

# SP Based Modeling of Mode Choice for School Trip in Khulna City: Preferences of Developing Countries

**Azharul Islam<sup>1</sup>, Md. Rokib Hasan<sup>2</sup>**

<sup>1</sup>Junior Engineer, City Region Development Project, LGED, Dhaka

<sup>2</sup>Lecturer, Department of Civil Engineering, World University of Bangladesh, Dhaka, **Bangladesh**

## Abstract

Choice of travel modes for school trip are modeled in this paper using discrete choice analysis to identify the most influential factors that induces people to use school bus. A Multinomial Logit (MNL) mode choice model was developed in this regard using Stated Preference (SP) surveys. Model was generalized using two case studies; Khulna Zilla School and Govt. Coronation Girls School. Both of the schools are located in Khulna City Corporation (KCC) area, one of the major City of Bangladesh located south-western part of the country. Attributes and their levels for SP survey were taken from preliminary survey conducted on the guardians. From model output, travel time, travel cost, teacher as supervising person and separate bus service for each school were found more influential factors for guardians to consider school bus for their children. Socio economic characteristics of guardians were also found significant to travel mode choice for school trip of their children. The results of the study can help the Khulna city authority to formulate school bus related policies to reduce the number of vehicles on the roadway. The findings can also be useful for other cities of Bangladesh as well as for other developing countries, particularly those in Asia, which share similar socio-economic characteristics.

*Keywords: school trip, discrete choice, multinomial logit, stated preference, attributes*

## 1. Introduction

High population density with limited road networks is the major cause of traffic related problems in the major cities of Bangladesh leading to capital city Dhaka. Huge traffic congestion is the daily scenario for the city trip makers. Situation becomes worst in peak hour at the starting and closing time of office, school and college [1, 2]. Moreover, a large number

of commuters use private car (low occupancy vehicle) for office trip in the absence of better quality public transport which also increase the number of vehicles on the roadway. In addition, large number of schools and colleges are located in city center which attract huge traffic during peak period. School and college authorities do not provide travel facility which induces people to use car, rickshaw or auto rickshaw (Compressed Natural Gas, CNG, operated) for school trip. All these lead to extra pressure on city transportation system and increase Vehicle Miles Travelled (VMT). Similar situation exists in the Khulna city, one of the major City of Bangladesh. This city is supporting around 1.44 millions of people with density of 14364 per square mile [3]. City road network is not sufficient to ensure smooth travel of this huge population which results traffic congestion in city road network. In addition, narrow road, on road parking, unauthorized road side activities, on road pedestrian movement and mix traffic increase the congestion index of the city [4]. Moreover, a large number of school and colleges were established on roadside without any parking facilities. Significant number of students using private vehicles or low occupancy vehicles that increase the number of vehicles on roadway and imposes huge congestion in the road network adjacent to schools due to loading and unloading of students during school starting and closing time. It is established in literatures that introducing school buses can go a long way in curbing school traffic related congestion [5, 6]. Therefore, focus of this paper is to develop a transport mode choice model for school trips in Khulna city with special concentration on modeling preference of school bus services. Khulna Zilla School & College and Govt. Coronation Girls School, two best institutions inside Khulna city corporation area, were considered as study area. The estimated model can provide useful insights on travel mode choice for school trips in

Bangladesh and can help in policy formulation that can induce people to use the school bus with reduction of travel demand. Moreover, the proposed model framework can be applied in modeling similar choices, both for developed and developing countries.

## 2. Literature Review

Several researches were conducted worldwide focusing school trips. Ewing Schroeer and Greene [7] analyzed the factors affecting choice of travel mode for school trip using revealed preference (RP) data from schools in Gainesville, Florida. They found factors such as school size, school enrollment and land use variables such as density and mix to be insignificant in mode choice. Rhoulac [8] investigated the factors affecting mode choice by performing mode choice modeling on two modes - school bus and cars, his findings indicated that factors such as total number of students in a household, student grades, household income, comfort level and perceptions of safety are significant in the decision making process. Vovsha and Petersen [9] investigated how the decision to escort children to school by parents is affected by intra household interactions. They considered children as active agents in the decision making process and developed a choice model for ride sharing. Factors such as the escort's gender and the children's age were found to contribute significantly in the decision to escort. Schlossberg *et al.* [10] investigated the effects of urban form and distance on choice of school travel mode for middle school children in Oregon and found that both factors play important roles in determining children's travel mode. The effect of sex on mode selection was investigated by McMillan *et al.* [11] who found that girls are 40% less likely to walk or bike to school compared to boys. A study conducted by Kerr *et al.* [12] found that choice of school travel mode is significantly affected by parental concerns and the neighborhoods environmental characteristics. A study by Cain [13] focused on teenage riders' perceptions on public transport. He concluded that due to financial, legal and parental constraints on the use of private cars, teenagers are more likely to

use public transport than the general population. McDonald [14] investigated the relationship between distance and school location and found that walking to school is very sensitive to travel time. Yarlagadda and Srinivasan [15] and McDonald [16] published papers on how school travel mode choice is affected by socioeconomic factors and the interdependencies between the travel patterns of parents and children. They found factors such as age, gender and ethnicity of child as well as parent's employment and work flexibility play important roles in mode choice. Campbell and Wang [6] studied extensively the factors affecting mode choice of school children and found that convenience and ratings of modal safety play important roles. Zhou, et al. [17] found grade level, distance from home to school and numbers of children in the family are more influential parameter to choose travel mode for school trip. Security and safety has also been found the primary factors of concern for parents to allow their children to walk or bike to school, especially for those living at short walk able distances in Florida [18]. The other significant subjective variables include grade levels, school attitudes, enjoyment, healthy, allowable grade level, and student's attitude. Fries, Erica, and Zhou [19] found that intersection safety and traffic speed/volume are the top barriers for both urban and suburban children to choose school travel mode choice in Illinois, U.S. Review of the literature reveals that mode choice modeling focusing school trip has strong methodology and importance. But modeling focusing on mode choice is very limited in Bangladesh [1, 2, 20, 21, 22, 23] and none of them was conducted focusing school trips which may have potential to reduce congestion problem of the country. Taking the importance, Choudhury et al. [24] developed a Multinomial Logit (MNL) mode choice model for school trip in Dhaka city using Stated Preference (SP) survey conducted among the parents of students from a premier school zone. The results showed that for school buses, there are strong cost and time sensitivities as well as a significant preference for increased comfort levels.

## 3. Sp Survey Design

### 3-1 Preliminary Survey

Preliminary questionnaire survey was conducted with seventy two guardians of Khulna Zilla School and Govt. Coronation Girls School. Under preliminary questionnaire survey, random selections were made to get unbiased information regarding their existing travel mode, travel time, travel cost, alternative travel modes, socio-economic characteristics etc. The main objective of the survey was to identify the most influential attributes and their levels for final survey.

### 3-2 Choosing attributes and their levels

From the initial survey work, seven attributes were chosen and different levels of each attribute were also established for SP survey. Choudhury *et al.* [24] developed a SP based Multinomial Logit (MNL) mode choice model for school trip. They have selected the attributes of school bus for SP surveys by focus group consultation. Explanations of each attributes and their levels are given in Table 1 and Table 2 respectively.

Table 1: Description of attributes

Attributes	Description
Travel Cost	The daily travel fare of school bus services (round trip per student) was considered in taka. Since people are very sensitive to travel costs and it depends on travel length and mode of transport, different levels of travel cost were chosen.
Travel time	The approximate travel time was measured in minutes for a one-way trip (either going to or returning from school). Different levels of travel time were considered.
Bus stoppage	It indicates the place where buses will stop to pick up or drop-off students. Door-to-door pickup may be feasible for minibuses, but for large buses it would take too much time.
Vehicle size	Vehicle size was categorized depending on the sitting capacity. Large buses may be safer in collisions and more efficient if they provide service to students of multiple schools. Minibuses can probably travel at higher speeds and are more agile in traffic.
Supervising	A teacher or assistant may be hired to

person	supervise the bus. He /She will ensure the safe pick up and drop of the students in round trip (home to school and school to home). He /She will also handle the problems that occur during the travel.
School bus system	A combined school bus system for a zone of city corporation or whole town may be introduced. Individual bus system for each school may also be introduced. Combined school bus service may be an effective tool to reduce traffic congestion.

Attributes with their levels: Table 2

Attributes	School Bus	Other Modes
Travel cost	400 Tk/ month 600 Tk/month 800 Tk/month 1000 Tk/month 1200 Tk/month	Same as now
Travel time	15 minutes more than now 10 minutes more than now Same as now 5 minutes less than now 10 minutes less than now	Same as now
Bus stoppage	In front of home From main road	Same as now
Comfort	Air conditioned Non air conditioned	Same as now
Vehicle size	10-15 seats (micro bus) 20-25 seats (mini bus) 40-45 seats (large bus)	Same as now
Supervising person	Teacher Assistant	Same as now
School bus system	Individual Combine	Same as now

### 3-3 Generation of choice sets and scenarios:

Profiles of all alternatives for school bus were generated using statistical software SPSS (Statistical

Program for Social Sciences) using partial factorial design. Full factorial design generated large numbers of profiles and it was very difficult to ensure even distribution in choice sets. Dominant profiles having the best or worst option of all cases were discarded. Three SP scenarios on school bus were presented for each respondent and choice sets were generated randomly to ensure distinct profile in each scenario. Combinations of profiles among different alternatives were also done randomly. With these SP scenarios, the respondents were asked about their socio economic characteristics, existing travel mode and travel pattern.

### 3-4 Main Survey

Questionnaires were projected for the parents of the students because it is likely that parents decide which mode their children will use. But there is some limitations of this approach since children's preferences may also affect mode choice to some extent [6]. However, in the strongly hierarchical decision pattern prevalent in Bangladesh, the effects of children's preference in not expected to be significant. Data was collected by field survey on 60 respondents from Khulna Zilla School and 60 respondents from Govt. Coronation Girls School with three SP scenarios from each. Khulna Zilla School is located at Court Para and Govt. Coronation Girls School is located at Ahsan Ahmed Road of Khulna city and accommodating 2500 students and 1400 students respectively. Under SP survey, they were asked to state their choice of transport for school trips. They were also asked about their socio-economic condition and current travel pattern. The data that was then analyzed using simple statistical tools and techniques.

### 4. Data Characteristics

Socioeconomic characteristics of people very often influence the decisions regarding travel behavior. Some important socio-economic characteristics of the respondents were analyzed first using simple statistical tools and techniques. It was found that percentage of respondents having female student is little bit higher than that of male student (47%). Around half of the total students are accompanied by their mother because 82% of them are housewives and they have plenty of time to accompany their children. Main professions of father of 41% students are found to be business followed by service (39%) and Rest of them are immigrants. Around 21% of the respondents own private vehicle (motorcycle or car). Income distribution of the respondents commend that 25% earn within the range of BDT 20,000 to BDT 30,000; 22% earn within the range of BDT 15,000 to BDT 20,000 and 23 % earn more than BDT 40,000.

Existing travel pattern of school going children and response of their guardians to the new travel mode (school bus) were analyzed. 65% of the respondents said that they prefer rickshaws as primary travel mode for school trip of their children due to its high accessibility from home to school and vice versa. It was also observed that more than half of the school going children used auto rickshaw as an alternate travel mode if they miss primary travel mode. Primary and alternative choices of travel mode for school trip are shown in Table 3. Respondents were asked about mode choice in SP scenarios and half of them stated their interest to school bus as primary mode. Travel mode share in SP scenarios is shown in Table 4.

Table 3

Travel Mode	Percentage
Primary	Rickshaw-65% Private Car-13% Motor Cycle- 14% Auto Rickshaw-8%
Alternative	Rickshaw-29% Private Car-3% Motor Cycle-10% Auto Rickshaw-58%

Table 4

Travel Mode	Percentage
SP Scenario	School Bus-47% Auto Rickshaw-4% Motor Cycle-6% Rickshaw-33% Private Car-10%

### 5. Model Development

Transportation mode choice model for school trip of the students of Khulna Zilla School and Govt. Coronation Girls School was developed using the software BIOGEME (Bierlaire Optimization toolbox for GEV Model Estimation). Attributes (travel time, travel cost etc.) were incorporated in the model as independent variables along with socioeconomic characteristics of the respondents as dummy variables. Five alternatives (auto rickshaw, motorcycle, private car, rickshaw and school bus) were considered and specification tests were done to get the best model. Model outputs were checked for the expected sign and magnitude of the coefficients. Results were also judged by statistical parameters (e.g. Final log likelihood, Adjusted R

square, t-statistics, etc.). Hypothesis of the variables that may have significant impact on mode choice of school trips are illustrated in Table 5.

**Table 5: Hypothesis of mode choice variables**

Variables	Hypothesis
Travel time	People's sensitivity to travel time may vary with different modes. Increase in travel time may create disutility to particular mode like school bus, rickshaw etc.
Travel cost	Travel fare sensitivity may vary depending on the mode characteristics. One unit increase in travel cost of any vehicle may impose disutility of that particular mode.
Comfort	People are more likely to use travel mode with air condition facilities because of comfort.
Supervising person	Peoples may be inclined to use school bus with a teacher as supervising person because they are more sensitive to the security of the children and may rely on the teachers for better security.
Bus stoppage	Peoples may have strong affinity to use the school bus from in front of their homes.
School bus system	People may be inclined to individual bus services because it may perform better due to unique control of school authority with higher responsibility.
Bus size	People may have strong affinity to use small (microbus) school buses.
Monthly income	Both the husbands and wives of low to middle income families are very often employed and it becomes difficult to

	escort their children from home to school and vice versa timely. Therefore they may be more likely to use the school bus.
Car ownership	People who don't have car may have strong affinity to the school bus.

At beginning, the model was estimated with generic travel time and travel cost and then other travel mode attributes (bus stoppage, school bus system, supervising person) were added successively as dummy variables. Socio-economic characteristics of the respondents were also added as dummy variables and remained or rejected from the model by specifications test. Choice set of respondents for school trip of their children consist of five alternatives (auto rickshaw, motorcycle, private car, rickshaw and school bus) as stated above. The utility functions of the mode choice alternatives for school trips are presented below where  $ASC_i$  indicates the alternate specific constant of the alternative.

$$V_{rickshaw} = ASC_{ric} + \beta_{tt\_ar\_ric} * rickshaw \text{ travel time} + \beta_{tc\_ar\_ric} * rickshaw \text{ travel cost}$$

$$V_{auto \text{ rickshaw}} = \beta_{tt\_ar\_ric} * auto \text{ rickshaw travel time} + \beta_{tc\_ar\_ric} * auto \text{ rickshaw travel cost}$$

$$V_{private \text{ car}} = ASC_{pc} + \beta_{tt\_pc\_mcl} * private \text{ car travel time} + \beta_{tc\_pc\_mcl} * private \text{ car travel cost}$$

$$V_{motorcycle} = ASC_{mcl} + \beta_{tt\_pc\_mcl} * motorcycle \text{ travel time} + \beta_{tc\_pc\_mcl} * motorcycle \text{ travel cost}$$

$$V_{school \text{ bus}} = ASC_{scb} + \beta_{tt\_scb} * school \text{ bus travel time} + \beta_{tc\_scb} * school \text{ bus travel cost} + \beta_{sp} * Supervising \text{ person dummy} + \beta_{sbs} * school \text{ bus system dummy} + \beta_{co} * car \text{ ownership dummy} + \beta_{mincome} * monthly \text{ income medium dummy}$$

The subscripts refer to either mode of travel or name of the variable. Here rickshaw, auto rickshaw, private car, motorcycle, school bus, supervising person, school bus system, travel time, travel cost, car ownership, monthly income are abbreviated as  $ric$ ,  $ar$ ,  $pc$ ,  $mcl$ ,  $scb$ ,  $sp$ ,  $sbs$ ,  $tt$ ,  $tc$ ,  $co$ ,  $mincome$  respectively. The betas ( $\beta$ ) refer to the sensitivity associated with each parameter. Coefficients of the utility functions were estimated using maximum likelihood approach. Model outputs with sign, magnitude and t-test are presented in Table 6

**Table 6: Mode choice model estimation results of school transport in Khulna city.**

Parameter	Value	Std. Error	t-statistic
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<i>ASC<sub>mcl</sub></i>	-0.0740	0.521	-0.14
<i>ASC<sub>pc</sub></i>	0.415	0.543	0.77
<i>ASC<sub>ric</sub></i>	2.48	0.297	8.34
<i>ASC<sub>scb</sub></i>	3.96	0.652	6.08
$\beta_{tc\_ar\_ric}$	-0.0119	0.00930	-1.28
$\beta_{tc\_pc\_mcl}$	-0.00771	0.00806	-0.96
$\beta_{tc\_scb}$	-0.0962	0.0119	-8.11
$\beta_{tt\_ar\_ric}$	-0.0725	0.0250	-2.89
<i>B<sub>tt\_pc\_mcl</sub></i>	-0.0336	0.0358	-0.94
$\beta_{ttscb}$	-0.0164	0.0126	-1.30
$\beta_{co}$	1.54	0.337	4.57
<i>B<sub>mincome</sub></i>	0.428	0.248	1.72
$\beta_{sbs}$	0.372	0.255	1.46
$\beta_{sp}$	0.412	0.251	1.64

Multinomial legit model with 14 estimated parameters and 360 observations. Initial log-likelihood: -579.394, Final log-likelihood: -394.919 and Adjusted rho-square: 0.29

The developed model has higher value of adjusted rho-square meaning that the data fits better with this model. However, some coefficients have very low t-statistics but remain in the model for strong prior hypothesis. The signs of the coefficients are agreed with the priori hypothesis also. Alternate specific constant (ASC) of model alternatives (motorcycle, private car, rickshaw and school bus) were measured assuming auto rickshaw as base. From the model output, it was found that remaining all else being constants, school bus is more preferable mode of transport. Motorcycle has the most negative alternative-specific constant, implying that it is the least preferred. The model also showed that people prefer lower costs and shorter travel times for any kind of transport mode. Signs of sensitivities associated with the parameters – travel time and travel cost gave negative as Expected. People's sensitivity to school bus travel time and travel cost differ than other that of modes though they have common sensitivity to car-motorcycle and auto rickshaw -rickshaw. It is also found that people are more sensitive to school bus travel cost than travel

time while inverse situation exists for other mode of transports. Coefficient of the dummy variables teacher as supervising person and individual school bus gave positive sign as expected and it give message that people will get higher utility from respective facilities of school bus. Comfort, bus stoppage and bus size were tested as a attributes of school bus but were found insignificant and gave illogical sign, Results indicates that peoples are indifferent to such facilities and these variables were discarded from the final model. Socio-economic characteristics have significant impacts on mode choice of the respondent as well. Positive sign in car ownership dummy means that peoples who does not own car get more utility from school bus. It is also found that middle income groups are more inclined to use the service school bus.

## 6. Conclusion

The findings of this research can be an effective tool for Khulna city transport authority to formulate school bus related policy for effective management of city transport system. Though people prefer individual school bus system, they should be motivated for combined school bus system for Khulna city. It will reduce total number of vehicle on roadway significantly during school starting and closing time as well as save time and money. It may be noted that the model framework can be also useful for other cities in Bangladesh as well as other developing countries. This framework can be a guideline to develop model focusing other special issue like office trip. The study has several limitations though. For example, the data collection was difficult due to non co-operative attitude of the respondents and the response rate of the guardians was low. Besides the results of this research were based on a very small sample size (300) relative to the target population and model was developed considering two case studies only. The results can be improved by increasing the sample size and study area also. More modern techniques to attract respondents to the surveys can be explored in future research. Further, the model created in this project is based on the basic multinomial logit, and it can be improved by studying other kind of models such as mixed logit models which have more flexible error structures.

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