Feasibility of School Buses in Dhanmondi, Dhaka

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1. Introduction

Dhaka, the capital of Bangladesh, is one of the most densely populated cities in the world. Dhanmondi is a residential area within Dhaka that has experienced the rapid development of many private schools over the past fifteen years. Most of the schools do not have an established school bus system, and since they all follow the same schedule, the roadways are consistently gridlocked with commuters during peak hours.

Congestion is a major problem for residents of Dhanmondi because it significantly increases travel time. Residents must leave home very early, sometimes even hours in advance, to be on time for their appointments. Additionally, the excessive noise, heat, and air pollution generated by vehicles deteriorates the quality of living. Administrative agencies have attempted to curb congestion by rerouting traffic, staggering start times and enforcing stricter traffic laws, but none of these methods has proven effective.

The primary cause of congestion in Dhanmondi is the sheer volume of traffic, which far exceeds the carrying capacity of existing roads. Without a school bus system, students ride their own cars to school, so the student-to-vehicle ratio is very high (close to 1). Therefore, establishing a school bus system would be an effective approach to reducing traffic volume and environmental damage.

The Harvey Mudd College (HMC) Center for Environmental Studies sponsored a summer project to investigate the feasibility of introducing school buses into Dhanmondi. The research was conducted by student researchers from HMC in collaboration with a faculty member of Bangladesh University of Engineering and Technology (BUET). This paper presents the details, results, and conclusions of the research.

2. Background

Description of Current Modes

The three primary modes of travel to/from school in Dhanmondi are car, rickshaw, and auto-rickshaw (CNG). A small fraction of students use school buses (in schools that currently offer the service), ride bikes, or walk to school. Here are brief descriptions of some of the travel modes:

Private Car

Private car is the dominant travel mode. Many families employ a driver/chauffer who maintains the car and drives the family to locations of interest. Students usually go to school with a driver and perhaps an accompanying parent. The driver will either drop-off the student at the school gate or park the car nearby so that he or the parent can accompany the student to the school gate.

Cars are the primary source of traffic congestion because there are so many of them, and because they are physically larger than rickshaws or bikes. School areas are especially congested because drivers/parents will often park their cars around the school entrance and sit idly while waiting for students to finish class. Cars also emit greenhouse gases, a significant source of air pollution.

Most of the reputable schools in Dhanmondi charge tuition that only middle and upper-class families can afford, so it is likely that the majority of the students' families are affluent enough to own at least one car. Beyond the significant initial investment required to buy a car, other costs include driver's salary (6000-8000 taka/month) and gas costs. Most cars run on Compressed Natural Gas (CNG), which is locally extracted and much cheaper than petrol or diesel. However, cars can only carry a small amount of CNG and therefore must be refueled often; CNG stations usually have long queues with waits of over an hour. The average gas consumption cost is about 3 taka per kilometer.

Rickshaw

The rickshaw is a three-wheeled vehicle, essentially a bicycle pulling a two-wheeled cart. When taking a rickshaw to school, younger students are typically accompanied by a parent/guardian while older students are likely to travel alone. Rickshaws are the slowest vehicles on the road, and on the small local roads they outnumber cars; Dhaka is also known as the "City of Rickshaws." Since rickshaws do not have engines, they are not directly responsible for air pollution by carbon dioxide emission. Rickshaws fares average 15 taka per kilometer. Unlike cars, rickshaws do not have any other accompanying expenses besides the fare.

CNG (Auto-rickshaw)

Auto-rickshaws are called CNGs because they run on Compressed Natural Gas. CNGs are three-wheeled vehicles that have engines and are faster than rickshaws, so it is not their speed but their sheer number that contributes to traffic congestion. They also emit harmful gases. CNGs are generally preferable to rickshaws when students live far from school; CNG fares average 25 taka per kilometer.

School Bus

School buses are the subject of this research. Currently, a small number of schools in Dhanmondi have implemented school buses. These school buses are usually microbuses each carrying at most 15 students. Most of these buses are air-conditioned, operated by a driver, and hire an assistant to supervise the students. Since the streets of Dhanmondi are narrow, very large buses (think of the the archetypal long, yellow American school bus) are not feasible. For this research, two different sizes of buses are proposed: a microbus (similar to what is available now) and a mid-size bus with a capacity of 20-30 people. These buses will pick-up and drop-off the students at designated bus stops close to their homes.

Traffic Behavior

Drivers of all vehicles are negligent of most traffic rules and regulations. Any lines drawn on the ground to designate lanes are usually ignored. Pedestrians usually cross the road by walking across oncoming traffic and expecting cars, rickshaws, and buses to yield to them.

Stated Preference Surveys

The traditional way to collect data for transportation demand modeling is to record individuals' travel choices (by asking or observing them) or to retrieve historical transportation choice data from a database. This type of data is called revealed preference (RP) data, and it shows, for example, how often an individual drives a car to work and how often he rides the bus to work. Hence, it reveals the person's preference for a certain mode. RP data often complement stated preference (SP) data; SP data are collected by conducting surveys in which people are asked about their preferences and/or choices in *hypothetical* situations.

SP methods have several advantages over RP methods. Since the choices given in a SP experiment are hypothetical, this allows for a lot of flexibility and wide range of variation of the attributes that are investigated. One important use of SP methods is finding out what people think about modes that don't currently exist; this cannot be accomplished with RP methods. To construct a successful survey concerning a nonexistent mode, a researcher must provide a sufficient description of the mode so that the respondent can accurately imagine himself in the proposed situation and make informed hypothetical decisions. Another advantage is that instead of relying on a limited pool of historical RP data, SP data can be obtained in larger quantities and from any cooperative segment of the population.

A disadvantage of SP data is that they are entirely gathered from what people say but might or might not do; hence the data may seem less reliable. To test the validity of SP surveys, researchers might repeat surveys (internal validation) or compare the data with RP data (external validation).

For this research, SP method was selected because although some schools use school buses, for most people school buses remain a non-existent mode. This method also provided researchers with the flexibility to study various interaction effects. An SP experiment was carefully designed to accomplish the following objectives:

- To evaluate public opinion of school buses amongst students and parents of students attending schools in Dhanmondi.
- To investigate and quantify user preferences for various attributes (such as cost, travel time etc.) and their levels.
- To study how user preference is affected by attitudes and perceptions.

3. Development of the SP Survey

The SP survey was designed through the following steps:

1) Identifying the primary mode choices
2) Choosing attributes, with help from a focus group
3) Defining attribute levels
4) Creating choice sets (profiles) and scenarios
5) Designing preliminary questions (current travel behavior, socio-economic, attitude and perception)
6) Pilot study and analysis
7) Revising SP survey

3.1) Primary Mode Choices

In Dhanmondi, most students either take a car or a rickshaw/CNG to school (rickshaws and CNGs are similar enough to be considered a single mode). Therefore, in order to find out what people think about school buses, the survey asks the respondent to compare his current mode with the school bus mode (current vs. hypothetical). In the survey, there are two pages of SP questions: Car vs. School Bus and Rickshaw/CNG vs. School Bus. The respondent should only fill out one. If the respondent uses both car and rickshaw/CNG, he can fill out both if he wants.

3.2) Choosing Attributes with Focus Group Consultation

Several parents and school administrators were consulted in order to identify important attributes of a school bus system. They were also asked for their general opinion of school buses, and whether they thought school buses would be feasible to implement in the Dhanmondi area. The general sentiment was that any method of reducing congestion was desirable, provided that the cost was not excessive. School administrators were more enthusiastic than parents about adopting school buses. From the focus group discussion, the six attributes that seemed to be the most important were:

- Travel time
- Security
- Comfort
- Vehicle size
- Time to the bus stop
- Cost

3.3) Description of Attributes

Cost	The monthly fare of school bus service (round trip) per student, in taka (1 US dollar ≈ 70 taka). Since cost increases with distance, two sets of fares are provided. Dhanmondi, Lalmatia, and Mohammadpur are local areas, while Mirpur, Gulshan, and Banani are further away. Since Dhanmondi's schools have excellent reputations, many students come from distant residences.
Travel time	The relative amount of time it takes for a one-way trip (either going to or returning from school). In general, school bus will be slower than car or rickshaw/CNG because they are not as capable of weaving in and out of traffic, as most vehicle drivers do. It is assumed that rickshaws/CNGs are more nimble and

therefore faster than cars in heavy congestion.

Time to the bus stop — The time it takes for the student to walk from his home to a bus pick-up or drop-off point. Door-to-door pickup may be feasible for microbuses, but for large buses it would take too much time.

Comfort — Air conditioning (A/C) is highly desired because it is hot and humid much of the time in Dhanmondi. However, money can be saved by eliminating A/C or using older buses, which were usually built without A/C.

Vehicle size — Microbuses (10-12 people) or large buses (20-30 people). Large buses may be safer in collisions and more efficient if they service students from multiple schools. Microbuses can probably travel at higher speeds and are more agile in traffic.

Security — A teacher or assistant may be hired to accompany the bus. Parents feel more comfortable if a school authority is on the bus with their children to maintain order and possibly discourage bullying. They probably prefer teachers over assistants because teachers are more familiar with the students and parents.

3.4) Defining Attribute Levels

The attribute levels were arbitrarily chosen to be as realistic as possible. The cost attribute level "750/1200 tk/month" and the comfort attribute level "New buses with air conditioning" were repeated in order to weight them; they are midrange values and therefore should realistically occur more often.

Table 1: Attributes and Levels

	Car/Rickshaw/CNG	**School bus**	
Cost	Same as now	**Local vicinity (Dhanmondi, Lalmatia, Mohammadpur, etc.)** 300 tk/month 500 tk/month 600 tk/month 750 tk/month 750 tk.month 800 tk/month 900 tk/month 1000 tk/month	**Further away (Mirpur, Gulshan, Banani, etc.)** 500 tk/month 800 tk/month 1000 tk/month 1200 tk/month 1200 tk/month 1500 tk/month 1800 tk/month 2000 tk/month
Travel time	Same as now	**Compared to Car** 30 minutes more than now 20 minutes more than now 15 minutes more than now 10 minutes more than now 5 minutes more than now Same as now 5 minutes less than now 10 minutes less than now	**Compared to Rickshaw/CNG** 20 minutes more than now 15 minutes more than now 10 minutes more than now 5 minutes more than now Same as now 5 minutes less than now 10 minutes less than now 15 minutes less than now

Time to the bus stop	N/A	None (door-to-door pick-up)	
		Up to 5 minutes walk	
Comfort	Same as now	New buses with air conditioning	
		New buses with air conditioning	
		New buses without air conditioning	
		Old buses without conditioning	
Vehicle size	Same as now	Microbus (10-12 people)	
		Large bus (20-30 people) serving multiple schools	
Security	Same as now	Accompanied by an assistant	
		Accompanied by a teacher	

3.5) Creating Choice Sets and Scenarios

A specific combination of attribute levels can be called a profile. The software SPSS was used to generate the minimum fractional factorial design, which yielded 64 profiles. Unrealistic profiles were discarded, while dominant profiles were set aside. The remaining set of profiles was 44 profiles in size.

This survey asks the respondent to compare his current mode with four different profiles. Three of these profiles are randomly selected from the remaining set (without replacement), while the fourth is randomly selected from the dominant set. The purpose of including a dominant profile is to test for validity; if the respondent selects one of the non-dominant profiles but not the dominant profile, he might not be reading the survey carefully enough or even paying any attention at all. These invalid responses were discarded.

3.6) Understandability

The questionnaire is intended for the parents of students who attend school in the Dhanmondi area because it is likely that parents determine which mode their children use to travel back and forth from school. These parents might not have a strong background in English, so the survey is administered in English that is as plain and simple as possible. The attributes and their levels are presented concisely and clearly. Students were asked to take home the survey for their parents to complete and to return the surveys by a certain date.

Since there were six attributes of interest, it was necessary to limit the mode choices to 2 at a time (there is no Car vs. Rickshaw/CNG vs. School Bus scenario), lest the scenarios become too unwieldy to contemplate.

3.7) Survey Format and Description of Preliminary Questions

The SP questionnaire contains five sections:

1. Current travel behavior questions
2. a) SP choice scenarios for car
   b) SP choice scenarios for rickshaw/CNG
3. Socio-economic questions
4. Diagnostic questions
5. Attitude and perception questions

Section 1: Current Travel Behavior

This section begins with a brief introduction about the research team and the relevance and importance of the research for the community. After that, the first question in this section asks about the respondent's current mode choice: car, rickshaw, CNG, walk, or other. The response to this question is used to determine which scenarios the respondent will be presented with later on in the SP scenario section. Next, there are questions about travel time, distance from home to school, and carpooling behavior. The data obtained from these questions may be used to identify relationships between geographic location and travel behavior.

Section 2: SP Choice Scenarios

This section starts with a description of the proposed school bus system. The six attributes mentioned earlier are explained in detail, and the respondent is told that she will be presented with several scenarios in which she must make a choice whether to continue using her current mode or to switch to the school bus system.

In Dhanmondi, most students take a car or ride a rickshaw or CNG to school. In the SP survey, there are separate sets of SP scenarios for car and rickshaw/CNG. If the respondent answered "car" for current mode choice in the travel behavior sections, he would fill out the set of scenarios designed for car users and skip the set for rickshaw/CNG users. The opposite is true for rickshaw/CNG users. If the respondent answered "walk" or "other" as his current mode choice, he would skip both SP scenario sections and proceed directly to the socio-economic questions. Each set contains 4 scenarios; examples of such scenarios are provided in Table 2 and Table 3 below. The attributes will be explained later on in this paper, in the section "Description of Attributes."

Table 2: Example of an SP choice scenario for car users

	Car	**School Bus**
Travel time (each way)	Same as now	5 minutes more than now
Vehicle size	-	Large bus (20-30 people) serving multiple schools
Security	Same as now	Accompanied by an assistant
Time to the bus stop	-	Up to 5 minutes walk
Comfort	Same as now	Old buses without A/C
Cost	Same as now	Dhanmondi,Lalmatia,Mohammadpur,etc.: Tk 1000/month Mirpur,Gulshan,Banani,etc.: Tk 2000/month
Which mode would you choose?	**Car** ☐	**School Bus** ☐

Table 3: Example of an SP choice scenario for rickshaw/CNG users

	Rickshaw/CNG	School Bus
Travel time (each way)	Same as now	15 minutes less than now
Vehicle size	-	Microbus (10-12 people)
Security	Same as now	Accompanied by a teacher
Time to the bus stop	Same as now	Up to 5 minutes walk
Comfort	Same as now	New buses with A/C
Cost	Same as now	Dhanmondi,Lalmatia,Mohammadpur,etc.: Tk 300/month Mirpur,Gulshan,Banani,etc.: Tk 500/month
Which mode would you choose?	**Current** ☐	**School Bus** ☐

In these examples, "Same as now" means that nothing changes from the current travel experience. The respondent may have to ask his children about their experience. Some attributes, such as variation in vehicle size, only apply to school buses, and therefore "Same as now" is replaced by a dash "-", meaning "not applicable."

There are also some mode-specific questions that are asked after or before the scenarios, such as how much the rickshaw/CNG fare costs.

Section 3: Socio-economic questions

This section contains general questions about the family, such as the student's grade level, parents' education and occupations, family size, availability of personal cars, and household income. The respondent is given the option of refusing to answer certain question if he feels that they are too personal.

Section 4: Diagnostic questions

The diagnostic questions ask the respondent which, if any, of the SP scenarios seemed unrealistic or difficult to understand. This feedback helped improve the clarity and realism of the survey during revision.

Section 5: Attitude and perception questions

Since SP questionnaires ask respondents to make hypothetical choices, the respondents will likely base their decisions on preconceived perceptions and attitude toward the subject. Therefore, the survey asks respondents to rate, from 1 (strongly disagree) to 5 (strongly agree) their level of agreement with several statements about various aspects of school buses and cars. For example, some aspects are:

- School buses are environmentally friendly. (environmental awareness)
- School buses are much slower than cars. (travel time)
- Using a car is more convenient than school bus; e.g. can take my child out for lunch/ to a coaching center after school if needed. (flexibility, convenience)
- School buses are not very comfortable. (physical comfort)

This section also asks respondents to rate, from Not Important to Very Important, how they feel about certain characteristics of a school bus system. For example:

- Affordable service
- Air conditioning in the buses
- Door-to-door pick-up and drop-off
- New buses

4. Data Collection

4.1) Pilot Study

Phase 1: Personal Contacts

The survey was personally administered to several parents and their feedbacks recorded. The average time recorded for completing the survey was around 15 minutes, and the majority of the respondents had little or no difficulty understanding the language and purpose of the survey. The respondents suggested minor adjustments, such as changing some of the costs to be more realistic. The revised form of the survey was then used for phase 2 of the pilot study.

Phase 2: Marie Curie School

Marie Curie School is a small English medium school with around 200 students. Marie Curie currently uses a few school buses, so their version of the survey included an additional SP section for school bus. Approximately 70 surveys were distributed there as a pilot test. However, only 13 responses were received. The results of the diagnostic tests indicated that majority of the students felt the choice scenarios were realistic and easy to understand.

4.2) Revising the Questionnaire

The results from the pilot study confirmed that the survey required no major changes. Some minor typos were corrected and slight changes made. For example, carpooling behavior was split into morning and afternoon sessions because some students might have different carpooling behavior in the morning and afternoon.

4.3) Survey Distribution

Maple Leaf International School

Maple Leaf is one the largest and oldest English medium schools in Dhanmondi, so its reputation is expected to contribute credibility and importance to the study. Maple Leaf teaches grades 3 through 10 and has a total population of about 4000 students.

Approximately 1400 surveys were distributed to Maple Leaf students in mid-June, right before the start of summer vacation. After summer vacation, a total of 86 students returned the survey.

Other Schools

Many of the English medium schools closed in June for summer vacation, so they were unwilling to participate in the survey: Sunnydale School, Mastermind School, Sunbeams School.

Personal Network

Approximately 50 surveys were distributed to family, friends, and neighbors, and 18 responses were collected. One personal contact was a teacher at a local coaching center and was able to distribute 300 surveys to his students, who returned 40 surveys.

Out of 1900 distributed surveys, 144 responses were received, for a response rate of 7.58%.

4.4) Statistics from the Collected Data

Socio-economic characteristics

- 66.7% of the students were female.
- 71.5% of the mothers were housewives.
- Most of the fathers and about half of the mothers received a Bachelor's degree or higher. See Figure 1.
- 68.8% of the respondents had access to a car, and most employed a driver.
- The average income was 77,243 taka per month, and only 16% of the respondents earned over 100,000 taka per month. Income distribution is shown in Figure 2.
- The majority of student who returned the survey were in Grade 5 (Figure 3).

Figure 1: Education levels of parents

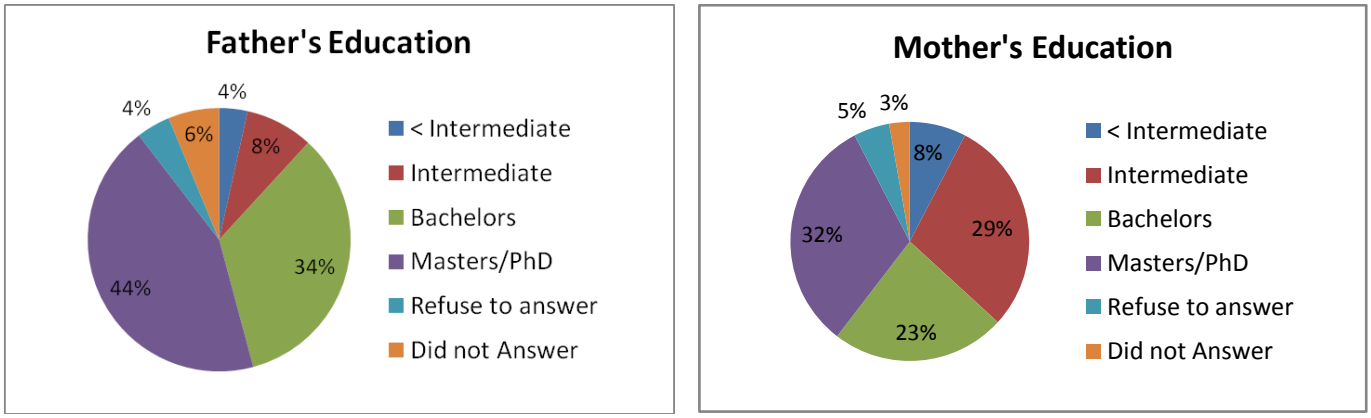


Figure 2: Income levels of the family

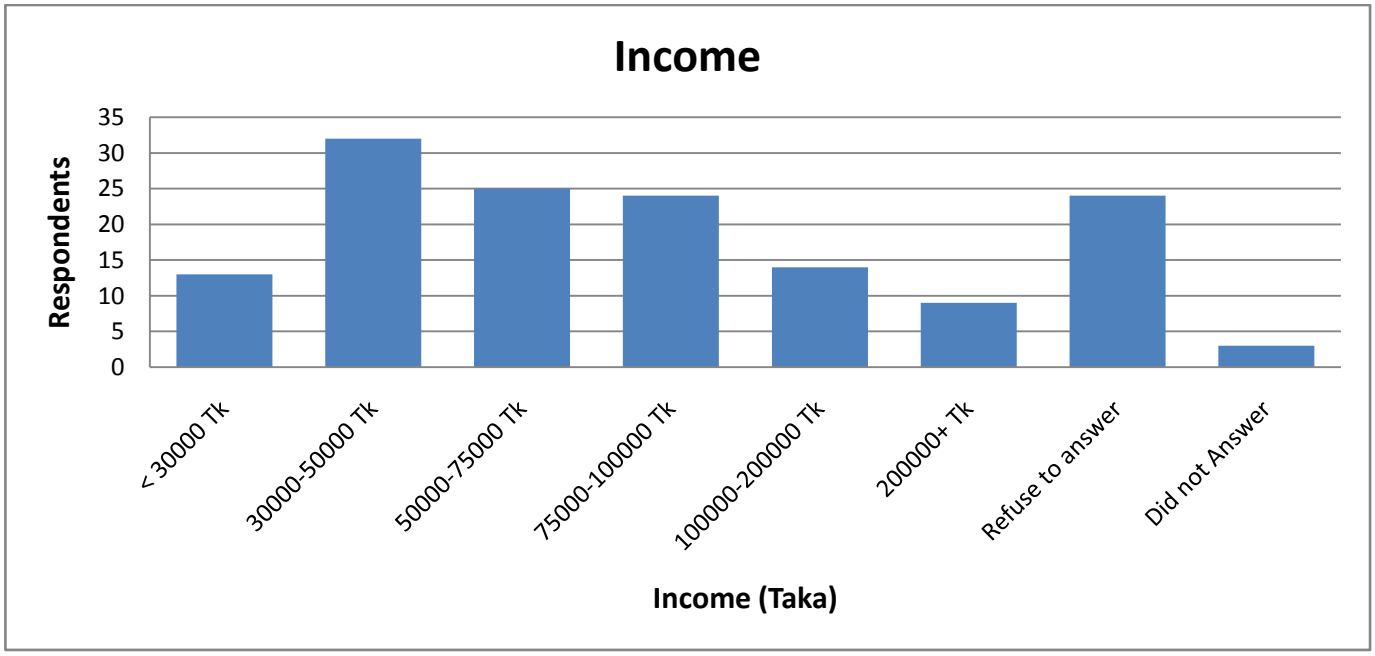
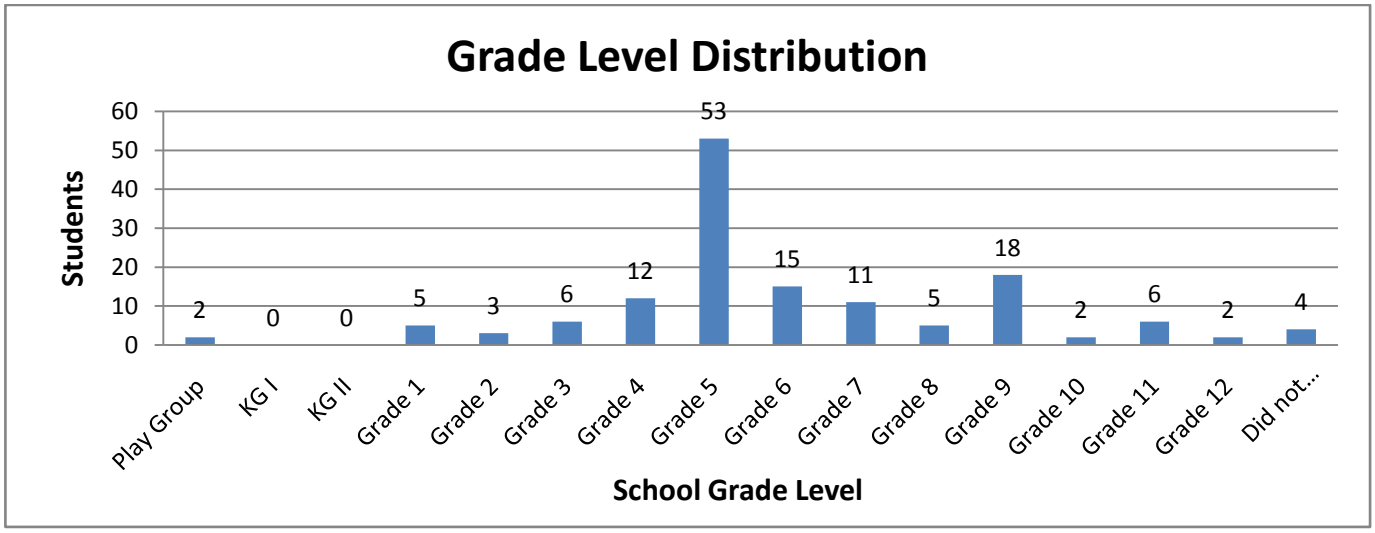


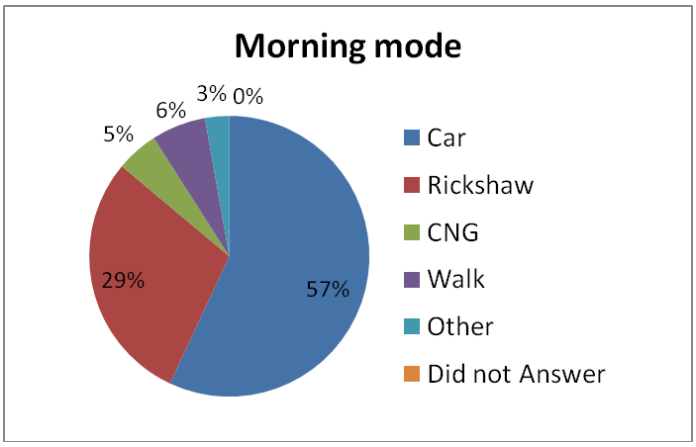
Figure 3: Grade level distribution of students



Current travel behavior

More than half of the respondents drive cars to school in the morning, while about a third take a rickshaw, as shown in Figure 4. The mode usage was similar in the afternoon. The travel times (in Figure 5) for the morning commute were spread out, ranging from 10 minutes to 45 minutes; the average would lie between 10-20 minutes. Figure 6 shows that three-quarters of the students don't carpool, a behavior that majorly contributes to congestion.

Figures 4 and 5: Currently preferred mode for traveling to school in the morning; Travel time in the morning



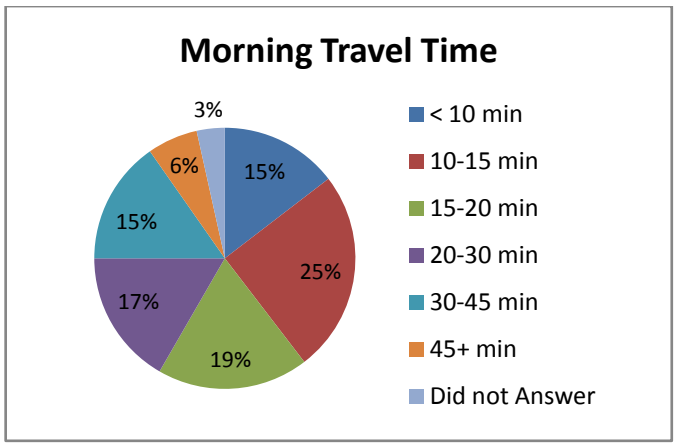
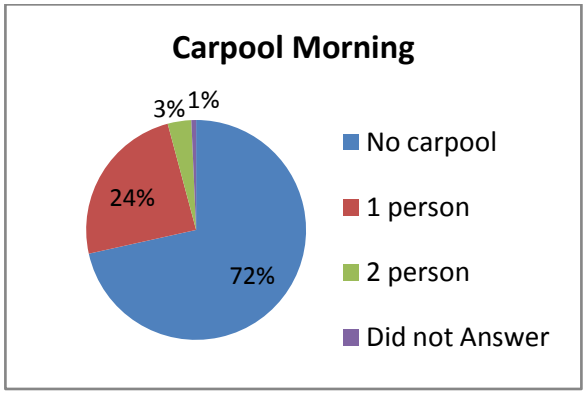


Figure 6: Carpool behavior in the morning

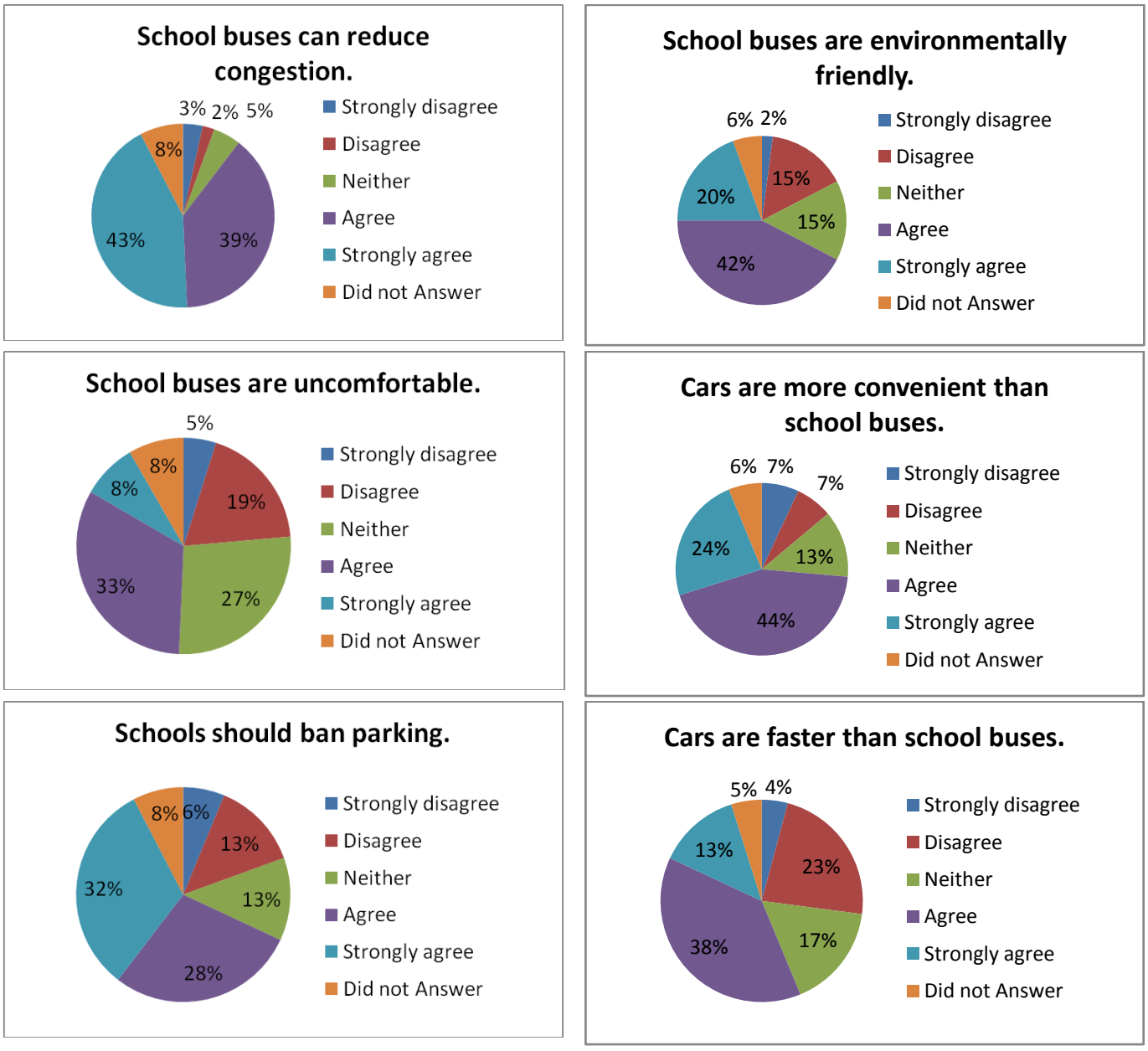


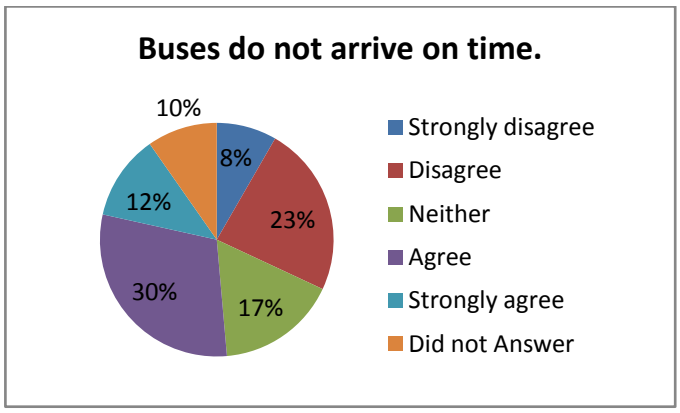
Perceptions about School Buses

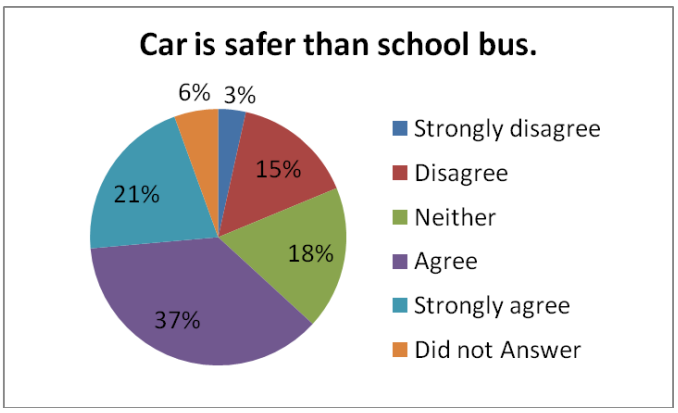
The selection of travel mode is influenced by the traveler's perception toward those modes. The survey asked several questions to gauge level of agreement with various statements concerning school buses and comparing school buses with cars.

Figure 7 shows the responses to the perception questions. More than half of the respondents believed that school buses can reduce congestion and benefit the environment, while more than 40% agreed that school buses were uncomfortable and don't arrive on time. When comparing school buses with cars, more than half agreed that cars were safer, faster, and more convenient than school buses. Sixty percent wanted schools to ban parking, which would reduce exhaust, congestion, and the danger of car accidents occurring in front of the school.

Figure 7: Perceptions of several statements about school buses





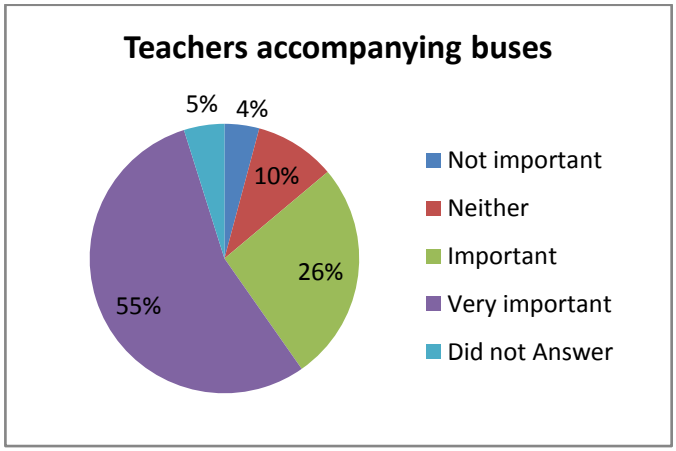


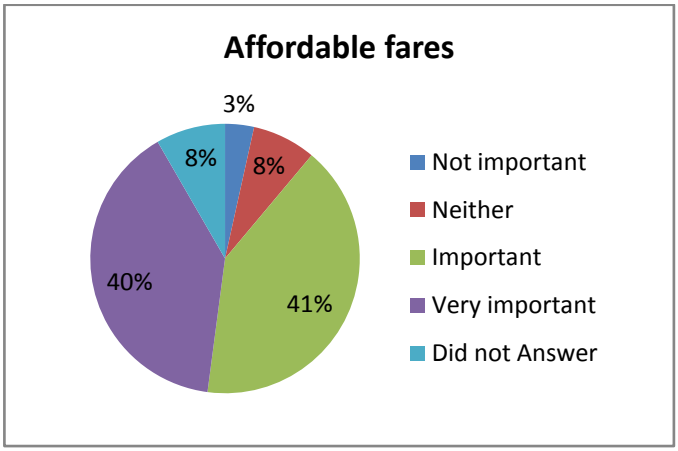
Attitudes about School Buses

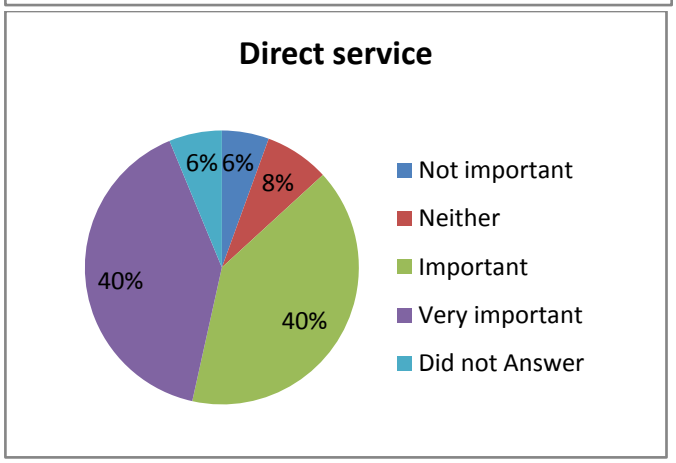
Respondents were asked to evaluate the importance of several aspects of school buses. If school buses are to be purchased in the future, this data can help in deciding which school bus features are worth investing in and which are not.

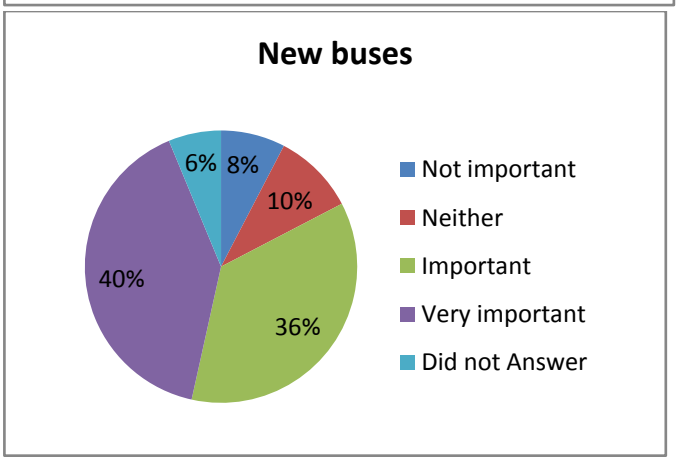
Figure 8 shows that affordability and teacher accompaniment were deemed the most important (both over 80%). This is expected because the security of their children is the parents' first priority, and the bus fees are also a major deciding factor. Most respondents agreed that measures to transport students to school on time (direct service, door-to-door pickup/dropoff, dedicated buses) and increase comfort (new buses and air conditioning) were of high importance but secondary to cost and security.

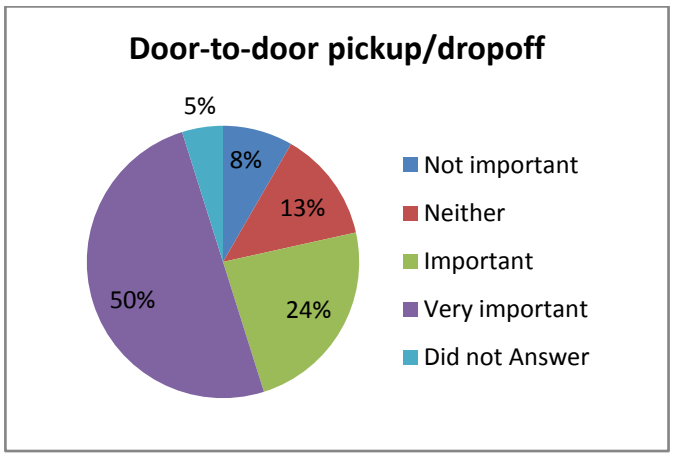
Figure 8: Importance of several features of school buses

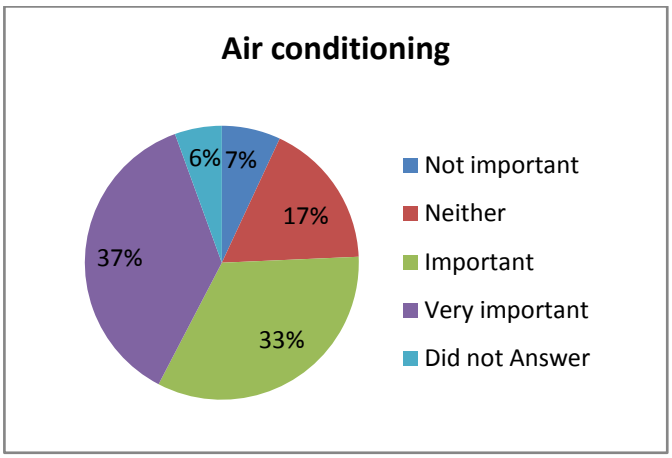


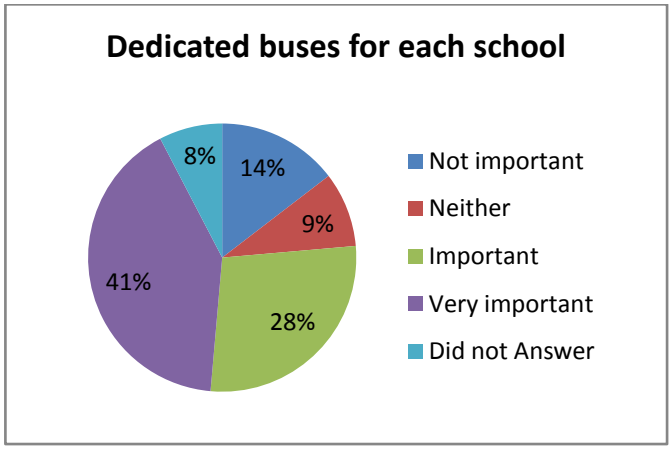












5. Data Analysis

5.1) Utility Functions

To model the decision-making behavior of individuals, it is useful to consider *utility*, a measure of attractiveness. When making a decision, an individual is faced with any number of alternative choices, each with a unique combination of attributes and level of utility. It is assumed that people seek to maximize utility. The random utility function is often used to generate utility values, and it takes into account not only the constant utility of each alternative and the socio-economic characteristics of an individual but also the random effect of measurement errors, unobserved attributes, and taste variation.

The utility function is the sum of an alternative-specific coefficient and several attribute variables multiplied by coefficients. The larger a coefficient is, the more sensitive people are to the corresponding attribute. To find these coefficients, a common first step is to use the *multinomial logit* (MNL) model to integrate the random element out of the expression. MNL can only be used if the choice set contains more than two alternatives and if the random element follows an extreme value distribution over the population. The second step is to use *maximum likelihood estimation* (MLE), a multiple regression procedure, to estimate the desired coefficients. MLE also outputs standard error, t-test, and rho-squared values.

5.2) Model Estimation

Biogeme

Bierlaire Optimization Toolbox for GEV Model Estimation (BIOGEME) is a software package used for maximum likelihood estimation of Generalized Extreme Value (GEV) models (Bierlaire, 2009). In other words, Biogeme performs discrete choice analysis based on maximum likelihood estimation technique.

The multinomial logit model was used to model the data. The attributes of the alternatives and socio-economic characteristics of the respondents were incorporated into the models. Different utility function specifications were constructed and their goodness of fit compared with Biogeme. The relative magnitudes and signs of the different coefficients were also predicted and matched with the output from the model. The best model was chosen according to the best fit and the most sensible values of the coefficients.

Variables (Model specifications)

Several respondent-specific socio-economic characteristics and mode-specific attributes were considered for an MNL estimation. The socio-economic characteristics are:

- Grade attended by student
- Gender of student
- Location of student
- Parent's occupations
- Parent's level of education
- Household size
- Number of additional children attending the same school, and if they have the same timing
- Car availability
- Monthly household income

The alternative-specific attributes that were considered for model estimation are listed below. Note that some of the attributes are only specific to certain modes.

- Actual travel time
- Waiting time to get the desired mode
- Total monthly cost
- Availability of mode
- Comfort level
- Security level
- Vehicle size (large bus vs. microbus)

5.3) Preliminary Estimated Model: MNL

The best-fit model obtained by performing MNL on the data using Biogeme is described below. The following expressions describe the utility function, U, associated with each mode of travel.

$$U_{bus} = \beta_{cost} * Cost_{bus} + \beta_{time} * Time_{bus} + \beta_{comfort} * Comfort_{bus}$$

$$U_{car} = ASC_{car} + \beta_{cost} * Cost_{car} + \beta_{time} * Time_{car} + \beta_{inertia} * Inertia_{car}$$

$$U_{rick} = ASC_{rick} + \beta_{cost} * Cost_{rick} + \beta_{time} * Time_{rick} + \beta_{inertia} * Inertia_{rick}$$

The subscripts refer to the mode of travel; rickshaw is abbreviated as rick. The betas (β) refer to the sensitivity associated with each parameter.

The ASCs are the alternative-specific constants relevant to each mode. This term captures the effect of all attributes not being considered for the model. It can be understood as the inherent preference for a mode. The bus mode does not have an ASC associated with it because in the model, we are estimating the ASCs relative to each other. Therefore the alternative-specific constant of bus is set to zero, and the other ASCs are evaluated relative to the ASC of bus.

$Cost_{mode}$ refers to the monthly cost of sending children to school using this mode. It is measured in hundreds of taka/month.

$Time_{mode}$ is the average time (in mins) that is required by the student to travel one-way to/from school using this mode.

$Comfort_{bus}$ refers to the comfort level of the bus. There are three levels of comfort as mentioned in Table 1, so this parameter is either 0,1 or 2.

$Inertia_{mode}$ is a binary dummy variable that is one (1) if the current mode of travel is the same as this mode. The inertia term captures the effect of inherent inertia for the current mode.

5.4) Predictions

Knowledge gained from the focus-group study and pilot study helped predict the results. In general, people prefer lower costs and shorter travel times. Therefore, the signs of sensitivities (betas) associated with these parameters should be negative; this implies that utility decreases with increased cost and travel times. People should prefer increased comfort, so they are positively sensitive to comfort. The sensitivities associated with the inertia dummies should also be positive because people are resistant to change and will most likely to not want to switch from their current modes.

5.5) Results

The results obtained from the preliminary MNL model are tabulated below:

Table 4: Coefficients obtained from preliminary MNL model

Parameter	Value	Std. Error	t-statistic
β_{cost}	-0.0487	0.0226	-2.16
β_{time}	-0.0385	0.0104	-3.70
$\beta_{comfort}$	0.592	0.158	3.74
$\beta_{inertia}$	4.30	0.754	-3.70
ASC_{car}	-2.99	0.879	-3.41
ASC_{rick}	-3.91	0.741	-5.27

Model: Multinomial Logit
Number of estimated parameters: 6
Number of observations: 330
Final log-likelihood: -215.6
Adjusted rho-square: 0.313

The negative sensitivities to cost and time, the positive sensitivity for comfort level, and the strong inertia for current mode match the predictions with 95% confidence. The t-statistic is a measure of confidence of the calculated values. If the absolute value of the t-statistic is greater than 1.96, it implies that the result has a confidence level of 95 percent. The alternative-specific constant for car is greater than that of rickshaw, which implies that in general people have a stronger preference for car.

5.6) Market Segmentation

A market segment refers to a subgroup of the respondents who share one or more characteristic that causes them to have similar needs. A market segmentation test is performed to verify whether a market segment in the model is significant. There can be several different market segments according to socio-economic characteristics of the respondent.

A market segmentation test begins by first making the null hypothesis that there is no significant market segmentation, i.e. the probability of an individual choosing an alternative is independent of a certain socio-economic characteristic. Then the respondents are split into several market segments and the model tested on each group separately.

Let the log-likelihood of the unsegmented or restricted model be $L_{restricted}$. Let the log-likelihood of each segment be L_x, where x refers to the various market segments. The sum of these log-likelihoods is the log-likelihood of the unrestricted model; let this be $L_{unrestricted}$. Market segmentation exists if:

$$-2 * (L_{unrestricted} - L_{restricted}) > (\chi(i))^2$$

where $\chi(i)$ is a function of i, the number of parameters being estimated (Louviere, 2000). In this model, since 6 different parameters are being estimated, $i = 6$. The value of the χ function for 6 parameters can be obtained from a table, and is equal to 11.07 for a confidence level of 95 percent.

Several market segmentation tests were carried out on the data. The respondents were segmented into these groups:

Gender:
- Student is female
- Student is male

Grade level
- Student attends grades Kindergarten -5
- Student attends grades 6-8
- Student attends grades 9-12

Mother's occupation
- Mother is a housewife
- Mother is not a housewife

Household size
- Household size greater than 4
- Household size less than or equal to 4

Car availability
- Family owns car
- Family does not own a car

Siblings
- Siblings attend the same school
- Siblings do not attend the same school, or no siblings present

Income
- Total household income less than 50,000 tk/month
- Total household income between 50,000 – 100,000 tk/month
- Total household income greater than 100,000 tk/month

The results obtained from the market segmentation tests are tabulated below:

Table 5: Market segmentation results

Test	**Group**	**Log-likelihood**	$L_{unrestricted}$	$-2 * (L_{unrestricted} - L_{restricted})$	**Market Segmentation?**
Gender	Restricted	-212.375	-200.314	24.122	Yes
	Females	-140.38			
	Males	-59.934			
Grade	Restricted	-212.006	-197.871	28.27	Yes
	Group 1	-106.669			
	Group 2	-49.924			
	Group 3	-41.278			
Mother's occupation	Restricted	-215.6	-204.396	22.408	Yes
	Housewife	-148.349			
	Not housewife	-56.047			
Household size	Restricted	-213.897	-205.663	16.468	Yes
	Greater than 4	-166.237			
	Less than 4	-39.426			

Car availability	Restricted	-215.6	-211.13	8.94	No
	Car available	-164.701			
	Car not available	-46.429			
Siblings	Restricted	-215.6	-206.697	17.806	Yes
	Siblings present	-102.875			
	Sibling absent	-103.822			
Income	Restricted	-178.629	-153.217	50.824	Yes
	Income group 1	-49.672			
	Income group 2	-72.215			
	Income group 3	-31.33			

5.7) Revised Model with Market Segmentation

Based on the tests performed, it is evident that there is significant market segmentation based on gender, household size, income etc. The initial model was updated to incorporate the effects of market segmentation. This was done by changing the utility function of the bus to include a dummy variable that would turn on (1) or off (0) based on the respondent's membership in a particular market segment. The resulting utility function of the bus is:

$$U_{bus} = \beta_{cost} * Cost_{bus} + \beta_{time} * Time_{bus} + \beta_{comfort} * Comfort_{bus} + \delta_{female} + \delta_{grade\_group\_2} + \delta_{grade\_group\_3} + \delta_{housewife} + \delta_{large\_household} + \delta_{sibling} + \delta_{med\_income} + \delta_{high\_income}$$

The deltas (δ) capture the effect of market segmentation. In Biogeme, dummy variables are created for each of the deltas shown above; these dummy variables turn 1 when the respondent belongs to that group; otherwise it is 0. The deltas shown above are actually the coefficients of these dummy variables, and the superscript refers to the market segment. Notice that all the market segments are not listed, because the values obtained are relative. This means that the rest of the deltas are set at zero. For example, the gender market segment δ_{male} is fixed at 0, and the value obtained for δ_{female} is relative to 0.

The utility functions of car and rickshaw are left unchanged because it is assumed that market segmentation only affect the decision maker's consideration of school buses. According to this model, the results are:

Table 6: Coefficients obtained from MNL model with market segmentation

Parameter	Value	Std. Error	t-statistic
β_{cost}	-0.0406	0.0252	-1.60
β_{time}	-0.0447	0.0115	-3.90
$\beta_{comfort}$	0.700	0.176	3.97
$\beta_{inertia}$	4.23	0.718	5.89

ASC_{car}	-3.19	0.900	-3.54
ASC_{rick}	-4.42	0.789	-5.60
δ_{female}	0.0932	0.332	0.28
$\delta_{grade\ \_group\ \_2}$	-0.190	0.384	-0.49
$\delta_{grade\ \_group\ \_3}$	0.453	0.339	1.34
$\delta_{housewife}$	-1.34	0.353	-3.80
$\delta_{large\ \_house\ hold}$	0.231	0.318	0.73
$\delta_{sibling}$	0.476	0.284	1.67
$\delta_{med\ \_income}$	0.488	0.319	1.53
δ_{high_income}	-0.731	0.434	-1.68

Model: Multinomial Logit
Number of estimated parameters: 14
Number of observations: 330
Final log-likelihood: -199.502
Adjusted rho-square: 0.338

This model has a higher adjusted rho-square value meaning that the data fits better with this model than with the preliminary MNL model. However, most of the deltas have very low t-statistics. This occurs because each market segment is much smaller compared to the full set; hence there are only a very small number of data points available to estimate delta from. However the signs of the deltas agree with prediction.

$\delta_{housewife}$ is large and negative, implying that mothers who do not work are less willing to let their children use school buses. Possibly these mothers prefer to escort children to school themselves.

$\delta_{large\ \_house\ hold}$ is positive, implying that large families favor school buses. This could be attributed to the inconvenience of picking-up and dropping-off multiple children at different schools or activities.

δ_{high_income} is large and negative, supporting the prediction that people who are richer have very little incentive to use school buses.

5.7) Further Testing

Nested logit (NL) is a generalization of multinomial logit that takes into account the interaction between alternatives (Louviere, 2000). For example, a respondent's decision may be influenced by the fact that both bus and car are motorized, while rickshaw is manually operated. This is called nesting and is illustrated in Figure 9 below. These types of interaction can be studies using nested logit. Biogeme has a built in nested logit (NL) model that can be used to test nesting.

Figure 9: Nested vs Multinomial Logit

NL tests were carried out on the data to verify two types of interactions. First, bus and car were nested together for being motorized. Next, bus and rickshaw were lumped together as both of these were public modes of travel. However, the tests from nested logit modeling were negative confirming that there was no significant nesting.

6. Conclusion

The results from the research support and conclude general predictions about cost and time. The negative values of alternative-specific constants for car and rickshaw imply that if all factors are kept same, the bus has higher utility than either car or rickshaw. Rickshaw has the most negative alternative-specific constant, implying that it is the least preferred mode of travel. However, people have very high inertias for their current modes of travel, and this inertia offsets the negative alternative-specific constant values for both car and rickshaw. This means that although a better mode, people do not want to switch to buses because they have an inertial preference for their current mode of travel. This also means that people may be convinced to switch from their current modes of travel by increasing awareness about the traffic situation in Dhanmondi, and helping them understand how a school bus system can actually improve the situation.

The utility functions obtained through this research can be useful for any group that is trying to implement a school bus system to improve the traffic situation in Dhanmondi. By adjusting the levels of service of the different attributes associated with each mode of travel before actually implementing the system, proper ridership is likely to be achieved. A realistic goal would be to implement a school bus system whose utility matches with that of the car, since car is the most widely used travel mode by students. This can be done in two ways:

- Increase the utility of the bus by reducing travel time or fare, or increasing comfort level.
- Reduce the utility of the car by imposing parking restrictions, and increasing travel time and cost.

Future Work

The results of this research were based on a very small sample size (144) relative to the target population. The results can be improved by increasing the sample size to at least 2000. Since the model is based on the generalized extreme value method, the sample size heavily influences the results. The model created in this project is based on the basic multinomial logit, and it can improved by studying joint logit modeling, multinomial probit modeling, and/or mixed logit modeling. A significant amount of literature exists on these models, which encourages further explanation of Dhaka's congestion problem.

Questionnaire on User Opinion of a School Bus System

Bangladesh University of Engineering & Technology (BUET)
Harvey Mudd College (Claremont, California, USA)

Traffic congestion in the school areas is a major problem in Dhaka. This congestion can be reduced in extent if more students use school buses. However, school buses are currently not very popular in Dhaka, particularly in the Dhanmondi area. A research team from the United States and the Department of Civil Engineering, BUET is currently investigating the reasons behind this. The results of this research will be presented to relevant authorities including the Dhaka City Corporation.

As part of this research, we are collecting data to find out what features of the school bus are most important to the users. Your responses are very important for our research. Thanks in advance for your help!

First, we are going to ask you about how your child comes to school and goes back.
(Please circle the correct answer)

1. How does your child **generally** travel to/from school?

In morning	a. Car	b. Rickshaw	c. CNG	e. Walk	f. Other:_____
In afternoon	a. Car	b. Rickshaw	c. CNG	e. Walk	f. Other:_____

2. How long does it take your child to go to school in the morning?
   a. Less than 10 minutes b. 10–15 minutes c. 15–20 minutes
   d. 20–30 minutes e. 30–45 minutes f. More than 45 minutes

3. How long does it take your child to return home from school in the afternoon?
   a. Less than 10 minutes b. 10–15 minutes c. 15–20 minutes
   d. 20–30 minutes e. 30–45 minutes f. More than 45 minutes

4. Who drops-off/picks-up your child to/from school?

Drop-off	a. Parent	b. Driver	c. Another relative	d. Neighbor/friend	e. Other: _____
Pick-up	a. Parent	b. Driver	c. Another relative	d. Neighbor/friend	e. Other: _____

5. Does your child go to school with any other student (including his brother/sister)?
   a. Yes b. No
   If Yes, with how many other children? _____

6. Does your child return from school with any other student (including his brother/sister)?
   a. Yes b. No
   If Yes, with how many other children?

6. What is your *current* home address?

_____
(You can omit the house number if you like: e.g. Dhanmondi Road No. 10/A, Mirpur Block No. 12 etc.)

We would now like to present some ***future*** situations with ***proposed*** school bus services.

The proposed regular school bus will have a monthly charge payable with the tuition. The travel time will depend on the route and can be longer or shorter than your current travel time. The bus may pick-up and drop-off your child at your home or from a central pick-up/drop-off point near your home. The children will be accompanied with teachers or attendants (non-teachers) while they are on the bus. The comfort levels can vary depending on the bus type and the bus may serve students from other nearby schools as well.

Now please compare the proposed school bus services described in next page with your current travel mode. In each case, state which one would you choose. For the current mode, consider that the situation is same as now (the travel time, cost etc. are unchanged).

If you currently travel by Car (If not, please go to the next page) ID : 101

Please compare the proposed school bus service with the current travel by car.
For each of the following situations, please state which one you would choose, by marking the box provided.

SITUATION #1

	Car	School Bus
Travel time (each way)	Same as now	10 minutes more than now
Vehicle size	-	Large bus (20-30 people) serving multiple schools
Security	Same as now	Accompanied by a teacher
Time to the bus stop	-	Up to 5 minutes walk
Comfort	Same as now	New buses without A/C
Cost	Same as now	Dhanmondi,Lalmatia,Mohammadpur,etc.: Tk 750/month Mirpur,Gulshan,Banani,etc.: Tk 1200/month
Which mode would you choose?	**Car** ☐	**School Bus** ☐

SITUATION #2

	Car	School Bus
Travel time (each way)	Same as now	5 minutes more than now
Vehicle size	-	Large bus (20-30 people) serving multiple schools
Security	Same as now	Accompanied by an assistant
Time to the bus stop	-	Up to 5 minutes walk
Comfort	Same as now	Old buses without A/C
Cost	Same as now	Dhanmondi,Lalmatia,Mohammadpur,etc.: Tk 1000/month Mirpur,Gulshan,Banani,etc.: Tk 2000/month
Which mode would you choose?	**Car** ☐	**School Bus** ☐

SITUATION #3

	Car	School Bus
Travel time (each way)	Same as now	10 minutes less than now
Vehicle size	-	Microbus (10-12 people)
Security	Same as now	Accompanied by an assistant
Time to the bus stop	-	Up to 5 minutes walk
Comfort	Same as now	New buses without A/C
Cost	Same as now	Dhanmondi,Lalmatia,Mohammadpur,etc.: Tk 900/month Mirpur,Gulshan,Banani,etc.: Tk 1800/month
Which mode would you choose?	**Car** ☐	**School Bus** ☐

SITUATION #4

	Car	School Bus
Travel time (each way)	Same as now	5 minutes less than now
Vehicle size	-	Large bus (20-30 people) serving multiple schools
Security	Same as now	Accompanied by an assistant
Time to the bus stop	-	Up to 5 minutes walk
Comfort	Same as now	New buses with A/C
Cost	Same as now	Dhanmondi,Lalmatia,Mohammadpur,etc.: Tk 600/month Mirpur,Gulshan,Banani,etc.: Tk 1000/month
Which mode would you choose?	**Car** ☐	**School Bus** ☐

How much do you think you can save on your car cost if you do not have to drop-off or pick-up your child/children by car?

a. Less than Tk 500
b. Tk 500 to Tk 800
c. Tk 800 to Tk 1000
d. Tk 1000 to Tk 1500
e. More than Tk 1500
f. Don't know

If you currently travel by Rickshaw/CNG (If not, please go to the next page) ID : 101

1. How long do you have to walk (e.g. to the main road, to a nearby bus stop) to get a CNG/Rickshaw?
   a. Less than 5 minutes b. 10 minutes c. More than 10 minutes

2.Do you generally have to wait more than 5 minutes to get a suitable rickshaw/CNG?
   a. Yes b. No

3. What is the rickshaw/CNG fare for each way? Tk _____

Now please compare the proposed school bus service with your current travel by rickshaw/CNG. In all situations, consider that the conditions for rickshaw/CNG are same as now (i.e. the travel time, cost, waiting time etc. are unchanged).

For each of the following situations, please state which one you would choose, by marking the box provided.

SITUATION #1

	Rickshaw/CNG	School Bus
Travel time (each way)	Same as now	5 minutes more than now
Vehicle size	-	Large bus (20-30 people) serving multiple schools
Security	Same as now	Accompanied by a teacher
Time to the bus stop	Same as now	Up to 5 minutes walk
Comfort	Same as now	New buses without A/C
Cost	Same as now	Dhanmondi,Lalmatia,Mohammadpur,etc.: Tk 750/month Mirpur,Gulshan,Banani,etc.: Tk 1200/month
Which mode would you choose?	**Current** ☐	**School Bus** ☐

SITUATION #2

	Rickshaw/CNG	School Bus
Travel time (each way)	Same as now	Same as now
Vehicle size	-	Large bus (20-30 people) serving multiple schools
Security	Same as now	Accompanied by an assistant
Time to the bus stop	Same as now	Up to 5 minutes walk
Comfort	Same as now	Old buses without A/C
Cost	Same as now	Dhanmondi,Lalmatia,Mohammadpur,etc.: Tk 1000/month Mirpur,Gulshan,Banani,etc.: Tk 2000/month
Which mode would you choose?	**Current** ☐	**School Bus** ☐

SITUATION #3

	Rickshaw/CNG	School Bus
Travel time (each way)	Same as now	15 minutes less than now
Vehicle size	-	Microbus (10-12 people)
Security	Same as now	Accompanied by an assistant
Time to the bus stop	Same as now	Up to 5 minutes walk
Comfort	Same as now	New buses without A/C
Cost	Same as now	Dhanmondi,Lalmatia,Mohammadpur,etc.: Tk 900/month Mirpur,Gulshan,Banani,etc.: Tk 1800/month
Which mode would you choose?	**Current** ☐	**School Bus** ☐

SITUATION #4

	Rickshaw/CNG	School Bus
Travel time (each way)	Same as now	10 minutes less than now
Vehicle size	-	Large bus (20-30 people) serving multiple schools
Security	Same as now	Accompanied by an assistant
Time to the bus stop	Same as now	Up to 5 minutes walk
Comfort	Same as now	New buses with A/C
Cost	Same as now	Dhanmondi,Lalmatia,Mohammadpur,etc.: Tk 600/month Mirpur,Gulshan,Banani,etc.: Tk 1000/month
Which mode would you choose?	**Current** ☐	**School Bus** ☐

Questions about your family

Now we would like to ask you some questions about your child and your family (to group the choices). All responses are confidential; no personal information will be revealed or tracked. **Please write-in or circle your answer.**

1. Which grade is your child in? (e.g. Playgroup, KG, 1, 2, etc.) _____

2. What is your child's gender?
   a. Male b. Female

3. Which of these best describes the parents' occupations?

Father:
- a. Manager/Official of a private company
- b. Government Official
- c. Professional (e.g. Engineer, Doctor)
- d. Teacher
- e. Businessman
- f. Other: _____
- g. Refuse to answer

Mother:
- a. Manager/Official of a private company
- b. Government Official
- c. Professional (e.g. Engineer, Doctor)
- d. Teacher
- e. Businessman
- f. House-wife
- g. Other: _____
- h. Refuse to answer

4. What is the highest educational level completed by the parents?

Father:
- a. Lower than intermediate level
- b. Intermediate level
- c. University (Bachelors)
- d. Postgraduate (Masters/PhD)
- e. Refuse to answer

Mother:
- a. Lower than intermediate level
- b. Intermediate level
- c. University (Bachelors)
- d. Postgraduate (Masters/PhD)
- e. Refuse to answer

5. How many members do you have in your household (in addition to you)? _____

6. How many children (less than 12 years do you have in your family)? _____

7. Do you have more than one child attending this school?
   a. Yes b. No

   If Yes, How many? _____

   Do they have same class timings (e.g. same start times and end times)?
   a. Yes b. No

8. Do you have a car for your personal use?
   a. Yes, it is a private car that is owned by my family
   b. Yes, it is an official/business/company car
   c. No

9. If you have a private car, do you have a driver?
   a. Yes b. No

10. In which range does your total monthly **household** income fall in (before tax and other deductions)?
    a. Less than Tk 30,000
    b. Tk 30,000 to Tk 50,000
    c. Tk 50,000 to Tk 75,000
    d. Tk 75,000 to Tk 100,000
    e. Tk 100,000 to Tk 200,000
    f. Tk 200,000 or more
    g. Refuse to answer

Questions about the scenarios

We would now like to have your feedback on the questionnaire. **Please circle your answer.**

1. Were you able to understand the choice scenarios?
   a. Yes b. No
   If No, which choices were not understandable?
   a. Situation # 1 b. Situation # 2 c. Situation # 3 d. Situation # 4

2. Did you think the alternatives were realistic?
   a. Yes b. No
   If No, which choices were not realistic?
   b. Situation # 1 b. Situation # 2 c. Situation # 3 d. Situation # 4

Additional Questions

We would now like to get your views on school bus and transportation system in general. **Please mark your answers.**

1. Which of the following do you think are important for improving the school bus service in Dhaka?

	Not important	Neither important nor unimportant	Important	Very important
a) More direct service (reduced travel times)	□	□	□	□
b) Door-to-door pick-up and drop-off	□	□	□	□
c) New buses	□	□	□	□
d) Air-conditioning in the buses	□	□	□	□
e) Teachers present in the buses	□	□	□	□
f) Affordable service (reduce fare)	□	□	□	□
g) Dedicated buses for each school (instead of buses shared by multiple schools)	□	□	□	□

2. Please indicate your level of agreement with the following statements

	1 (strongly disagree)	2 (disagree)	3 (neither)	4 (agree)	5 (strongly agree)
a) Schools should ban parking.	□	□	□	□	□
b) The car is more secure and safer than school bus.	□	□	□	□	□
c) Using school buses can reduce congestion.	□	□	□	□	□
d) The school buses are not very comfortable.	□	□	□	□	□
e) School buses are environment friendly.	□	□	□	□	□
f) School buses are much slower than cars.	□	□	□	□	□
g) School buses do not arrive/leave on time.	□	□	□	□	□
h) Using a car is more convenient than school bus (e.g. can take my child out for lunch/ to a coaching center after school if needed).	□	□	□	□	□

Thank you for participating in our questionnaire!
If you have any questions you can contact us at cfc@ce.buet.ac.bd or 9665650 Ext 7201

Appendix B: Biogeme Code

```
// Binary Logit model for mode choice with generic coefficients
// Stated preference data from Dhanmondi, Dhaka, Bangladesh
// Mobashwir Khan, Jason Wang, Charisma F. Choudhury

[Choice]
choice

[Beta]
// Name                Value   LowerBound     UpperBound     status (0=variable, 1=fixed)
BETA_COST              0.0    -100.0         100.0          0
BETA_TIME              0.0    -100.0         100.0          0
BETA_INERTIA           0.0    -100.0         100.0          0
BETA_COMFORT           0.0    -100.0         100.0          0
ASC_HIGHINCOME         0.0    -100.0         100.0          0
ASC_MEDIUMINCOME       0.0    -100.0         100.0          0
ASC_FEMALE             0.0    -100.0         100.0          0
ASC_SIBLING            0.0    -100.0         100.0          0
ASC_LARGEHOUSEHOLD     0.0    -100.0         100.0          0
ASC_GRADEGROUP1        0.0    -100.0         100.0          0
ASC_GRADEGROUP2        0.0    -100.0         100.0          0
ASC_HOUSEWIFE          0.0    -100.0         100.0          0


[Utilities]
// Id   Name    Avail   linear-in-parameter expression (beta1*x1 + beta2*x2 + ... )

  0     Car     car_av         ASC_CAR * one + BETA_COST * costC + BETA_TIME * car_tt + BETA_INERTIA *
car_inertia

  1     Bus     one            ASC_BUS  * one + BETA_COST * bus_cost +BETA_TIME * bus_tt + BETA_COMFORT *
bus_comfort + ASC_FEMALE * female + ASC_GRADEGROUP1 * gradegroup1 + ASC_GRADEGROUP2 * gradegroup2 +
ASC_HOUSEWIFE * housewife + ASC_LARGEHOUSEHOLD * largehousehold + ASC_SIBLING * sibling + ASC_MEDIUMINCOME
* medium_income + ASC_HIGHINCOME * high_income

  2     Rick    rick_av        ASC_RICK * one + BETA_COST * costRR +BETA_TIME * rick_tt + BETA_INERTIA *
rick_inertia


[Expressions]
one = 1
rick_av = (mode_morning == 0) || (mode_afternoon == 0)||(distance == 0) //|| (choice == 2)
car_inertia = (mode_morning == 0) || (mode_afternoon == 0)
rick_inertia = (mode_morning == 1) || (mode_afternoon == 1)
car_tt =average_current_tt * car_inertia
rick_tt =average_current_tt *rick_inertia
costRR = costR * 40
car_cost = curr_cost_totalavg * car_inertia
rick_cost = curr_cost_totalavg * rick_inertia
bus_cost1 = bus_cost *distance
bus_cost2 = bus_cost * (distance ==0)
car_cost2 = car_cost * (distance ==0)
rick_cost2 = rick_cost * (distance ==0)
medium_income = (income_seg == 1)
high_income = (income_seg == 2)
female = (gender == 0)
gradegroup1 = (grade_seg == 1)
gradegroup2 = (grade_seg == 2)
housewife = (m_occ == 5)
largehousehold = (household_size > 4)
sibling = (add_children > 0)


[Exclude]
car_av = 99999.0 || curr_cost_totalavg = 99999.0 || average_current_tt = 99999.0 || choice = 99999.0 || id
= 346 || id = 1565 || id = 974 || id = 110 || id = 103 || id = 851 || id = 850 || id = 1474 || id = 1431
|| id = 933 || id = 927 ||distance = 99999 || costR > 40



// Origin market segmentaion || distance = 0 || distance = 99999.0 ||
// Income group market segmentation || income_seg = 0 || income_seg = 1 || income_seg = 99999.0
// Siblings market segmentation || add_children > 0 || add_children = 99999.0 ||
```

```
// Car availablity market segmentation || car_av = 99999.0 || car_av = 1 || car_av = 2 ||
// Household size market segmentation || household_size = 99999.0 || household_size > 4 ||
// Mother's occupation market segmentation || m_occ = 99999.0 || m_occ != 5 ||
// Grade group market segmentation || grade_seg = 99999.0 || grade_seg = 0 || grade_seg = 1
// Gender Market Segmentation || gender = 99999.0 || gender = 1

// missing cost_relatives || id == 105 || id = 170 || id = 131 || id = 102 || id = 162 || id = 847 || id =
116 || id = 1547 || id = 7 || id = 9 || id = 354 || id = 663
// Dominant test failures || id = 346 || id = 1565 || id = 974 || id = 110 || id = 103 || id = 851 || id =
850 || id = 1474 || id = 1431 || id = 933 || id = 927
// missing cost_relative_weighted || id = 131


[Model]
// Currently, only $MNL (multinomial logit), $NL (nested logit), $CNL
// (cross-nested logit) and $NGEV (Network GEV model) are valid keywords
//
$MNL
```

Appendix C: Bibliography

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