands about 30,572 by busses alone. Except this 1,461 Auto Tempo, 728 Maxi and 1,109 Auto Rickshaw are also moving on this road. Extract of the survey is given in Annex. 2.2c. the passenger for Dhaka along with local passenger is expected to be more.

Expected Passenger for Railway Commuter Services:

Transport requirements grow faster than that of GDP and population growth of the country. In case of Bangladesh, GDP growth is expected to be 5% to 8% in the coming years, where as population growth may be restrain in 1.5%. But in case of Dhaka and its surrounding areas the growth will be faster. On this fact it will not be unrealistic to assume that passenger transport requirement in this area will grow at the rate 8% to 10%. This requirement cannot be meeting by road transport only since the roads approaching Dhaka are already congested.

Passenger movement between Dhaka – Narayanganj as mentioned above leads to estimate that there is immediate requirement of farther rail based commuter service for 10,000 passengers Per-Direction-Per Day (PPDPD). Passenger movement from Gazipur, Narshindhi and Tongi show high potential of commuter passenger. It is estimated that at present rail based commuter passenger along Dhaka- Gazipur and Dhaka Narshindhi will be around 6000 and 4000 PPDPD respectably and about 8,000 PPDPD between Dhaka-Tongi.

6.3 CURRENT CONDITION OF RAIL INFRASTRUCTURE AND ROLLING STOCK

6.3.1 Current Conditions of Railway infrastructure

6.3.1.1 Dhaka-Narayanganj Route:

(1) Railway Track

This is a sixteen kilometer stretch; meter gauge (MG) single line passes mostly through densely populated area of Dhaka and Naryanganj city. There are three intermediate railway stations, and one Halt in a business center of Dhaka on the route. The route is crowded by thirteen authorized and eleven unauthorized level crossing gates.

The railway track is meter gauge (1,000mm), main line standard of 11.75 tons maximum axel load and maximum permissible speed is 50 km/h. The rail is 75lbs A type, 42 feet long, which was laid in 1978 on wooden sleepers fastened by dog spikes and double shank elastic spike. The sleeper density is N+3 on straight line and N+4 on curve, where N means length of rail in yards. The rail wear has gone beyond limit of 5%; sleeper unserviceable limit has also gone far beyond limit of 10%, now it varies from 51% -81%. There is no ballast on the track.

Presently there are varying speed restrictions from 30km/h to 15km/h at different places of the track.

(2) Operating, Signaling and Communication System:

BR operates train services in the section based on 'Absolute Block System' for single line operation. The operating safety criteria are defined in the General and Subsidiary (G&S) Rules. This requires that a train can be sent from a station (say Dhaka) to the next station (Gandaria) only when line clear has been obtained from Gandaria. To grant line clear, the Station Master of Ganaria shall have to be satisfied that the last train for which line clear was granted had arrived completely inside the station. After that, the Station Master, Gandaria, through cooperative operation of the block equipment with the Station Master, Dhaka, can grant line clear for the next train to leave Dhaka. After getting line clear, the Station Master Dhaka can clear the Starter and advance starter allowing the train to proceed to Gandaria.

Presently 20 number of trains run on this section. Sectional capacity of the section is 25x2. Thus, it has spare paths to run more number of trains.

The four stations of the section were provided with Non-interlocked Mechanical type 'Semaphore' signaling system and block workings with old type Tablet instrument, installed in fifties. The signaling system at Gandaria and Narayanganj stations has been changed to non-interlocked color-light system in the year 2004. Thus, the signaling system of the section still remains in poor condition.

The telephone system is based on composite optical fiber cum copper cable comprising Optical Fiber

(OF) and copper conductors. Telephone of the stations and the Tablet instrument are connected through copper wire of the composite cable.

(3) Railroad Crossing System:

There are as many as twenty four Level Crossing Gates (Railroad Crossing) in the sixteen kilometer route of which thirteen are authorized. These Gates are classified in 'Special Class', 'A- Class' and 'B Class' Gates, summery of these Gates are at Annex-3.1.1. None of these Gates are interlocked but eleven numbers of these are connected with concern Station Buildings by telephone.

(4) Stations:

The station buildings on the section, except at Dhaka are not in good condition. The passenger Platform, where passenger detrain and entrain, at Gandaria, Fatulah stations are low and there is none at halt Postugola. At Dhaka there are two separate platforms for Narayanganj bound local trains.

There are loop lines for crossing trains at stations, one each at Gandaria, Fatullah and two each at Chasara and Narayanganj. The length of these loops varies from 250 -500M, which is enough for crossing commuter trains.

6.3.1.2 Dhaka–Tangi-Joydevpur :

This route passes through centre of the Dhaka city and densely populated residential and commercial area like Banani, Uttara to Tongi and then goes to joydevpur/Gazipur through the area where doesn't densely populated but it has a suburb characteristic. The twenty three kilometer route from Dhaka to Tongi is double track Duel Gauge, where both Broad Gauge (BG) and Meter Gauge (MG) trains can ply. There are four intermediate railway stations, namely Tejgaon, Banani, Cantonment and Biman Bandar in the section and it is over crowded by thirty seven Level Crossing gates of which twenty three are authorized. A single line Duel Gauge, nine kilometer long track connects Tongi with Joydevpur. There is one intermediate station, named Dhirashram. As many as seventeen Level Crossing Gates are there of which only two are authorized.

The present position of the **Railway Track** on the section:

The entire track has been changed from Meter Gauge (MG) to Duel Gauge (DG), and commissioned in 2009. The track parameters are shown next:

		Dhaka- Tongi	Tongi –Joydevpur
Track Length	:	23km	9km
Loading	:	Double Track Duel Gauge	Single Track Duel Gauge
		(BG+ MG)	(BG+MG)
Track Rail	:	90lb-A	90lb- A
Sleeper	:	Pre stressed Concrete (PC)	Pre stressed Concrete (PC)
Sleeper Density	:	N+5	N+5
		(N means length of Rail in Yards)	
Rail Fasting	:	Elastic Rail Clip (ERC) Type	
Ballast Cushion	:	8 inches	
Max. Permissible speed	:	65 km/h MG: 75 km/h BG	
Axel Load	:	24 Authorized	2 Authorized
Level Crossing	:	13 Un-Authorized	16 Un-Authorized

(1) Operating System:

BR operates train services in the section based on 'Absolute Block System' for Double line operation up to Tongi and then for single line operation. . The operating safety criteria are defined in the General and Subsidiary (G&S) Rules. Train Operation follows as described above.

Currently BR is operating 80 numbers of trains on Dhaka-Tongi section of which 46 are intercity and rest are Mail/Express, local and container trains. The sectional capacity i.e. maximum number of trains that can run on the section is 56x2.This section is over congested at the rush hour of morning and evening.

Tongi-Joydevpur section has a sectional capacity of 22x2. Currently 40 trains are running on this section of which 26 are intercity trains. This section is also congested in the rush hour of morning and evening.

(2) Signaling and Communication System:

The present relay based interlock (RBI) color light signaling system of all five stations in Dhaka-Tongi section are being replaced by Computer based (CBI) signaling system with electrical point machines, color light signals, operated and controlled from station master key board. The replacement work will be completed by December'09. In Tongi –Joydevpur section, Joidevpur is provided with computerized signaling with electrical point machines, color light signals, operated and controlled from station master key board. But the intermediate station, Dhirashram remains with non interlocked color light signal system.

The telephone system of the section is based on composite optical fiber cum copper cable comprising Optical Fiber (OF) and copper conductors. Telephone of the stations and the signaling instrument are connected through copper wire of the composite cable.

(3) Rail-Road Crossing System

There are thirty seven Level Crossing (LC) gates between Dhaka and Tongi of which twenty four are authorized and thirteen are unauthorized. These twenty four authorized LC gates, eleven are provided with signaling and approach warning system.

In Tongi- Joydevpur section there are as many as seventeen Level Crossing Gates of which only two are authorized. Detail of these is given at Annex-3.1.1

(4) Station Facilities:

Dhaka station is located in the city centre with facilities of good approach roads and has good facilities for public transport connectivity. The station has extensive passenger as well as freight handling facilities. There are 11 passenger platforms with covered sheds, waiting rooms, embarkation and disembarkation facilities at platforms, ticket counters etc. Two platforms are exclusively built for Narayanganj bound local trains. Rolling stock maintenance facilities like Loco shed, Diesel Locomotive Workshop, Carriage Shed are also adjacent to the station area. Other stations of the section are connected with good public transport approach, passenger platforms with covered sheds, waiting rooms, embarkation and disembarkation facilities at platforms, ticket counters etc.

6.3.1.3 Togi–Narshindhi Route

This route is a portion of Tangi–Bhairab railway section on main trunk line of BR connecting Chittagong. It passes through suburb of the Dhaka city for a while and then proceeds towards Chittabong connecting industrial area at Ghorashal and district head quarter Narshindhi at a distance 22 km and 32km respectably. The 32km route from Tongi to Narshindhi is single track Meter Gauge. There are 6 intermediate railway stations on the route, namely Pubail, Nalsota, Arikhola, Ghorashal Flag, Ghorashal and Jinardy in the section. These Nalsota and Ghorashal Flag are non-crossing D class stations. There are 44 numbers Level Crossing gates of which 35 numbers are authorized.

Present position of the **Railway Track** in the section:

Tongi –Narshindi

Track Length	:	32km
Loading	:	Single,Meter Gauge (MG)
Track Rail	:	75lb-A
Sleeper	:	Pre stressed Concrete (PC)
Sleeper Density	:	N+5 (N means length of Rail in Yards)
Rail Fasting	:	Elastic Rail Clip (ERC) Type
Ballast Cushion	:	6 inches
Max. Permissible speed	:	65 km/h MG: 75 km/h BG
Axel Load Level Crossing	:	35 Authorized, 9 Un-Authorized
Platform	:	

An ADB aided development project for conversion of the single track of Tongi-Bhairab section in to double track with improved signaling system is going on and is schedule to be completed by 2013.

(1) Operation

Operation of trains in this section follows 'Absolute Block System' for MG single line as described earlier. Presently 40 numbers of trains run per day on the section while the sectional capacity is only 22x2 numbers of trains per day. Thus the section is saturated to its full capacity.

(2) Communication and signaling System

The signaling system of the crossing stations in the section, Pubail, Arikhola, Ghorashal, Jinardy and Narshindi are all relay based interlocked color light system. The telephone system is based on composite optical fiber cum copper cable comprising Optical Fiber (OF) and copper conductors. Telephone of the stations and the signaling instrument are connected through copper wire of the composite cable.

(3) Rail Road Crossing System**.**

There are forty four Level Crossing (LC) gates between Tongi and Narshindi, of which 35 numbers are authorized and 9 numbers are unauthorized.

Detail of these level crossing gates are given at Annex-3.1.1

6.3.2 Railway rolling Stock

(1) Locomotive:

BR has 286 numbers Locomotives (208MG+ 78BG), of which 246 numbers are active (175MG+71BG). These locomotives are from various countries and makes. Most of the locomotives are more than twenty years old and 40 % of the fleet crossed thirty years of their age. Maintenance of locos suffers from shortage of spares and budget, resulted in low availability which is in the range of 75% - 82%. Presently BR is facing shortage of locomotives for running schedule passenger and freight trains. BR's present locomotive holding detail including country of origin, year of manufacture, power etc is given at annex. 3.2a

BR is using 5 locomotives to run nineteen pair of commuter trains of which 2 locomotives to run 10 pair on Dhaka- Narayanganj, 1 locomotive to run 2pair on Dhaka- Joydevpur and 2 locomotives to run 7 pair between Chittagong- Chittagonj University stations.

(2) Carriages:

Bangladesh Railway is holding 1,379 number of passenger coaches (Excluding OCV) of which 1,067 numbers are MG and 312 numbers are BG. The carriages are of many categories and makes. However, these are broadly calcified into two categories, Intercity and non-Intercity carriages. Non-Intercity carriages are used for running Local and Commuter trains. Presently there are 586 numbers of MG Non-Intercity carriages of which 40 numbers (33 on rake + 7spare) are used for 19 pair commuter trains on the three routs, Dhaka-Narayngan, Dhaka-Joydevpur and Chittagong-Chittagong University. Maintenance of carriages also suffers form shortage of spares and budget resulted in low availability for effective service. Availability of carriages is about 75%. BR's present carriage holding detail including its age profile is given at annex. 3.2b.

Freight service is not a subject of this study; as such position of BR Freight wagons is not included here.

6.4 CURRENT IMPROVEMENT PLAN OF EXPANSION OF COMMUTER SERVICES

BR's development plan primarily targeted towards improvement of National Railway where commuters train operation has not been exclusively thought over. In a compelling situation BR has introduced very limited number of commuter services to face immediate dire necessity of transportation in and around Dhaka, with its available infrastructure and conventional rolling stock.

These trains are unable to meet the present, not to speak of the future need.

However, the present development programs/projects which has impact on Commuter Train service expansions around Dhaka are described here under:

6.4.1 Infrastructure:

(1) Construction of Double Line between Tongi and Bhairabazar including Signaling.

ADB supported "Railway Sector Investment Program" to augment Bangladesh Railway (BR) transportation capacity is now being implemented. Loan Agreement for implementation of the program was signed between ADB and GOB in April, 2007. This program has six components, Construction of Double Line between Tongi and Bhairabazar is the main one. Cost of the Project is about US$ 224 milliom of which US$ 74 million is in foreign currency. Consultants were engaged in Aug 2007 for implementation of the program and tender was floated in July 2008 for selection of General Contractor. But the Tender could not be finalized and in Oct 2009, it has been decided to re tender the same.

Project implementation authority BR now targeted to float the Tender again by Dec'2009 and the physical work hopefully will be started in July'2010. It will take three years to be completed by June'2013.

Implementation of this project will increase the line capacity of 22x2 to 44x2 trains per day against present use of 20x2 trains per day.

(2) Line Capacity Improvement between DHAKA and TONGI

Line capacity between DHAKA - TONGI is already saturated and no more trains can be introduced in the section particularly in the rush hour of morning and evening. Therefore, the program for line capacity improvement has been given priority of the six components of ADB supported "Railway Sector Investment Program".

An appraisal report on the 'Line Capacity Improvement' has been made by ADB consultants in April 2008. The report recommended introduction of intermediate Block Signaling for enhancement of line capacity in the section. The scope of the recommend project includes installation of 20 intermediate block signals (IBS), 10 in each direction on the double line with Centralized Traffic Control (CTC) System and Video Monitoring of 10 Level crossing gates.

Cost of this project has been estimated to be US$ 6.25 million of which US$ 5.59 million in foreign currency. The implementation schedule envisaged by the consultant is 3month for approval, 6 month for tender finalization and 15 months for physical work, in total 24 months. Implementation of this project will increase the Line Capacity from 56x2 to 112x2 trains per day as against present use of 40x2 trains per day.

ADB is supporting the recommendation of the Appraisal Report but has question on protection of railway track by fencing, segregation of level crossing, resettlement of issues within the right of way, which are vital for fast and safe operation of railway. These issues have not been addressed in the report or by some other project yet. Therefore it seems that implementation of the project may be delayed. BR project implementation authority is not certain about the time frame for implementation of this project.

(3) Improvement and Rehabilitation Dhaka- Narayanganj

BR has conducted a Feasibility Study for improvement of the section in 2007. The Study proposes to renew the track with heavier Rail, Steel sleeper, rebuilding of Bridges improvement of two platform, rebuild 4 station Buildings, rehabilitation and introduction of color light signals. This project will improve the present dilapidated condition of the track.

The project is being implemented from GOB's own fund. The cost for the project has been estimated as BDT. 434 million (US$6.2 million @ BDT70=1US$). Development Project Proforma/ Proposal (DPP) has been approved by GOB and the project is included in the current Annual Development Budget. Tendering process is complete and physical work will start soon and it is scheduled to be completed by June 2011. Implementation of this project will increase speed of the trains' vis-à-vis the Line Capacity will increase from 25x2 to expected 30x2 trains per day as against present use of 11x2 trains per day.

In the project paper nothing has been mentioned regarding providing stations on newly developed traffic generating points in the section. This aspect is important for expansion of Commuter Service, therefore needs to be examined.

(4) BR thinks that for expansion of commuter trains between Dhaka- Joydevpur, doubling of railway track between Tongi- Joydevpur is a must since the line capacity is already saturated. They will prepare PDPP soon and submit it to GOB for approval. The estimated cost of the project may be around BDT 800 million (US$ 11.42 million)

Implementation of this project will increase the Line Capacity from 22x2 to 42x2 trains per day as against present use of 20x2 trains per day.

(5) Construction of Double Line between Dhaka-Narayanganj

BR is now considering doubling of the track between Dhaka- Narayanganj. Chief Engineer/ East of BR is preparing Preliminary Development Project Proforma/ (PDPP) for the project. The estimated cost of the project may be around BDT 1,600 million (US$ 22.85 million)

Implementation of this project will increase the Line Capacity from 25x2 to 50x2 trains per day as against present use of 11x2 trains per day.

6.4.2 Rolling Stock

BR has seven on going development Projects related to Rolling Stock. These include procurement of locomotives, container freight wagons, workshop machinery, and rehabilitation of carriages, locomotives and improvement of workshops.

A new project has been initiated by BR which is directly related with expansion of commuter trains in and around Dhaka is ‘Procurement of 20 Set (Set consists of 3 units) of Diesel Electric Multiple Unit (DEMU) for Bangladesh Railway’. It has submitted Preliminary Development Project Proforma/Proposal (PDPP) to the Planning Ministry. The project implementation schedule is July 2010 to June 2015 and the estimated cost of the project is US$ 63.18 million of which US$ 43.45 million is in foreign currency. BR envisaged financial assistance for this project from EXIM Bank of Korea or some other donor Agency/ Country.

The DEMUs will be utilized to expand commuter trains on Dhaka-Narayanganj, Dhaka-Joydevpur, Dhaka-Narshindhi and Chittagong- Feni sections. Maintenance facility of this new type of rolling stock is not included in the project. It is learnt that BR has not yet made any proposal for its maintenance facility improvement to service the DMEUs.

6.5 ISSUES FOR EXPANSION OF COMMUTER SERVICES OF BANGLADESH RAILWAY

There are large number of commuter passenger for Dhaka from the study area i.e. from stations on the railway route to Narayanganj in the south, Joydevpur in the north-west and Narshindhi in the north-east. Estimated commuter passengers at present on these routs, in addition to the present, are 10,000; 6,000 and 4,000 PPDPD respectively.

The main issue for the Railway is 'how to serve the commuter passenger' integrating urban transport network of Dhaka.

The railway is now operating ten pair of commuter trains between Dhaka- Narayanganj, two pair between Dhaka- Joidevpur, recently one pair of these has been extended up to Narayanganj. Thus the trains in Dhaka-Narayanganj section actually stand at eleven pair. These trains are always over crowded; passengers are riding on the roof of the trains even on lean period of the day. This situation is common in case of local trains in the study area during pick hours of morning and evening.

To serve these Passengers, number of Commuters train is to be increased on Dhaka- Narayanganj, Dhaka–Tongi-Joidevpur and Tongi-Narshindhi section. The issues for increasing commuter trains are multifarious. These are:

a) BR has no proper rolling stock for commuter train operation. The trains are operated with conventional Locomotives and Passenger Carriages resulting in increase in operating cost.
b) BR does not have adequate number of rolling stocks for additional Commuter Trains.
c) The railway track (sections) between Dhaka – Tongi, Tongi- Joidevpur and Tongi- Narshindhi are saturated in respect of train operation and at present there is no path to introduce more trains particularly in pick hours of morning and evening.
d) Operating Sections are long for running frequent commuter trains.
e) The rail track of Dhaka– Narayanganj section is in dilapidated condition. However it has paths to accommodate some more trains. Without double tracking, these paths may not be adequate to meet the demand of passenger fully.
f) There are too many Rail-Road crossings on the sections, on an average one in every 600- 1000 meters, which restricts the speed of the trains. The trains are very slow, running at an average speed of 23-26 km/h.
g) Operation of high frequency commuter trains requires dedicated and grade separated track which has not been envisaged yet.

6.6 IMPROVEMENT PLAN OF EXPANSION OF COMMUTER SERVICES

BR in a compelling situation has introduced a very limited number of commuter services to face immediate dire necessity of transportation in and around Dhaka. The trains have been introduced with its available infrastructure and conventional rolling stock which is unable to meet the present, not to speak of the future need of a big metropolitan city like Dhaka. Therefore, it is essential to adopt an improvement plan for expansion of commuter services.

6.6.1 Improvement Policy for Expansion of Commuter Services

The Strategic Transport Plan, a study for guidance to the development of transportation infrastructure for Dhaka, over the next 20 years has recently been accepted by the Bangladesh Government. This study report is now considered base for transport development, institutional changes and policy adoption towards overall improvement of transport situation in Dhaka. The study has recommended a fund of one billion US$ for improvement of railway but did not specify any improvement policy or a plan. BR may now prepare policy and plan for its improvement, including Commuter Services.

Bangladesh is a densely populated country, small in area and as such travel distances in most cases are short. This situation demands high frequency transportation mode for medium and short distance travel. In particular this is truer for people in and around cities. In this scenario BR should adapt policies for introduction of frequent short distance trains (Commuter Trains) in and around big cities and then may expand it as needed.

BR has introduced some commuter trains around Dhaka with many limitations. Now its policy needed to concentrate on connecting district headquarters and important cities around Dhaka with more frequent commuter trains. In achieving this, the following policies may be suggested.

a) Increase line capacity,
b) Introduce proper rolling stocks.
c) Introduce improved operating system
d) Private participation in rolling stocks
e) Dedicated Track for Commuter Service as long term plan.

6.6.2 Target Passenger to be carried by Commuter Services

The target passengers, in addition to the present, to be carried in the initial year by Commuter Service are estimated as under:

a)	Dhaka- Narayanganj	10,000 PPDPD (Passenger Per Direction Per Day)
b)	Dhaka –Joydevpur	6,000 PPDPD
c)	Dhaka- Narshindhi	4,000 PPDPD
d)	Dhaka –Tongi	8,000 PPDPD

The estimate has been carried out on the passenger movement data. Passenger movement by road (data) is derived and calculated from traffic volume as in AADT 2007, Cordon Line Survey-2009 and by rail it has been calculated from number of tickets sold at concern stations. Therefore these data cannot be taken as highly qualified one. However these data indicates demand for commuter trains on Dhaka- Narayanganj, Dhaka- Joydevpur(Gazipur) and Dhaka- Narshindhi and also Dhaka-Tongi, which commensurate with practical experience. Though the data indicate very high demand, for the practical purpose it has been moderately teamed and estimated. However, need be, physical surveys on the field may be conducted to get passenger demand when feasibility study will be done for implementation of project.

6.6.3 Improvement Measures for Railway Infrastructure

Bangladesh railway's five Infrastructure development projects are directly related to Commuter Train Service expansion. These are described in para 4.1. Of the five, c and Dhaka-Narayanganj Railway Rehabilitation Projects are likely to be completed by 2013 and 2011 respectably.

The important project 'Dhaka- Tongi line capacity improvement', without which facilities of 'Tongi-Bhairab Double Line' project may not be utilized, is being delayed. This transpires that extension of Commuter Trains between Dhaka- Norshindhi may not be possible till such time this project is implemented. The envisaged 'Tongi- Joydevpur Double Line Project' seems to be far away, without which expansion of commuter trains between Dhaka-Joydevpur may not be possible.

Therefore, implementation of these 'Dhaka- Tongi line capacity improvement' and 'Tongi-Joydevpur Double Line' projects are to be given priority for expansion of Commuter Trains between Dhaka-Joidevpur, Dhaka- Narshindhi and Dhaka-Tongi.

Construction of 'Double Line between Dhaka-Narayanganj' is not a priority now since the line capacity which will be improved through implementation of 'Improvement and Rehabilitation Dhaka- Narayanganj' may meet the requirement of Commuter Trains for initial year. Study may be conducted to investigate its feasibility.

6.6.4 Improvement Measures for Railway Rolling Stock

Commuter Trains require proper rolling stocks but BR does not have such stocks. As mentioned earlier BR introduced commuter trains with its available conventional rolling stocks which cannot provide expected service to its commuter passengers. Therefore, proper efficient rolling stocks for expansion of Commuter Trains as well as replacement of existing conventional ones are required to be procured.

BR is presently caring 10,000 PPDPD in Dhaka-Narayanganj and 2,000 PPDPD in Dhaka-Joidevpur by 13 pair of commuter trains. It is targeted that farther 28,000 PPDPD are to be carried by expanded commuter trains (Para.6.2). On the basis of this requirement of rolling stock is estimated.

The requirement stands 24 sets of DMEUx3 =72 Cars. (One set is comprised of one power car and two trailer cars). Detail is at Annex.- 6.4.

6.6.5 Investment Costs

(1) Infrastructure:

Expansion of Commuter services is related to five infrastructure development project as mentioned in para- 4.1. ADB is funding for two projects, 'Tongi-Bhairab Double Line project' and 'Dhaka- Tongi Line Capacity Improvement Project'. GOB is funding 'Improvement and Rehabilitation Dhaka- Narayanganj project'. Construction of 'Double line between Dhaka-Narayanganj' project is not very urgent at this stage and needs further study.

Rest one, 'Construction of Double line between Dhaka-Joydevpur' project is considered to be urgent. This project is required to be financed.

- The section Tongi- Joydevpur is 11Km long have one intermediate station.
- The section is Duel Gauge (BG+MG). Construction cost of Duel Gauge by the side of existing railway track is not readily available. However, this has been estimated on the basis of Recommended Cost of Construction of Infrastructure shown in Railway Master Plan.

Cost of construction of 11Km Duel Gauge Line @ BDT. 155 million per Km, is about BDT. 1,705 million (US$ 24.3 million).

(2) Rolling Stock:

Commuter services for the target passenger will require 24 sets of DEMUs (Para.6.4).

BR has initiated a development project for procurement of 20 sets of DEMU with an estimated cost of BDT 4,385.60 million (US$ 63.18million) of which BDT 3,016.14 million (US$ 43.45) in foreign currency. BR expects that this will be financed by EXIM Bank of Korea or some other donor.

On this basis estimated cost of 24 sets of DEMU, stands BDT. 5,262.72 million (US$75.82 million)

Annex. 6.4

Assessment of rolling Stock Requirement

One Set of Diesel Electric Multiple Units (DEMU)
is composed of one Power Carriage and Two Trailer Carriages.

Carriage Capacity is 180 Passenger.

Train composed of two sets of DEMU and passenger capacity 1,080 numbers.

Section	Target Passenger in PPDPD	Section length	Present Average Journey Time: hr-min	Estimated journey Time: hr-min	Required Number of Trains: in Pair	Number of Train sets required	Total Number of Carriages Required	Remarks
Dhaka-Narayanganj	20,000	16 Km	0- 42	0-35	20	4	24	
Dhaka- Joydevpur	8,000	34Km	1- 20	1-00	8	2	12	
Dhaka- Narshindhi	4,000	57Km	1- 55	1-40	4	2	12	
Dhaka- Tongi	8,000	23Km	1- 15	0-40	8	2	12	
Spare						2	12	
Total					40	13	72	

APPENDIX 7: DEVELOPMENT OF A MODE CHOICE MODEL FOR DMA SUPPLEMENT PART: WILLINGNESS TO PAY STUDY

7.1 BACKGROUND

Providing an affordable and sustainable transport option for Dhaka, a mega-city of more than 12 million people, is currently the biggest challenge facing the country. In the Strategic Transport Plan (STP 2006) for Dhaka Metropolitan Area (DMP), ten alternative strategies have been evaluated and an improved public transportation system coupled with improved roadway system has been proposed. The improved public transportation system includes new mass rapid transit (MRT) systems comprising of a blend of Bus Rapid Transit (BRT) and Metro Rail (grade separated rail). The details of the proposed strategy have been presented in Appendix A.

A key concern regarding effectiveness of the proposed MRT system in Dhaka is the affordability of the potential users. This raises the question how much are people Willing-to-pay (WTP) for the improved services. However, since BRT and Metro, or modes of comparable level of service have never been implemented in our country, there are no Revealed Preference (RP) data for determining the WTP for these modes. Moreover, WTP depends on attitudes and personal preferences of the users and is strongly affected by socioeconomic factors. Therefore, an 'imported' WTP from other countries is not expected to be adequate or dependable.

Stated Preference (SP) surveys, also called self-stated preferences for market products or services, have been widely applied in the areas of marketing and travel demand modeling, separately or jointly with Revealed Preference (RP) data with observed choices of product purchase or service use. It is an efficient method to analyze consumers' evaluation of multi-attributed products and services, especially when there are hypothetical choice alternatives and new attributes. WTP values calculated from SP surveys have been successfully used in feasibility studies and design of new or improved transport initiatives. The features of SP techniques (discussed in more detail in the next Section) make them an ideal candidate for application for determining WTP for MRT in Dhaka City.

The organization of the report is as follows: we first present the theoretical basis and methodology of the survey. The different phases of the survey are presented next along with the corresponding findings. This is followed by a summary of findings and discussion on results and future research directions.

7.2 THEORETICAL BASIS AND METHODOLOGY

Overview of Methodology

Over the years, many stated preference approaches have been deployed to measure people's associated WTP: the most effective ones being direct (close-ended) contingent valuations (DCV), ranking exercises (RE), hypothetical referendum approaches (HRA) and stated preference choice exercises (CE).

improvement (e.g. how much are you WTP for reducing 5% emissions). In RE, they are asked to rank the attributes of interest according to their preference. In HRA, they 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 (e.g. would you be willing to contribute Tk Y to cover the cost of avoiding environmental damage X?) . 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 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. An example is given below in Table 7.2-1.

Table 7.2-1 Example of Choice Scenario

	Bus	**BRT**
Travel time (each way)	Same as now	10 minutes less than now
Comfort	Same as now	Articulated low floor buses A/C
Cost	Same as now	
Which mode would you choose?	**Bus**	**BRT**

CE experiments offer some important advantages over the other methods, principally, the ability to estimate coefficient values for attributes with relative ease and capture the tradeoffs 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.

Considering the advantages and appropriateness, CE experiments have been used for determining WTP for MRT in this study. In order to make the hypothetical choice scenarios closer to reality, both BRT and Metro Rail have been presented side by side as alternative options (since in STP, a blend of BRT and Metro have been suggested). These new options are compared against the existing travel modes (e.g. Car, Bus, Richshaw, Tempo, CNG and Taxi).

The planned sample size is 1000, 700 from current bus users and 300 from other mode users. Since the emphasis was on knowing the WTP of the potential riders of the BRT and Metro Rail routes proposed in STP, the data collection from current bus users was planned along these routes. In order to capture the preferences of users of other transport modes, data collection has been planned from offices located near the proposed route. It may be noted that the data collection plan is based on the critical assumption that travelers who currently cannot afford car, bus, taxi, tempo, rickshaw and

CNG will not be able to afford MRT as well (which are expected to have much higher fares compared to the existing public transport system).

Discrete choice models will be estimated from the pre-test and final data and WTP values will be calculated using the coefficients of time and cost.

The schematic diagram of the steps for determining the WTP has been presented in Figure 7.2-1. The outputs are marked by shading.

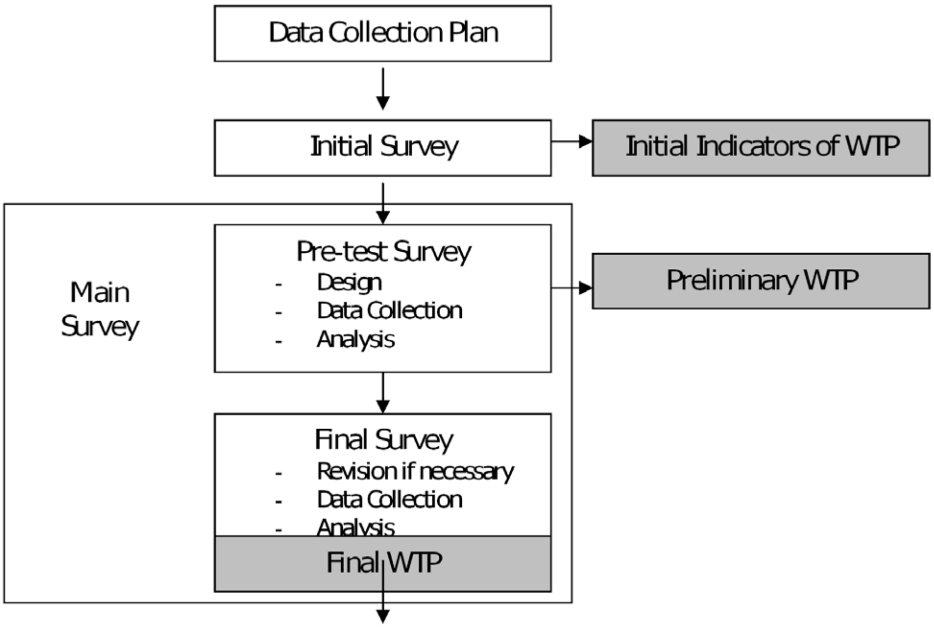


Figure 7.2-1 Steps of the SP Study

It may be noted that though the possibility of conducting a focus group study was considered in the beginning, literature review revealed existing work on focus groups by Mamun et al. (2009). This detailed study explores the WTP for the qualitative attributes of improved public transport options for Dhaka and was found to be sufficient and rigorous. This made any additional focus group studies redundant. Rather results from the findings of that study were used as the basis of our initial survey.

Details of Survey Design

In order to have the SP attribute values close to reality, the general practice is to use the RP values as 'anchors' or 'pivots'. However, 'adaptive' surveys, as commonly used in developed countries using the Internet or using Computer Aided Personal Interviews, are not possible to implement in our case. Due to resource limitations, the only feasible option for our data collection is paper-based surveys and the SP choices are presented along-side the current or 'As Now' situations. A sample choice is presented below:

BRT তে বাসগুলো পরিষ্কার পরিচ্ছন্ন থাকবে এবং বাসগুলো সুনির্দিষ্ট সময়সূচী মেনে চলবে। এ ছাড়া প্রতি ৫ মিনিটে একটি বাস পাওয়া যাবে, বাস ছাড়ার পরে ১০ মিনিট সময় কম লাগবে এবং ভাড়া ৭ টাকা বেশী লাগবে।

সেক্ষেত্রে আপনি কোন সার্ভিসটি ব্যবহার করবেন উলেখ করুন।

BUS BRT

This approach has been used in some other transport studies without any loss of accuracy/limitation.

Presenting the SP choices has been very challenging from several aspects. In particular, the travelers are expected not to have an a-priori perception about BRT and/or Metro Rail and elaborate descriptions were required along with pictures of the two systems:

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 একাধিক বগি বিশিষ্ট বড় বাস চালু করা হবে। এই বাসগুলো রাস্ড়ার 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।

Figure 7.2-2 BRT Show Card

মেট্রো ট্রেন ব্যবস্থায় রাস্ড়া দিয়ে, রাস্ড়ার নীচ দিয়ে বা ফ্লাইওভারের মত ব্রিজ দিয়ে ট্রেন চলাচলের ব্যবস্থা করা হবে এবং এর ফলে যাতায়াতের সময় **অনেক অনেক কমে** যাবে। 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 ইজঞ-র তুলনায় **অনেক অনেক বেশী** হবে।

Figure 7.2-3 Metro Show Card

be biased by the pictures and make their decisions based on that rather than the descriptions and levels of service. So, the pictures were used only 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).

The survey consisted of the following set of questions:

a. Questions about the current travel behavior of the respondents
b. SP Scenario
c. Socio-economic questions
d. Questions to understand the level of understanding

The questions on current travel behavior for public transport users comprised questions to get the following information (in the context of their current trip):

1. Name of bus-stop
2. Time of day
3. Origin (Type and rough address)
4. Destination (Type and rough address)
5. Expected journey time

6. Current waiting time
7. Approximate fare
8. Other available modes
9. Reason for using the public transport
10. Frequency of travel in that route

For car users the corresponding information (related to the most recent car trip) was as follows:

1. Origin (Type and rough address)
2. Destination (Type and rough address)
3. Approximate starting time[1]
4. Approximate end time
5. Availability of bus service (with reasonable walking distance)
6. Availability of other modes
7. Reason for using car
8. Frequency of making that kind of trip
9. Access to car (self-owned, company car)
10. Driver appointment
11. Approximate car cost per month
12. Approximate car cost for the trip in discussion (This will be asked indirectly.
    For work trips, respondents will be asked: "if you had the option to use a company car for free for this trip, how much do think you could have saved?"
    For non-work trips, respondents will be asked: "if you had the option to use a friends car for free for this trip, how much do think you could have saved".

In SP scenario, in order to keep the choice task tractable, the number of attributes was limited to three. The attribute levels were selected to be different for small, medium, long and very long trips (to make the choice scenarios realistic). Since travelers tend to perceive time better than distances, this classification was based on experienced/expected travel times. The following ranges have been used in this regard.

Table 7.2-2 Trip Class Definitions

Trip class	Trip duration (minutes)
Short 1	5-30
Medium	31-45
Long	46-60
Very Long	>60

[1] Time of day will be calculated from starting time. Journey time will be calculated using start and end times.

In order to select the most important attributes, an initial survey was done (detailed in next section). Multiple levels have been assumed for each attribute. The upper and lower ranges of the levels have been determined on the findings from the initial survey. In order to limit the size of full factorial design, the number of levels has been minimized as well.

In order to ensure unbiased results, hypothetical attribute values are generated for SP choice scenarios using experimental design techniques. The statistical software SPSS has been used in this regard. From the full factorial design, extreme/dominant combinations have been eliminated. Dominant choices corresponded to cases where the Metro Rail LOS is more than 1 level worse than BRT.

Because of the complexity of the choice task and unfamiliarity with the new modes, the choice task was limited to one per respondent to avoid confusion.

Discrete Choice Model Development

Discrete choice models are used to gain insight into what drives the decisions that individuals make when faced with a number of alternatives. These models are constructed by specifying the range of alternatives that were available to the decision maker, and describing each of these alternatives with a utility equation which reflects the levels of each of the attributes that were present in the choice that they faced. Each term in the model is multiplied by a coefficient which reflects the magnitude of its impact on the decision making process (Ben-Avika and Lerman, 1985; Train, 2003).

It is the model coefficients that are estimated in the model calibration procedure. The model is based on the assumption that each respondent chooses the alternative that provides him or her with the highest utility. An error term is included on each utility function to reflect unobservable factors in the individual's utility. The estimation can therefore be conducted within the framework of random utility theory, i.e. accounting for the fact that the analyst has only imperfect insight into the utility functions of the respondents.

The most popular and widely available estimation procedure is logit analysis. The estimation procedure produces estimates of the model coefficients, such that the choices made by the respondents are best represented. The standard statistical criterion of Maximum Likelihood is used to define best fit. The model estimation provides both the values of the coefficients (in utility terms) and information on the statistical significance of the coefficients.

Additional terms and non-linear variations in the variables can be added to these utility functions, with the testing of the appropriate forms for the utility functions being an important part of the model estimation process. By examining different functional forms we can investigate whether different groups of respondents place different values on the attributes in the choices, and can also test whether there are certain groups of respondents that are more likely to systematically choose one alternative over another (i.e. whether or not there are market segmentations). The potential correlations among alternatives (nested logit models) will be tested.

The WTP values can be calculated using the ratios of attribute and cost coefficients and can be segmented based on socio-economic groups (based on income, age, eductation level, car ownership, current preferences etc.) found from the market segmentation tests. The corresponding mathematical representations have been presented in next section.

In this study, we will be using the statistical estimation software BIOGEME (http://roso.epfl.ch/biogeme) for estimating the discrete choice models. BIOGEME has been developed and updated by leading researchers in the field of Discrete Choice Analysis around the world. It supports, Multinomial Logit Model, Nested Logit Model, Cross Nested Logit Model and can handle panel data and models with random coefficients (Mixed Logit Models). Moreover, it is available for free which makes it easier for interested future researchers and practitioners to replicate the work using this software.

Calculation of WTP

The relative preference for an alternative mode or the desirability for it can be quantified by its utility function.

The utility of an alternative mode i of individual n can be expressed as follows:

$$U_{in} = \beta_i X_{in} + \varepsilon_{in}, i \forall C_n$$

where,

X_{in} = *Vector of attributes of mode i corresponding to individual n*

β_i = *Coefficient of* X_{in}

ε_{in} = *Raandom error term corresponding to utility of mode i for individual n*

C_n = *Choice set of individual n*

The functional form of the probabilities depend on the distribution of ε_n ; e.g. if ε_n is assumed to be Gumbel distributed, the functional form is Logit, if ε_n is assumed to be normally distributed, the functional form is Probit etc. β s can be estimated from the collected SP choice data using Maximum Likelihood Technique.

Now, assuming that *k* market segments exist among travelers (e.g. there are *k* income groups in the population and each have significantly different WTP) and there are j attributes in the utility function, the utility of an alternative mode *i* of individual n_k (where n_k belongs to market segment *k*) can be expressed as follows:

$$U_{in_k} = \sum_j \beta_i^j X_{in_k}^j + \varepsilon_{in_k}, i \forall C_{n_k}, n_k \in k$$

where,
j *denotes attributes;e.g. travel time(tt), travel cost(tc), frequency(fr) etc.*
k *denotes market segments*
$X^{j}_{in_k}$ = *Attribute j of mode i corresponding to individual* n_k
(where n_k *belongs to marketsegment k)*
β^{j}_{ik} = *Coefficient of* $X^{j}_{in_k}$ *(sensitivity for attribute j of alternative i to travelers belonging to market segment k)*
ε_{in_k} = *Random error term corresponding to utility of mode i for individual* n_k
C_{n_k} = *Choice set of individual* n_k

The estimated coefficients can be used to directly calculate the mean WTP:

WTP for Travel Time (tt):

$$WTP^{tt}_{ik} = \frac{\beta^{tt}_{ik}}{\beta^{tc}_{ik}}$$

β^{tt}_{ik} = *sensitivity for tt of alternative i to travelers belonging to market segment k*
β^{tc}_{ik} = *sensitivity for tc of alternative i to travelers belonging to market segment k*

WTP for Frequency (fr):

$$WTP^{fr}_{ik} = \frac{\beta^{fr}_{ik}}{\beta^{tc}_{ik}}$$

β^{fr}_{ik} = *sensitivity for service frequency of alternative i to travelers belonging to market segment k*
β^{tc}_{ik} = *sensitivity for tc of alternative i to travelers belonging to market segment k*

Similarly, mean WTP for other attributes like comfort, safety, security etc. can also be determined. Moreover, the confidence interval associated with the WTP can be calculated using the standard errors of the estimated coefficients (examples of such WTP outputs are presented at Choudhury et al. 2008).

7.3 INITIAL SURVEY

The main objectives of the initial survey are as follows:

1. Identify the important attributes of different transport modes as perceived by the users;
2. Get an idea about the ranges of WTP for improved public transport system (i.e. for reduced travel time, reduced waiting time, reduced no. of transfers etc.).

The initial survey was conducted in two phases. In first phase the survey was conducted among current bus users and in second phase it was conducetd among non-bus users. It was difficult to collect diverse work and non-work trip data from current non-bus users in a short time. For example, 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 was 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.

In order to overcome the difficulty, members of the data collection team (graduate students of BUET) were asked to question people from their personal network (including BUET employees) who currently do not use bus. The collected data turned out to cover car users only. However, this was not deemed to be a critical limitation since the bus users and car users in Dhaka represent the transport user groups with the lowest and highest affordability and their responses are expected to reflect the maximum and minimum ranges of WTP (which is the key interest of the initial survey).

The findings of the two surveys are summarized below.

For Current Bus Users

The initial survey among the bus users has been conducted on 13th of September, 2009. The survey questionnaire can be broadly divided into three different sections. The aim of the 1st section was 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 2nd section consisted of some open ended questions to get an idea about the ranges of the users'

WTP for reduced waiting time, travel time, reduced no. of transfers etc. In this part the respondents were also asked to mark different attributes of transport modes as important or unimportant. The third part contained some questions about the socio-economic characteristics of the respondent. The full questionnaire is appended in Appendix-4B. It may be noted that the WTP questions for travel time were classified based on duration of trips.

32 completed questionnaires were obtained from Airport, Mohakhali, Shahbag and Azimpur bus stops. The findings from the study are summarized below:

<u>Important mode attributes as perceived by the users</u>

- 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 has emerged as the most important attribute while reduction in travel time and cleaner and more comfortable buses were perceived as 2nd and 3rd important attributes by the users.
- The following table shows the ranking of different attributes as perceived by the users.

Table 7.3-1 Rankings of Imporved Public Trasnport Attributes (Current 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 service	5
Underground metro rail Service	7
Have better bus stops	8
Direct service to destination	9
Keep the same fare	10

WTP Ranges:

A brief summary of the obtained WTP ranges are given below.

Waiting time reduction:

- The respondents were asked how much extra fare they were willing to pay for total 5 minutes waiting time.
- The average WTP for all trip duration was found to be 2.023 taka with a maximum of 10 taka and a minimum of 0 taka for all trip durations.
- However it was found that the WTP for reduced waiting time were greater for short trips than for long trips.

Travel time reduction:

- 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.

Table 7.3-2 Mean WTP for reduced travel time for different trip durations

Average for	WTP (extra) for 5 min reduction (Tk)	WTP (extra) for 10 min reduction (Tk)	WTP (extra) for 15 min reduction (Tk)	WTP (extra) for 20 min reduction (Tk)
TT 15 to 30 min	1.500	3.100	-	-
TT 31 to 45 min	0.438	1.125	1.250	-
TT greater than 45 min	0.154	1.346	2.077 tk	4.308

- For short trips WTP for reduced travel time were 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 were used to determine the ranges of travel cost to be tested in the main survey. Following table summarizes the maximum and minimum values of WTP as obtained from the initial survey for different trip duration.

Table 7.3-3 WTP ranges for reduced travel time for different trip durations

WTP	TT 15 to 30 min		TT 31 to 45 min		TT > 45 min	
	Minimum (Tk)	Maximum (Tk)	Minimum (Tk)	Maximum (Tk)	Minimum (Tk)	Maximum (Tk)
5 min reduction	0	6	0	3	0	2
10 min reduction	0	10	0	2	0	4
15 min reduction	0	0	0	3	0	5
20 min reduction	0	0	0	0	0	10

Based on the results of the initial survey the following three attributes were selected for the main survey:

1. Frequency
2. Travel time
3. Cost

Sum of WTP for reduced waiting time (i.e. for increased frequency) and WTP gives indication on the total WTP. So, the maximum WTP as obtained from the initial survey was 20 tk (maximum 10tk for reduction in waiting time and maximum 10 tk for reduction in travel time) . Similarly the minimum WTP was 0 tk.

The results thus gave useful indication on the WTP ranges which were used for the main survey design. However, for the pre-testing phase, the ranges were assumed to be on the high end on purpose so that the upper ranges can be more clearly captured. Based on the findings from the pre-test survey, this may require revision on the Final Survey.

Based on this the minimum value of increase in travel cost to be tested in the main survey for BRT has been taken as 3 tk and the maximum has been taken as 20 tk and those for Metro have been taken as 5 tk and 25 tk respectively.

This resulted the following levels for the Pre-test/Preliminary survey for current bus users:

Table 7.3-4 Lievels of Attributes

FACTORS	LEVEL	FOR BRT				FOR METRO			
		SHORT (TT 15-30 min)	MEDIUM (TT 31-60min)	LONG(46-60 min)	VERY LONG (>60 min)	SHORT (TT 15-30 min)	MEDIUM (TT 31-45min)	LONG (46-60 min)	VERY LONG (>60 min)
In vehicle 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 (tk)	1	+ 3	+ 5	+ 7	+ 7	+ 5	+ 7	+ 10	+ 10
	2	+ 5	+ 7	+ 10	+ 10	+ 7	+ 10	+ 12	+ 15
	3	+ 7	+ 10	+ 15	+ 15	+ 10	+ 12	+ 15	+ 20
	4	+ 10	+ 12	+ 20	+ 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

For Current Car Users

The data collected as part of the initial survey for the car users have been collected among personal contacts of data collection teams and BUET employees.

It was anticipated that the WTP and importance of different attributes for improved public transport to the users will be different for work trips and for non-work trips. In order to capture the difference the survey questionnaire had two versions; one for work trip and the other for non-work trip. A total of 77 complete questionnaires were obtained (37 for work trips and 40 for non-work trips). The questionnaire of both versions have been appended in Appendix B.

<u>Important attributes for improved public transport as perceived by the users</u>

- More reliable and on time service has emerged as the most important public transport attribute for the car users as contrary to the bus users. Cleaner and more comfortable buses and reduced travel time were the 2nd and 3rd most important public transport attributes respectively for the car users.
- Ranking of different public transport attributes as perceived by the car users are given in the table below.

Table 7.3-5 Rankings of Imporved Public Transport Attributes (Current Car Users)

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

<u>WTP ranges:</u>

It was found that in many cases the car users had very little idea about the fare of the existing public transport modes and in some cases they had no idea at all. So, it was difficult for them to answer when they were asked how much fare (total) they were WTP for a travel time reduction of 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) and some replied in terms of absolute value (like 10 tk , 30 tk etc.). It makes the task of finding the reasonable range for WTP more difficult. Maximum and minimum values of the WTP are summarized in the table below.

Table 7.3-6 WTP ranges for reduced Travel Time (TT)

Trip duration	TT reduction	For Work Trip		For Non-work Trip	
		Minimum (Tk)	Minimum (Tk)	Minimum (Tk)	Minimum (Tk)
15 to 30 min	5 min	0	30	0	20
	10 min	0	50	0	30
31 to 46 min	5 min	0	30	0	20
	10 min	0	35	0	23
	15 min	0	40	0	25
46 to 60 min	5 min	0	100	0	25
	10 min	0	110	0	25
	15 min	0	120	0	30
	20 min	0	130	0	50
	30 min	0	140	0	40
> 60 min	5 min	0	0	0	30
	10 min	0	20% more than now	0	32
	15 min	0	25% more than now	0	34
	20 min	-	50% more than now	-	37
	30 min	-	75% more than now	-	40
	40 min	-	80% more than now	-	45

As mentioned earlier the table does not provide a very clear idea about the WTP ranges to be tested in the pilot survey or main survey; however it is clear that there is significant difference in WTP for work trips and for non-work trips and the WTP values are higher for work trips than for non-work trips.

In addition to the above findings there were some general findings regarding the travel behavior of the car users.

- Flexibility, safety and less travel time (faster than other modes) were the three principal reasons for using car.
- A significant difference was observed among the car users in willingness to switch to public transport for work trips and non-work trips;
- 54% of the respondents were willing to switch to improved public transport system if there are any but in case of non-work trip only 35% are willing to switch to improved public transport mode.
- It was also found that there was a lack of knowledge about the availability of public transport among the car users.
- Some 14% of the respondents said that they didn't know wheather any public transport were available for their trips or not. The levels for attributes of current car users are still under construction.

7.4 MAIN SURVEY

The main survey was executed in two phases:

1. Pre-test/preliminary survey
2. Final survey

The pre-test or preliminary survey was conducted first with a small sample of respondents.
The purpose of the pre-test was as follows:

- to analyze the data and to test if the presented WTP ranges were appropriate
- to estimate preliminary models and check if the trends of the coefficients match the a priori hypotheses or can be justified by the supporting information

The findings of the pre-test survey were used to fine tune the final survey.

In this chapter, we first present the details of the pre-test surveys. The details of the survey design, data collection plan, findings and subsequent modifications are presented in this regard. The final survey details are presented next. The preliminary analysis of the pooled data from all surveys is presented next followed by the detailed model development using discrete choice analysis. The Willingness-to-Pay (WTP) results are presented in the end.

7.4.1 Pre-test and Final Survey

Both the pre-test survey and final surveys were done separately for the following groups:

1. Current Bus/Tempo (including Maxis) users
2. Current users of other modes
    a. Car users
    b. CNG/Taxi users
    c. Rickshaw users

Data for current Bus/Tempo users were collected from stops and onboard. Data for other mode users were collected from shopping malls, schools, airport, railway stations, offices and over phone.

For data collection from office, a more verbose version of the questionnaire was handed out to employees of the office and collected after a week.

For data collection over phone, the survey questionnaire was read out to people who had already participated in the initial survey and had given their consent to participate in further surveys.

7.4.1.1 For Current Bus Users

Survey design

Three attributes i.e. frequency, travel times and travel costs were used for the design in describing the Metro Rail and BRT. The frequency affected the waiting time associated with the mode. Five levels were used for frequency, four levels were used for both travel time and travel cost.
The levels of attributes used for the bus pre-test are presented in Appendix 4D (Table 4D1).

Pre-test survey among the bus users was conducted in two phases. Two separate models have been estimated using the data from each phase. A brief summary of the key findings of the two surveys are provided below.

Pre-test survey: Phase 1:

Data:
71 valid data were obtained form the phase 1 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). Among the 71 respondents, 12 had access to car (2 had self owned car, 9 had family owned car and 1 had office owned car).

Findings:
Among the 71 respondents 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 was estimated using these 71 observations.

The estimated model results are presented in Appendix 4F (Table 4F1). The model had 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 values).

Modifications:

For the above mentioned limitation (wrong sign of waiting time/frequency), the description of frequency was rephrased in the Phase 2 survey. In the final survey, 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 to represent more realistic waiting times.

Moreover, an additional question was asked about the major attributes considered (i.e. explicitly asking: What attribute(s) did you take into consideration while making your choice). This response was expected to provide useful indication for cross-checking data (if needed). (84% said that thaey considered travel time, 57% said that they considered travel fare and 38% said that they considered frequency while taking the decision.)

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 2nd phase 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 4D (Table 4D2).

It was decided that there will be a second phase of pre-test (Phase 2) to double check that the updated survey indeed overcomes the limitations of the first phase pre-test survey.

Pre-test survey: Phase 2:

Data:

In the Phase 2 survey 93 valid data were obtained. The trip length distributions indicated a more uniform distribution and the additional trip length group was 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).

Analysis showed good coverage of all levels of attributes. Among the 93 respondents 23 had access to car (6 self owned car, 16 family owned car and 1 office owned car).

Findings:

Among the 93 valid data 2, 55 and 36 respondents chose bus, BRT and Metro Rail respectively. In response to the question regarding the major attributes considered 84% respondents stated that they considered time, 57% stated that they considered fare and 38% stated that they considered waiting time while choosing the alternatives. A multinomial legit (MNL) model was estimated using these 93 data point and revealed anticipated signs for all attributes. The results are presented in Appendix 4F (Table 4F2).

Modifications:

Since the findings from the Phase 2 survey were satisfactory, no changes for all levels of attributes were made in the Final survey.

7.4.1.2 For Other Mode Users

Survey design

Three attributes i.e. frequency, travel time and travel cost (same as for the bus users) were used for the design in describing Metro Rail and BRT. The number of levels used was also same as that for the bus users that is: five levels were used for frequency, four levels were used for both travel time and travel cost.

For, frequency, no changes were made in the frequency levels (frequency values were kept same as for the bus users).

Since time was presented as travel time reduction from the current trip; it was assumed that there will be greater time reduction for rickshaw users than for car and CNG and Taxi users. Consequently, greater time reductions were used for the rickshaw than for the car and CNG and Taxi users. For the car and CNG and Taxi users same values were used for travel time reduction.

Costs were represented as absolute cost to avail a trip using Metro Rail and BRT as opposed to the cost increase from the current mode (car, CNG and Taxi or rickshaw) corresponding to that trip. This change was warranted based on the findings of the initial survey, where it was observed that car users very often do not have any clear idea about the current bus fares. Therefore, absolute costs were presented in (e.g. Tk 50, Tk 80 etc.) rather than cost increases and decreases (e.g. Tk 15 more than now, Tk 20 more than now etc.).

Three different level of service in terms of travel cost were presented to the rickshaw users, car users and the CNG and Taxi users assuming that the willingness to pay would have been different for these three user groups. The travel cost presented to the CNG and 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 detailed table of attributes have been inserted in Appendix 4E (Table 4E1-4E3).

Pre-test Survey

Data:

The pre-test survey was conducted on 15 and 17 December, 2009 among the car, rickshaw and CNG 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.

Findings:

Three different generic MNL models were estimated for car, CNG/Taxi and Rickshaw users. The estimation results are included in Appendix 4F (Table 4F3-4F5).

Apart from the sign of frequency for Metro Rail and Car users, all coefficients had expected signs (the coefficient of frequency was statistically insignificant).

Modifications:

The values of the frequency levels have been reduced according to the Table 4E7-in Appendix 4E for all the versions of the survey questionnaire.

The time levels were kept same in the Final survey as those used for the pre-test survey for all 3 versions of the survey.

The cost levels were slightly adjusted in the Final survey based on the detailed ranges of fares obtained from the current users in the pre-test survey.

For Car and Rickshaw users, BRT fare was kept same, but the Metro Rail fare were increased a bit compared to the BRT fare. The changed fare values are presented in Appendix 4E (Table 4E4-4E5).

For CNG/Taxi users both the BRT fare and Metro fare were increased from those used in the pilot survey. From the pre-test survey it was found that most of the presented BRT and Metro Rail fares were less than the CNG/Taxi fares. Consequently sensitivity towards travel cost was found to be insignificant in the estimated model. From the collected pilot data minimum values of the CNG/Taxi fare were 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 4E; Table 4E6).

7.4.2 Preliminary Analysis

7.4.2.1 Data Inventory

461 valid responses were collected from current Bus users in the Final survey. The full inventory of data is presented in Table 7.4-1. The data collection locations for buses are detailed in Table 7.4-2. In each case the valid samples are included in parenthesis.

Table 7.4-1 Data Inventory

		No.s of Data Collected				
		Pre-test:		Final Survey (valid)	Total by Mode (valid)	% by mode
		1st phase (valid)	2nd phase (valid)			
By the surveyors	Bus	72 (71)	96 (93)	468 (461)	636 (625)*	67.95
	Tempo			22 (22)	22 (22)	
	CNG	39 (39)		56 (55)	95 (94)	9.72
	Taxi			18 (18)	18 (18)	
	Rickshaw	54 (54)		87 (84)	141 (138)	12.18
	Car	32 (32)		87 (87)	119 (119)	10.15
From office**	Bus	—		12 (0)		
	Tempo			0 (0)		
	CNG	—		7 (0)		
	Taxi	—		0 (0)		
	Rickshaw					
	Car			8 (0)		
	Total				1031 (1016)	100.00

* The phase 1 pre-test data was not used for estimation

** The initial plan was to collect data from three offices : Ericson Bangladesh (Gulshan), Bangladesh National Insurance Company (Motijheel) and BRAC (Mohakhali) but the initial data from office (collected from Ericson Bangladesh) was not found to be very useful (had missing entries for multiple fields).

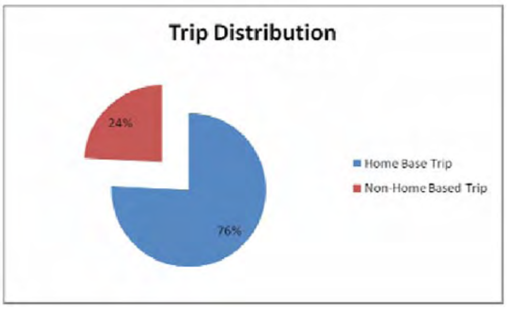
Table 7.4-2 Data Collection Locations of Bus

Locations	Pre-test Phase 1	Pre-test Phase 2	Final Survey
Uttara	12 (12)	8 (8)	52 (51)
Motijheel		16 (13)	56 (56)
Gabtali bus Station		8 (8)	40 (40)
Mirpur		8 (8)	56 (56)
Malibag			10 (10)
Farmgate	12 (11)		18 (18)
Shahbag	12 (12)	16 (16)	20 (20)
Premium Bus stops/ On-board	12 (12)	24 (24)	94 (91)
Gulistan	12 (12)		18 (17)
Nawabpur			20 (19)
Moghbazar	12 (12)		8 (8)
Kamal Atarturk	12 (12)	8 (8)	44 (43)
Tejgaon (shat rastar mor)			20 (20)
Mohakhali		8 (8)	12 (12)
Total	72 (71)	96 (93)	468 (461)

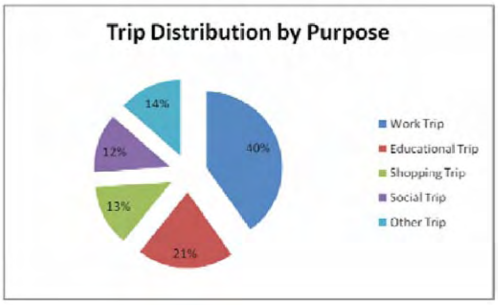
Out of the 1016 total valid responses, the first phase bus pre-test data (71observations) were not used for the model estimation. In addition, origin-destination, income and socio economic data were unknown for 17 respondents. Therefore, for discrete choice model development, the remaining 928 observations were used.

7.4.2.2 Data Characteristics

The data with valid origin destinations (938 responses) were categorized in two ways. Firstly, all the trips were grouped into home based trips and non-home based trips; then the trips were classified as working trips, educational trips, shopping trips, social trips (visiting to friends' & relatives' house) and other trips. Percentage of the trips falling into different categories is shown below in the form of pie charts.



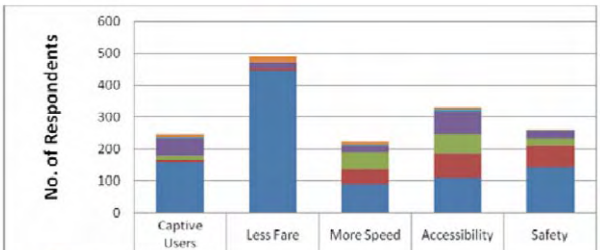
(a)



(b)

Figure 7.4-1 (a) Trip Distribution (HBT & NHB), (b) Trip Distribution by Purpose

The respondents were asked to mention the reason they feel important for choosing the mode they were using for that particular trip. A significant difference has been observed among different mode users while mentioning the reason. For example among the Bus and Tempo users low fare was 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 was accessibility. The following bar chart shows the no. of respondents by mode choosing different attributes of their current modes.



	Captive Users	Less Fare	More Speed	Accessibility	Safety
TEMPO	10	20	11	6	2
TAXI	1	0	4	6	2
RICKSHAW	54	17	18	70	23
CNG	15	0	52	61	23
CAR	8	7	46	79	67
BUS	158	446	92	108	144

Figure 7.4-2 Reason behind choosing different modes

To get an idea about how dependable the data were (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 were frequent users of the routes as depicted in the chart below.

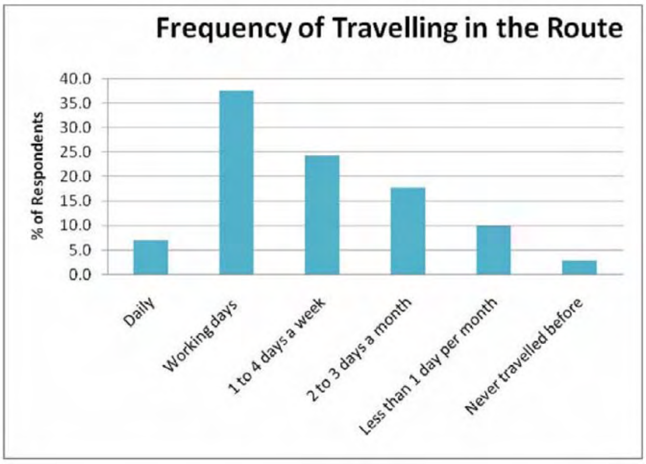
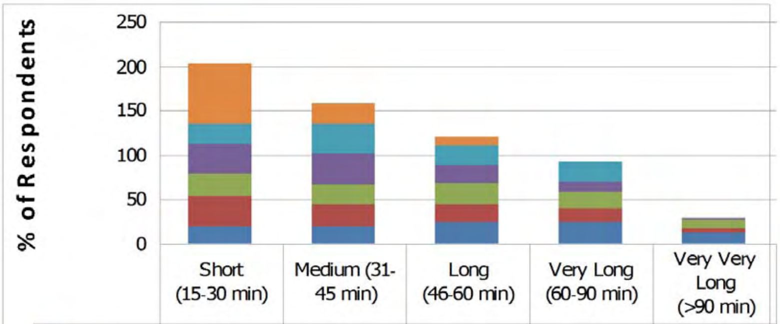


Figure 7.4-3 Travel frequencies of the users in the routes

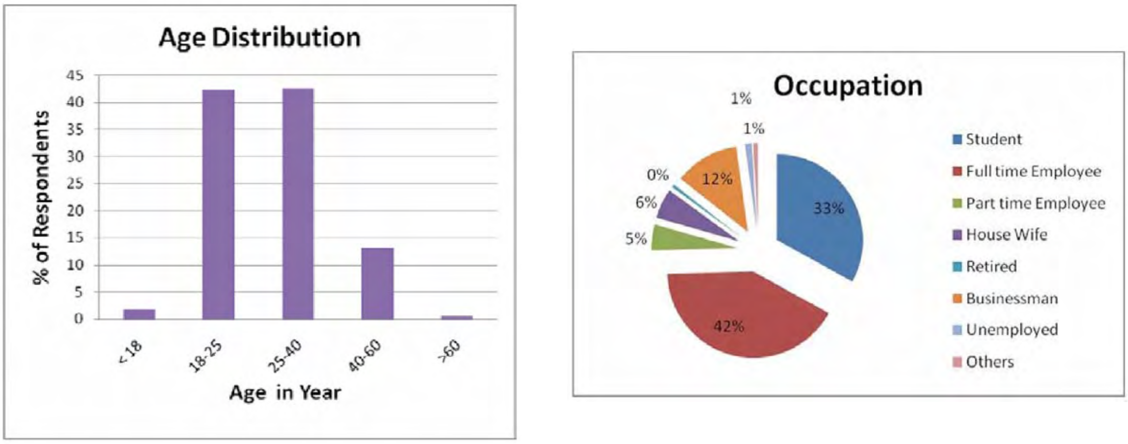
The data were collected for almost all lengths of travel (in terms of travel time). The trip length distribution of different modes is presented below in the form of a bar graph. Trips were classified into short, medium, long, very long and very very long trips.



	Short (15-30 min)	Medium (31-45 min)	Long (46-60 min)	Very Long (60-90 min)	Very Very Long (>90 min)
TEMPO	68.2	22.7	9.1	0	0
TAXI	22.2	33.3	22.2	22.2	0
RICKSHAW	32.4	34.5	20.9	11.5	0.7
CNG	25.5	22.3	23.4	18.1	10.6
CAR	34.5	26.1	20.2	16	3.4
BUS	19.4	18.8	24.2	24.2	13.4

Figure 7.4-4 Trip length distribution by different modes

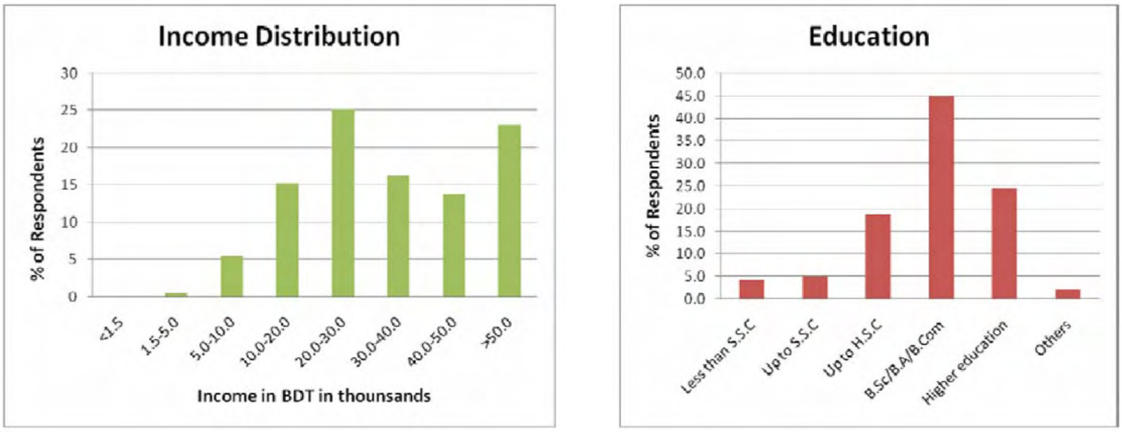
To ensure that the choice of all groups of people in terms of age, occupation, education, income etc. are being reflected in the survey ; the respondents were asked about their socio economic variables. The distribution of these variables is shown below in the forms of pie charts or bar graphs through Figure 7.4-5 to Figure 7.4-8. The average household size of the respondents was found to be 4.6 persons per household.



(a) (b)

Figure 7.4-5 (a) Age distribution of the respondents, (b) Occupation distribution of the respondents

More than 80% of the respondents were in the age of 18 to 40 years of old while in terms of occupation most no. of the respondents (42%) were full time employees and 33% of the respondents were students.

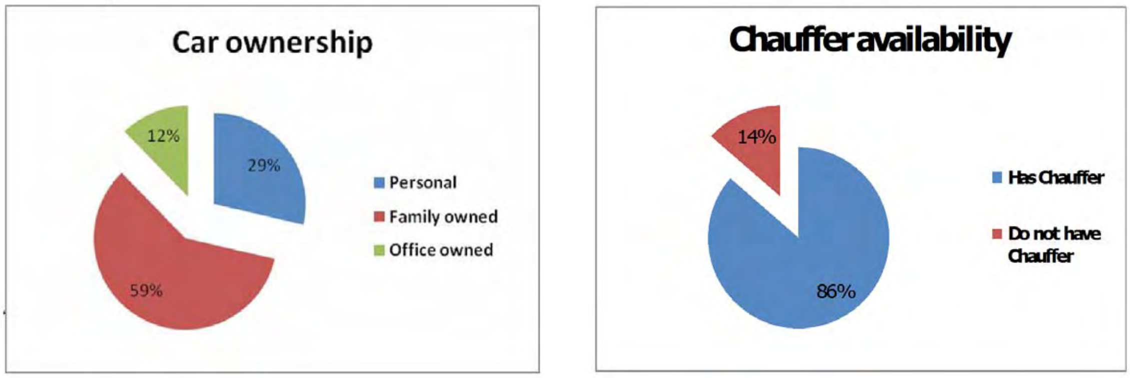


(a) (b)

Figure 7.4-6 (a) Income distribution of the respondents, (b) Education scenario of the respondents

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. In case of education, a major portion of the respondents (45%) were found to have completed their bachelor degrees.

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 the charts below.



(a) (b)

Figure 7.4-7 (a) Car ownership and (b) Driver ownership among the respondents

Lastly the gender distribution among the respondents was as follows.

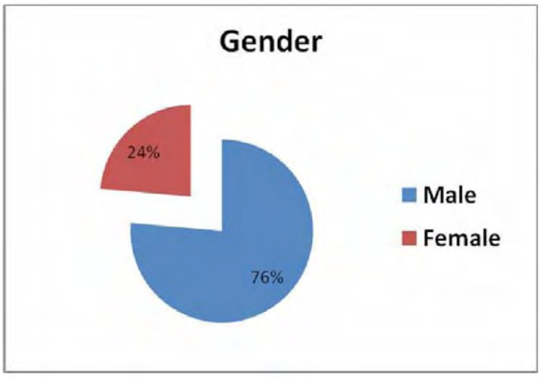


Figure 7.4-8 Gender distribution of the respondents

Most of the data (about 50%) were collected from the bus stops and in our country a small percentage of women use buses for their daily travel which may be one of the reasons for poor reflection of female in the survey. Moreover, it has also been found that female respondents were reluctant to answer the questions as reported by our surveyors.

7.4.3 Discrete Choice Analysis

7.4.3.1 Base Model

A simple Multinomial Logit (MNL) model was developed first as the base model choice model by pooling the data of Bus/Tempo, Car, and CNG/Taxi,users. Since, in the individual SP choices, the choice sets consisted of the current mode, BRT and Metro Rail (instead of all available modes), in the pooled data, the choice sets were 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 a current bus/tempo user, the choice set will thus be Bus/Tempo, BRT and Metro Rail. For a current car user, the choice set will thus be Car, BRT and Metro Rail. For a current CNG/Taxi user, the choice set will thus be CNG/Taxi, BRT and Metro Rail.

The pooled model structure is presented in Figure 7.4-9.

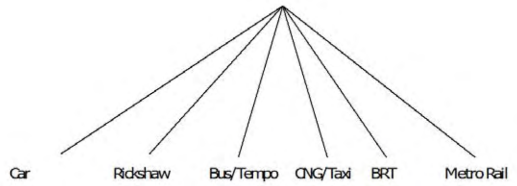


Figure 7.4-9 Pooled MNL Model Structure

The model was estimated using the Maximum Likelihood Estimation (MLE) Technique. The software BIOGEME (http://roso.epfl.ch/biogeme) along with the non-linear optimization code DONLP2 (Spellucci 1998) was used in this regard.

In the pooled model, statistical tests were performed to compare generic vs. alternative specific model coefficients. The adjusted rho-square values (ρ 2) and the significane of the tstats of the parameters were used as the decision criteria in this regard. The adjusted rhosquare can be expressed as follows:

$$\bar{\rho}^2 = 1 - \frac{L(\beta^*) - k}{L(0)} \qquad (1)$$

Where, L(β^*) is the maximum log-likelihood value, L(0) is the maximum log-likelihood

value, k is the number of estimated parameters.

$\bar{\rho}^2$ thus discounts 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.

The specification tests indicated generic coefficients for fare, travel time and waiting time except for travel time by Car and Metro Rail and fare for CNG/taxi, Car and Rickshaw. The results are presented in Table 7.4-3.

Table 7.4-3 Estimation Results of MNL Model

Model: Multinomial Logit Number of estimated parameters: 11 Number of observations: 928 Number of individuals: 928 Null log-likelihood: -1019.512 Init log-likelihood: -1019.512 Final log-likelihood: -870.749 Adjusted rho-square: 0.135

Name	Value	Std err	t-test
ASC_bus_tempo	0.00	fixed	fixed
ASC_brt	1.00	0.212	4.71
ASC_car	0.909	0.458	1.99
ASC_cng_taxi	0.478	0.728	0.66
ASC_metro	0.524	0.246	2.13
ASC_rickshaw	0.477	0.321	1.49
BETA_cost (Tk)	-0.0456	0.00939	-4.86
BETA_cost_p2p (Tk)	-0.0190	0.00763	-2.49
BETA_tt (min)	-0.0650	0.00970	-6.70
BETA_tt_car (min)	-0.0466	0.0102	-4.55
BETA_tt_metro (min)	-0.0570	0.0102	-5.57
BETA_wtime (min)	-0.0394	0.00825	-4.77

Where,

ASC_bus_tempo, ASC_car, etc. are alternative specific constant associated with the corresponding modes,

BETA_tt = coefficient of travel time for Bus/Tempo, CNG/Taxi, Rickshaw and BRT,

BETA_tt_car = coefficient of travel time for car,

BETA_tt_metro= coefficient of travel time for Metro Rail,

BETA_cost = coefficient of fare for all modes except CNG/Taxi and Rickshaw,

BETA_cost_p2p = coefficient of fare for CNG/Taxi and Rickshaw and fuel cost for car (modes that provide point to point to point service),

BETA_wtime = coefficient of waiting time for all modes.

In interpreting the coefficient values the following points should be considered.

A positive coefficient in the table means that the variable level or constant has a positive impact of utility and so reflects a higher probability of choosing the alternatives to which it is applied.

A negative coefficient means that the variable level or constant has a negative impact on utility and so reflects a lower probability of choosing the alternative to which it is applied. The value shown after each coefficient estimate is the t-ratio. This defines the (statistical) significance of the coefficient estimate; regardless of the sign, the larger the t-ratio, the more significant the estimate. A coefficient with a t-ratio greater than +/-1.960 is estimated to be significantly different from zero at the 95% confidence level. A t-ratio of +/-1.645 is significantly different from zero at the 90% confidence interval.

In reporting the model we present a number of model fit statistics in Table 7.4-3.

The log-likelihood is defined as the sum of the log of the probabilities of the chosen alternatives, and is the function that is maximised in model estimation.

The Null log-likelihood is the likelihood value obtained if all parameters are zero. In this case, this is equal to the Initial likelihood since the starting values of the parameter estimated were zero.

The Final log-likelihood refers to the likelihood value at convergence. The higher the Final log-likelihood, the better is the model fit with the data. The Final log-likelihood always increases with addition of new variables.

Adjusted rho-square (Eqn 1) discounts for the increase of number of parameters (i.e. loss of degrees of freedom) and hence, if the Adjusted rho-square increases the improvement in model fit is considered to be statistically significant.

The utility functions corresponding to the MNL model are as follows:

U_bus_tempo= ASC_bus_tempo + BETA_tt * tt + BETA_cost * fare + BETA_wtime
* wt + E_bus_tempo

U_car= ASC_car + BETA_tt_car * tt_car + BETA_cost_p2p * fuel_cost + E_car

U_cng_taxi=ASC_cng_taxi + BETA_tt * tt + BETA_cost_p2p * fare + BETA_wtime
* wt + E_cng_taxi

U_rick=ASC_rick + BETA_tt * tt + BETA_cost_p2p * fare + BETA_wtime * wt + E_rick

U_brt= ASC_brt + BETA_tt * brt_tt + BETA_cost * brt_fare + BETA_wtime * brt_wtime + E_brt

U_metro= ASC_metro + BETA_tt_metro * metro_tt + BETA_cost * metro_fare + BETA_wtime
* metro_wtime + E_metro

Where,
U_bus_tempo, U_car etc. are systematic utility functions of the corresponding modes,
tt= travel time in current mode (in minutes),
wt= waiting time associated with current mode (in minutes), 0 for car,
fare = fare of corresponding current mode for the trip in question,
fuel_cost = fuel cost associated with the trip in question (generated from travel time),
brt_tt, metro_tt = travel time in BRT and Metro Rail respectively (in the SP),
brt_wt, metro_wt = waiting time in BRT and Metro Rail respectively (in the SP),
brt_fare, metro_fare = fare for BRT and Metro Rail respectively (in the SP),
E_bus_tempo, E_car, E_cng_taxi, E_rick, E_brt, E_metro are random error terms assumed to Identically and Independently Gumbel distributed.

It may be noted that when the current 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), most of them responded that they do not know. Therefore, the cost associated with the car travel was generated as part of the analysis. While cost generation, it was considered that since it is very unlikely that the current car users will abandon their cars altogether after introduction of improved public transport options, there will be no substantial change in the fixed costs. Therefore, it was assumed that the car cost associated with the trip in question is only fuel cost. Though the origin and destination of the trip was known, the route used for the trip or the distance traversed were unknown in the analysis. Therefore, the fuel costs were 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 16Tk/cubic meter).

The results indicate that all else being equal, all modes are preferred over Bus/Tempo, BRT being the most preferred mode. However, it should be noted that the Alternative Specific Constants 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). Although some of the alternative specific constants were statistically insignificant at 95% level of confidence, they were still included in the model for model uniformity purposes.

Coefficients of costs, travel times and waiting times are highly significant (more than 95% level of confidence) and indicate disutility (as expected). The sensitivity to cost is less for modes which provide direct service to destination (car, CNG/Taxi and Rickshaw) or point to point service (car). This is expected for two reasons:

- People are willing-to-pay more for direct services
- People using these modes have higher affordability and hence less cost sensitivity

It may be noted, that it was not possible to estimate a separate cost coefficient due to ‘identification problem’ arising from full-collinearity between car cost and car travel time.

The disutility of waiting time was found to be less than that of travel time (contrary to the trend in developed countries).

7.4.3.2 Testing for Nested Structures

The assumption of MNL structure was tested using potential nested structures (based on potential correlation among modes). The following nesting structures were tested in this regard:

1. Private and Public (Figure 4.13 A)
2. Private, Personalized and Public(Figure 4.13 B)
3. Shared and non-shared (exclusive use) (Figure 4.13 C)
4. Motorized and Non-motorized (Figure 4.13 D)
5. Road based and rail-based (Figure 4.13 E)

6. Existing and new (Figure 4.13 F)

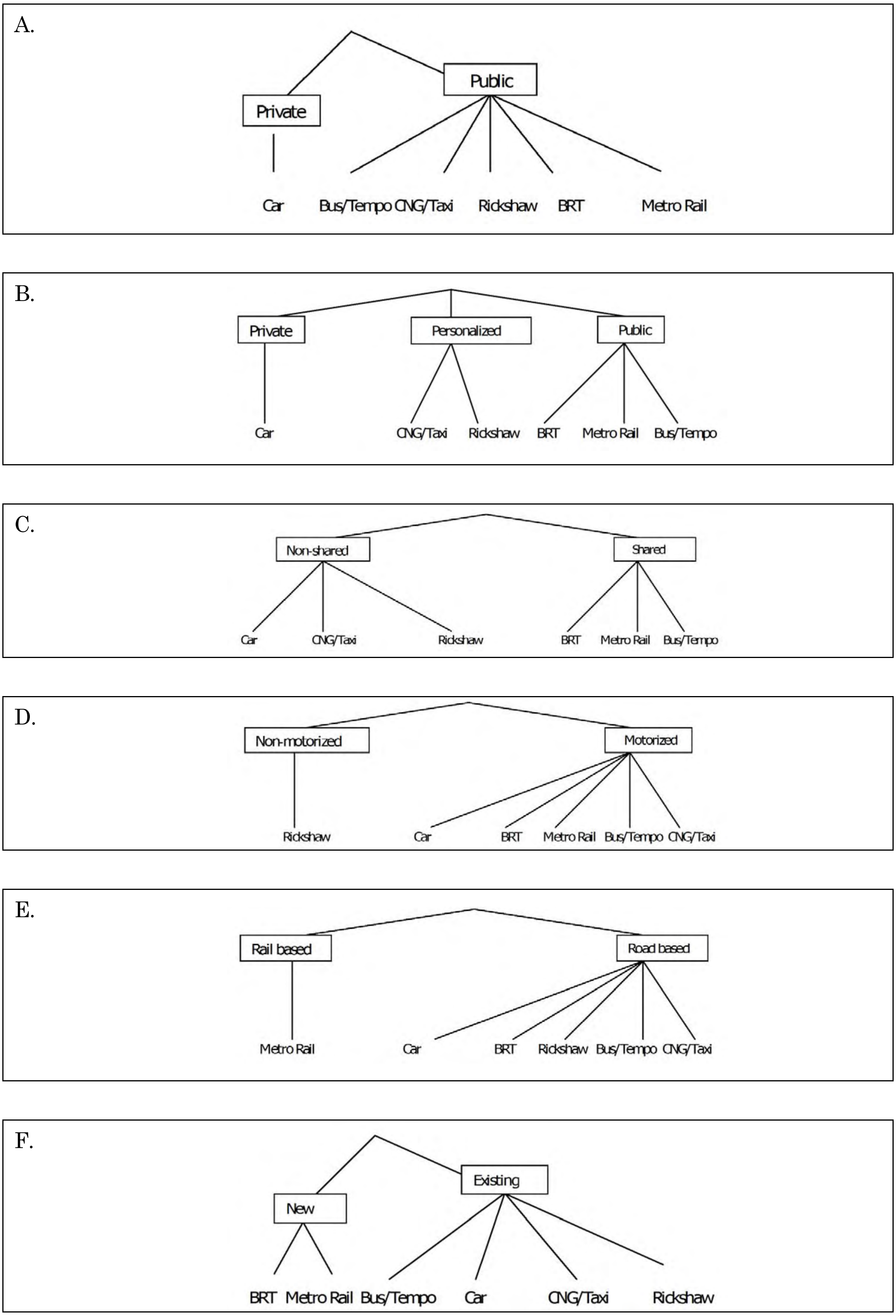


Figure 7.4-10 NL Model Structures

For testing if the nesting hypothesis is valid, the adjusted rho-squared values and the significance of the nesting scale parameters were considered. The summary of the results is appended in Table 4G1 of Appendix 4G.

The tests indicated that only the nesting of Existing and New Modes was statistically significant. This basically indicates that there is unobserved correlation among the exiting and the new modes. This Nested Logit (NL) model was used for further analysis and elaborated later.

7.4.3.3 Market Segmentation Tests

For market segmentation tests, the Likelihood Ratio (LR) Test Statistic was used. The LR Statistic is calculated as follows:

$$LR = -2(L_R - L_{UR})$$

Where,

L_R is the final likelihood of the restricted (unsegmented/pooled) model and L_{UR} final likelihood of the unrestricted (segmented) model. n is the loss in degree of freedom (difference in number of parameters between the restricted and unrestricted model). The ratio is assumed to be χ^2 distributed with n degrees of freedom.

If, LR > χ_n^2 , the segmentation is significant. If not, it is statistically insignificant.

The summary of market segmentation tests is presented in Table 7.4-4. The segmentation on income and gender were found to be statistically significant and further elaborated in the subsequent sections.

Table 7.4-4 Market Segmentation Test Results

Criteria	Groups	Conclusions from Likelihood-Ratio Tests	Modifications in the model (if warranted)
Mode	1. Bus/Tempo 2. Car 3. CNG/Taxi 4. Rickshaw 5. BRT 6. Metro Rail	Not significant (after introduction of the alternative specific coefficients)	Not applicable
Trip Length	1. Short (30 min or less) 2. Medium (31-90min) 3. Long (>90min)	Not significant	Not applicable
Income	1. Low (<20K/month) 2. Medium(20-40K/month) 3. High (40K/month)	Significant	Incomer segment specific WTP
Age	1. Young 2. Old	Not significant	Not applicable
Gender	1. Male 2. Female	Significant	Additional disutility for Bus/Tempo for female
Employment	1. Work/Study 2. Do not work/study	Not significant	Not applicable
Employment 2	1. Work 2. Study 3. Do not work/study	Not significant	Not applicable

Criteria	Groups	Conclusions from Likelihood-Ratio Tests	Modifications in the model (if warranted)
Education	1. Higher than HSC 2. HSC or lower	Not significant	Not applicable
Purpose	1. Origin/Destination is office 2. Other	Not significant	Not applicable
Purpose 2	1. Destination is office 2. Other	Not significant	Not applicable
Car Ownership	1. Own car 2. Do not own car	Not significant	Not applicable
Driver	1. Have driver 2. Do not have driver	Not significant	Not applicable
Trip frequency	1. Travel 1-4 day/ more 2. Other	Not significant	Not applicable

Segmentation on Income

The respondents were segmented to three income groups:

1. Low Income: <Tk 20K/month
2. Medium Income (Tk 20K-40K/month)
3. High Income (Tk 40K/month)

Note that since the data was collected from people who can currently afford a non-walk mode, the poorest of the poor who cannot afford any transport mode where not present in the data. This is justified since this group is not likely to be able to afford the improved transport options anyway.

It was hypothesized that higher income groups will have higher affordability and hence less cost sensitivity and more time sensitivity.

One problem with estimation of the income segmented model was there were very few or no observations of certain mode choices in certain income groups. For example, there were only 5 respondents in the low income group who had access to car and none of them chose car in the SP. The income specific mode choice was therefore further analyzed before the model estimation. These are presented in Figure 7.4-11.

The LR Test Results are presented in Table 7.4-5. The unrestricted model was the base model with data from all income groups. The restricted model was the segmented model that is the model where all parameters were assumed to be different for the three income groups.

Table 7.4-5 LR Test Results for Income Segmentations

	Unrestricted Model	Restricted Model	Loss in Degrees of Freedom	LR	Critical χ^2
Final LL	-852.251	-872.614	20	40.726	31.41

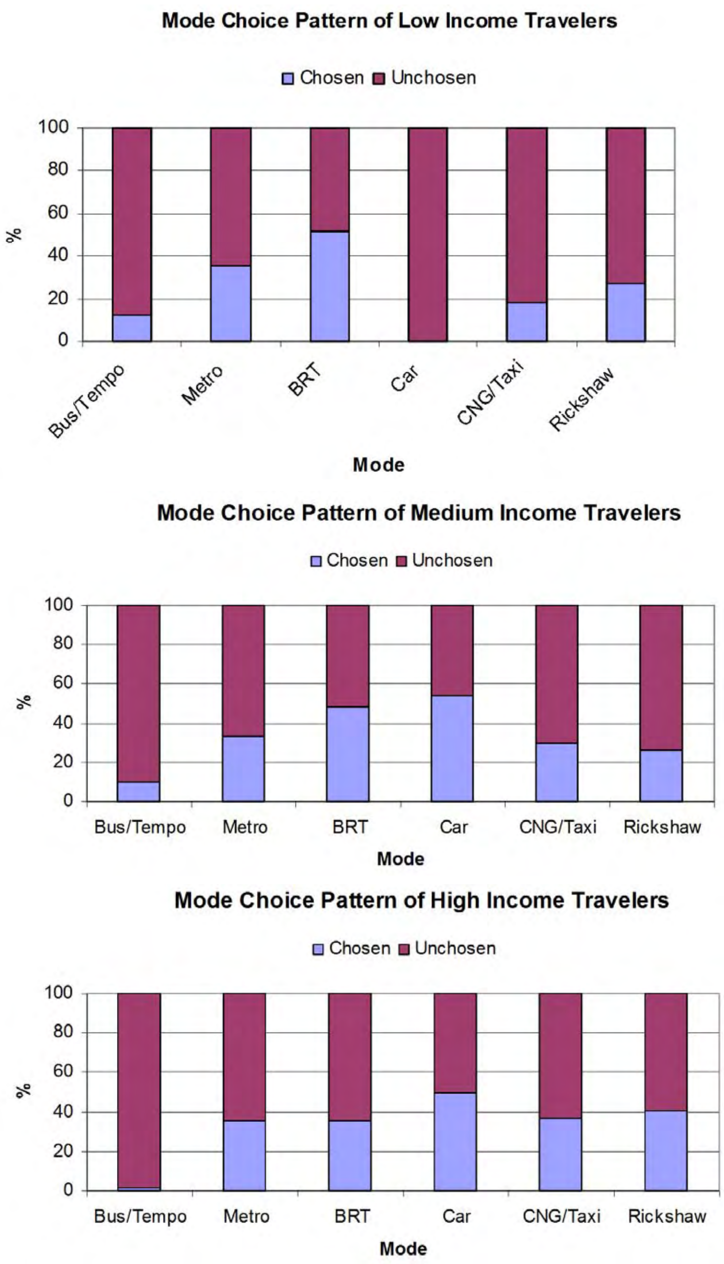


Figure 7.4-11 Mode Choice Pattern of Different Income Groups

Several model variations were attempted (e.g. introducing segment specific time and cost coefficients but the segmentation was still significant). Therefore, the results are presented separately for each group in the subsequent sections.

Segmentation on Gender

The hypothesis was male and female had significantly different choice patterns and LR tests were conducted. The results are presented in Table 7.4-6.

Table 7.4-6 LR Test Results for Gender Segmentations

	Unrestricted Model	Restricted Model	Loss in Degrees of Freedom	LR	Critical χ^2
Final LL	-849.698	-872.614	11	22.936	19.68

The segmentation was therefore found to be statistically significant.

The base model was reestimated with a female dummy for bus and that term was statistically very significant. The segmentation on gender was not significant after inclusion of this dummy.

7.4.3.4 Final Model

The final model structure is presented in Figure 7.4-12.

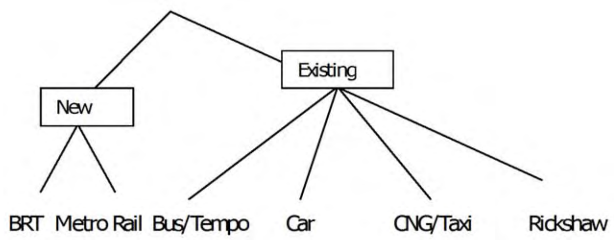


Figure 7.4-12 Final Model Structure

The estimation results of the final model are presented below in Table 7.4-7.

Table 7.4-7 Estimation Results of NL Model

Model: Nested Logit Number of estimated parameters: 13 Number of observations: 928 Number of individuals: 928 Null log-likelihood: -1019.512 Init log-likelihood: -1019.512 Final log-likelihood: -865.735 Likelihood ratio test: 307.555 Rho-square: 0.151 Adjusted rho-square: 0.138

Name	Value	Std err	t-test
ASC_bus_tempo	0.00	fixed	fixed
ASC_brt	1.22	0.291	4.18
ASC_car	1.06	0.503	2.12
ASC_cng_taxi	0.657	0.75	0.88
ASC_metro	0.91	0.382	2.39
ASC_rickshaw	0.512	0.344	1.49
BETA_cost (Tk)	-0.0415	0.0091	-4.58
BETA_cost_p2p (Tk)	-0.0192	0.00728	-2.64
BETA_tt (min)	-0.0513	0.0125	-4.11
BETA_tt_car (min)	-0.0493	0.0134	-3.69
BETA_tt_metro (min)	-0.0452	0.0118	-3.84
BETA_wtime (min)	-0.0346	0.00782	-4.43
BETA_bus_fem	-1.58	0.735	-2.15
Nest_Existing	1	fixed	fixed
Nest_New	*1.50*	*0.399*	*3.75*

Where,

ASC_bus_tempo, ASC_car etc. are alternative specific constant associated with the corresponding modes,

BETA_tt = coefficient of travel time for Bus/Tempo, CNG/Taxi, Rickshaw and BRT,

BETA_tt_car = coefficient of travel time for car,

BETA_tt_metro= coefficient of travel time for Metro Rail,

BETA_cost = coefficient of fare (fuel cost for car) for all modes except CNG/Taxi and Rickshaw,

BETA_cost_p2p = coefficient of fare for CNG/Taxi and Rickshaw and fuel cost for car

(modes that provide point to point to point service),

BETA_wtime = coefficient of waiting time for all modes,

BETA_bus_fem = coefficient of female dummy for bus,

Nest_Existing= Scale coefficient for nest of existing modes

Nest_New= Scale coefficient for nest of new modes

The corresponding utility functions are as follows:

U_bus_tempo= ASC_bus_tempo + BETA_tt * tt + BETA_cost * fare + BETA_wtime * wt
+ BETA_bus_fem * female_dummy +E_bus_tempo

U_car= ASC_car + BETA_tt_car * tt + BETA_fare_p2p * fuel_cost + E_car

U_cng_taxi=ASC_cng_taxi + BETA_tt * tt + BETA_fare_p2p * fare + BETA_wtime * wt
+ E_cng_taxi

U_rick=ASC_rick + BETA_tt * tt + BETA_fare_p2p * fare + BETA_wtime * wt + E_rick

U_brt= ASC_brt + BETA_tt * brt_tt + BETA_fare * brt_fare + BETA_wtime * brt_wtime + E_brt

U_metro= ASC_metro + BETA_tt_metro * metro_tt + BETA_fare * metro_fare + BETA_wtime
* metro_wtime + E_metro

Where,

U_bus_tempo, U_car etc. are systematic utility functions of the corresponding modes,

tt= travel time in current mode (in minutes),

wt= waiting time associated with current mode (in minutes), 0 for car,

fare = fare of corresponding current mode for the trip in question,

fuel_cost = fuel cost associated with the trip in question (generated from travel time),

brt_tt, metro_tt = travel time in BRT and Metro Rail respectively (in the SP),

brt_wt, metro_wt = waiting time in BRT and Metro Rail respectively (in the SP),

brt_fare, metro_fare = fare for BRT and Metro Rail respectively (in the SP),

female_dummy = dummy for female respondents, 1 if the respondent is female, 0 otherwise,

E_bus_tempo, E_car, E_cng_taxi, E_rick, E_brt, E_metro are random error terms assumed to be randomly distributed error terms with generalized extreme value distributions with correlation among E_brt and E_metro (new modes) and among E_bus_tempo, E_car, E_cng_taxi and E_rick (existing modes).

The results have similar trends as the MNL model: the alternative specific constants for Metro Rail, CNG and Rickshaw being slightly higher in magnitude from the MNL model. The alternative specific constants for Car and BRT are slightly less in magnitude than the MNL model. The relative magnitudes of the constants are same as the MNL model though indicating that all else being equal, all modes are preferred over Bus/Tempo, BRT being the most preferred mode. However, it should be noted that the Alternative Specific Constants 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). Although some of the alternative specific constants were statistically insignificant at 95% level of confidence, they were still included in the model for uniformity purposes.

Coefficients of costs, travel times and waiting times are highly significant (more than 95% level of confidence) the sensitivity to travel time slightly less compared to the MNL model.

Similar to the MNL model, the sensitivity to cost is less for modes which provide direct service to destination (car, CNG/Taxi and Rickshaw) or direct service from origin (car).

The disutility of waiting time was found to be less than that of travel time (contrary to the trend in developed countries).

An interesting point to note is that both the time and cost sensitivities are less for Car and Metro Rail, those of Car being the least. The less sensitivity to travel time implies that travel in Car and Metro Rail are slightly less for Metro Rail (indicating people have less cost sensitivity or in other words, more willing-to-pay for Metro Rail compared to other modes). This may be due to the perceived higher level-of-service of Metro Rail.

The dummy term introduced for female respondents for preference for Bus/Tempo indicate that female respondents have significantly less preference for bus (i.e. the current female bus travelers, have higher propensity to switch to improved public transport services like BRT and Metro Rail).

The nest coefficients indicate that the ‘New’ nest has higher scale (lower variance) which may be due to policy bias (i.e. respondents may be prone to select BRT/Metro Rail since they have a strong interest that these are built in reality).

7.4.3.5 Willingness-to-Pay (WTP) Values

The WTP for each attribute were calculated by dividing the respective parameters by the corresponding cost coefficients. Since the travel time and travel cost coefficients were found to be alternative specific for several modes, the WTP for travel time were found to differ for different current mode user group. As CNG/Taxi and Rickshaw user groups had same time and cost coefficients, they had the same WTP for travel time reduction values.

Though the coefficient of waiting time was generic, since the travel cost coefficients were alternative specific for several modes, the WTP for waiting time were also found to differ for different current mode user group. As CNG/Taxi and Rickshaw user groups had same time and cost coefficients, they had the same WTP for waiting time reduction values.

The results are presented in Table 7.4-8.

Table 7.4-8 WTP Values for Different Mode User Groups

	Bus/Tempo	Car	CNG/Taxi/ Rickshaw
Coefficient of Travel Time (in min)	-0.0513	-0.0493	-0.0513
Coeffcient of Waiting Time (in min)	-0.0346	-0.0346	-0.0346
Coefficient of Travel Cost (in Tk)	-0.0415	-0.0192	-0.0192
WTP for Travel Time Reduction(Tk/min)	1.24	2.57	2.67
WTP for Waiting Time Reduction (Tk/min)	0.83	1.80	1.80

As seen in the table, the WTP for travel time reduction was found to be highest for CNG/Taxi and Rickshaw users and lowest for the Bus/Tempo users. The WTP for waiting time reduction was found to be higher for Car and CNG/Taxi user groups.

Since, the market segmentation tests revealed significant segmentation on income, income segmentation specific WTP were also calculated. However, these results do not provide very useful information as in the income segmented model (the t-stats of cost and time are significant at 85% level of confidence only). The WTP results are presented in Table 7.4-9.

Table 7.4-9 WTP of different income groups

A. High Income Group (household income >Tk 40, 000/month)

	Bus/Tempo	Car	CNG/Taxi/ Rickshaw
WTP for Travel Time Reduction(Tk/min)	0.51	1.29	0.79
WTP for Waiting Time Reduction (Tk/min)	1.05	1.61	1.61

B. Medium Income Group (household income Tk 20,000-Tk 40, 000/month)

	Bus/Tempo	Car	CNG/Taxi/ Rickshaw
WTP for Travel Time Reduction(Tk/min)	1.21	2.29	2.67
WTP for Waiting Time Reduction (Tk/min)	0.67	1.47	1.47

C. Low Income Group (household income <Tk 20, 000/month)

	Bus/Tempo	Car	CNG/Taxi/ Rickshaw
WTP for Travel Time Reduction(Tk/min)	0.68	No Observations	0.55
WTP for Waiting Time Reduction (Tk/min)	0.65	No Observations	0.52

The results indicate that the middle income group have higher WTP for travel time saving compared to the high income group (which is non-intuitive).However, this is actually plausible since the high income group may have better access to information, be more receptive to technology and more inclined to opt for new modes. On the other hand, this may be due to justification bias as well (a common problem of SP is people often opt for what they should do rather than what they would really do in SP, the problem being higher for high educated segments). In any case, because of the low statistical significance, the income segmented results should not be given much weightage.

7.5 CONCLUSION

7.5.1 Summary

In this report, the WTP for attributes of improved public transport modes (BRT and Metro Rail) has been quantified. An extensive SP survey has been done in this regard. In the SP survey, the respondents were presented with BRT and Metro Rail options side-by-side their current modes and asked to make a mode choice. The attribute levels varied among respondents and were allocated based on a minimum factorial design. An initial survey was executed to identify the key attributes and explore the range of attributes that are realistic.

The data was collected among different mode users (Bus/Tempo, Car, CNG/Taxi and Rickshaw) and the best efforts were made to ensure a heterogeneous sample with representations from different socio-economic groups, trip purpose, origin-destinations, trip lengths and time of day. The data was collected in two phases: first a pre-test data was collected among a small sample to test the design and validity of attribute ranges. The surveys were then modified it required and then tested among bigger samples.

The collected data was used for developing discrete choice models and coefficients of travel times, waiting times and cost were estimated using maximum likelihood techniques. The models were enriched based on market segmentation test results. The estimated coefficients of the best model specification were used for calculation of the WTP values.

Results indicate that respondents have higher WTP for travel time compared to waiting times. The segmentation results indicate that the CNG/Rickshaw users have the highest WTP for travel time savings followed by the car users. Income group specific WTP’s were also determined, though the results were not very conclusive due to high standard errors.

The results provide useful insights for planning of improved public transport options like BRT and Metro Rail. These can be very useful for feasibility studies as well as determination of fare structures. They can be also useful for designing special incentives (e.g. identify the preferences of different market segments).

7.5.2 Potential directions for further modifications

The current study has several limitations for applications beyond WTP calculations.

Firstly, the developed models were based on pseudo-random sampling (random samples collected from potential riders). In some cases, there were small observations in sub-samples (e.g. of high income travelers) and the model can be enriched by collecting further data.

Secondly, the results are based on SP only and not anchored against revealed preference (RP) data. There is a huge potential to improve these models by combining it with the household interview data collected as part of STP or more recently by the JICA Team. Therefore, though the data cannot be directly used for predicting market shares, they have the potential for being used for that purpose through population synthesis and microsimulation.

Moreover, the mode choice models developed in this study were limited to MNL and NL and unobserved heterogeneity among respondents were ignored. There is provision of improving the models by applying more advanced discrete choice techniques like mixed logit (random coefficient) and latent class models.

REFERENCE

Ben-Akiva, M. and Lerman, S. (1985) Discrete Choice Analysis: Theory and Application to Travel Demand. The MIT Press, Cambridge, USA

Bierlaire, M. (2003) BIOGEME: A free package for the estimation of discrete choice models , *Proceedings of the 3rd Swiss Transportation Research Conference*, Ascona, Switzerland.

Bierlaire, M. (2008) An introduction to BIOGEME Version 1.7, biogeme.epfl.ch.

Bliemer M., Rose J. and van Blokland (2009) Experimental Design Influences on Stated Choice Outputs: An Empirical Study in Air Travel Choice, 12th Conference of the International Association of Travel Behavior Research, Jaipur, India.

Choudhury C., Tsang F. , Burge P. , Rohr C., Sheldon R. (2008) Measuring Willingness-to-pay for Green Options, Proceedings of the European Transport Conference, The Netherlands.

Cirillo, C., Daly, A. and Lindveld, K. (1998) Eliminating Bias due to the Repeated Measurements Problem in SP Data" in Operations Research and Decision Aid Methodologies in Traffic and

Hanley N., Wright R. and Adamowicz (1998) Using Choice Experiments to Value the Environment: Design Issues, Current Experience and Future Prospects, Environmental and Resource Economics, Volume 11, Issue 3, pp. 413–428.

Louis Berger Group, Inc and Bangladesh Consultants Ltd (2006) The Strategic Transport Plan for Dhaka.

Mamun A., Riley T. and Bristow A. (2009) The Importance of Public Transport Attributes in Explaining Mode Choice Behavior in Dhaka, Paper presented at the Annual Conference of the Universities' Transport Study Group (UTSG), UK.

Spellucci P. (1998) A new technique for inconsistent QP problems in the SQP method, Mathematical Methods of Operations Research, Volume 47-3, pp- 355-400.

Train, E. (2003) Discrete Choice Methods with Simulation. Cambridge University Press.

Transportation Management, Labbé, M et al. (eds.), Springer.