# Modeling the factors affecting mode choice behaviour for school trips in Dhaka City, Bangladesh

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## ABSTRACT

This paper aims to examine mode choice behaviour for school trips in Dhaka City, one of the densest cities of the world. To explore the factors that affect high school students' choice of travel mode for school trips are examined through a travel diary survey conducted in 2012 that generated a sample of 245 students in grades 6-10 in Dhaka City, Bangladesh. A multinomial logit model (MNL) and a random parameter logit (RPL) model are used in the empirical investigation. The choice set includes four different modes: car, three wheel pedal-powered vehicles (TWPV), walk, and bus. The model results show that increase in travel time decreases the probability of choosing alternative modes. In addition, socio-economic factors such as household monthly income, home ownership, and number of children at household play a vital role in choosing auto for school trips. Similarly, presence of intersection nearby home reduces the probability of walking. It is also found that personal and household attributes, and transportation system characteristics has significant influence on children`s mode choices for school trips. Understanding mode choice behaviour is crucial in reducing peak-hour localized traffic congestion. It will also provide useful insight to assist in effective planning and implementation of policies such as Safe Routes to School (SR2S) in developing countries.

*Key Words: School Trips, Travel Modes, Random Parameter Logit Model, Developing country*

# INTRODUCTION

This paper presents the findings of a random parameter logit model that examines the determinants of mode choice for school trips of children in Dhaka City, Bangladesh. Whereas school-going population has been increasing over the past two decades (Shin, 2005) in United States, for the city like Dhaka rapid urbanization and growing inclination for school enrollment of children, a higher growth rate can be presumed. School children are the most vulnerable group at risk of traffic accidents involved in walking and cycling (Morris et al, 2001). Moreover, security concerns such as crime and travel distance are found to increase the level of non-active commuting in developing nations (Kerr et al, 2005; Rose, 2000). Since school trips are considered to be the most universal opportunity for incidental physical activity among children (Boarnet et al.,2005), understanding the activity travel pattern of children has become important to transportation and urban planners, public health officials, and other policy makers to ensure active travel among children (Yarlagadda and Srinivasan, 2008; Boarnet et al, 2005; McDonald, 2005). Several studies have shown that children who use walking or biking to and from school trips are more physically active than who do not (Sidharthan et al, 2010; Cooper et al. 2003; Loucaides and Jago, 2008). However, the public health implications of school bound trips have received limited attention in developing countries. Thus, the contribution of built environment and influential factors to promote the use of active transportation for school trips are unexplored. Moreover, the school travel patterns of children are critical for reasons such as alleviating localized traffic congestion near schools around start and closing times which is a leading imperative for the transport system in Dhaka City. Factors influencing children's mode of school travel are needed to be examined to expand benefits from policies and programs like Safe Routes to School (Yarlagadda and Srinivasan, 2008) while, school travel also have strong spatial, temporal, and modal linkages with travel patterns of parents (Malone, 2001).

Although several authors have recently investigated children's mode choice for school trips in the context of developed countries, studies on children in the developing countries are very limited. Whereas considering the complexity of urban life, rapid economic growth and increasing traffic congestion, it is necessary to examine what factors are affecting mode choice of children within that context. Nevertheless, with the rising purchasing power due to globalization and newly adopted financial mechanisms that support vehicle ownership, the City is experiencing continued growth of 37,000 cars annually in the streets (Choudhury, 2010) which exert more auto driven trips to and from school.

Affordability is another issue of concern which dictates travel behaviour of school going children. Providing safe and convenient transportation for children has also become a challenge for households for a variety of other reasons, including absence of walk-able streets, poor safety and security conditions, and a growing number of dual-earner households. Beyond these, due to the absence of any zonal restriction in enrollment and marked diversity in school qualities, children of Dhaka City travel longer distance for schooling. Thus, in peak hours school trips are adding problems in the transportation network of Dhaka. Studies show that longer daily travel, general tendency of using unsustainable mode of transportation, and daily exposure to congestion and vehicular emissions are not only affecting the physical and mental health of the students but also impeding their performances in the classroom (Godfrey et al., 1998). In this context, this study attempts to fill some gaps in understanding travel behaviour of children in Dhaka City, which is one of the megacities in the world. Expectedly, the findings of this study will inform future policy concern for sustainable transportation system for Dhaka. The rest of the paper is organized as follows: it begins with a brief review of recent literature in children's travel pattern and mode choice modeling. Next, it provides an overview of the data that form the basis of the subsequent model estimation. This is followed by a discussion of the empirical results. Finally, the paper concludes with a summary of contributions.

# LITERATURE REVIEW

While school trips are the most universal opportunity for incidental physical activity among children (Pediatrics, 2009), motorized mode use for school trips is promoting future unsustainable travel mode choice (Line et al, 2010). In addition, walking or biking to school trips increases physical activity and reduces health related problems (Kerr et al., 2006; Alexander et al., 2005), but school travel patterns, mobility, health and physical activity as well as overall life style are changing due to the dramatic increase of car use for daily trips to school over the last 15-20 years (McDonald, 2007). This increased use of car not only limits children's independent mobility but it also increases traffic congestion and environmental pollution (DiGuiseppi et al, 1997). Beside car use, a wide variety of factors influencing mode choice for school trips can be found from the literature. Generally speaking, mode choice models for children`s travel behaviour are few. Recent empirical results show that home to school distance, socio-economic characteristics, built environments attributes, household characteristics, etc influence children mode choices. Many empirical studies on adults' travel behaviour demonstrates interrelationships between travel mode choice and origin-destination distances, built environment, socio-economic profile of the users attributes of the modes etc (Cervero, 2002; Schwanen et al., 2004; Guo and Chen, 2007).

Cities of developing countries can be characterised with high density population and high mixed land use pattern, which are more prone to traffic congestion and air pollution due to continuing rapid growth of their population which increases the demand of mobility (Schafer, 1998; Afroz et al., 2003). Dhaka, the capital city of a rapidly growing developing country, is dominant in terms of population concentration, economy, trade and commerce, education, and administration compared to rest of the country. It plays vital role in the national transport sector as more than 44% of country's total transport fleets (over 77% cars, 87% taxi, 68% microbus, 40% trucks) are daily running on its road surface. Dhaka's transport environment can be characterized by mixed-modes transports using the same road space due to the absence of segregated lanes for motorized and non-motorized, traffic congestion, delays, mismanagement, conflict of jurisdictions, poor coordination among organizations and increasing environmental problems. Road traffic accident is also a notable problem due to rapid motorization and Dhaka is accounted for 23% of country's road accidents (Hoque et al, 2006). Studies suggest that pedestrians are involved in half of all road collisions in Dhaka and two-thirds of all traffic related fatalities are pedestrians. Non motorized passengers are the next vulnerable road user in Dhaka involving 18% of overall collisions. All these factors along with complexity of modern life influence the change in mode of family mobility from active to non-active and car oriented which directly affects children's travel patterns through immaturity and dependency on adults (Burgmanis, 2012).Thus, many parents prefer private cars for their children (if they can afford one) given that Dhaka City inherits a poor public transportation system, and limited school bus program. Moreover, due to traffic safety and personal security, children in Dhaka city are needed to be accompanied by parents or adult members of the family (e.g. 63.4% in this study conducted in February, 2012).

Independent mobility of children is also affected by perceived safety concerns of traffic and crime. Travel distance is also associated with inactive commuting to school (Black et al., 2001; Boarnet et al., 2005). Additionally, factors such as characteristics of built environment such as the presence of sidewalk, bike lanes are positively associated with walking or biking to school as well as active commuting to school (Timperio et al., 2004; Ewing et al., 2004; McMillan, 2003). Children from high density areas are more likely to use motorized modes than children from lower density areas (McMillan, 2003; McDonald, 2005). Another contributing factor to inactive commuting to school is the increasing travel distance between home and school (Godfrey et al., 1998; McMillan, 2003; McDonald, 2005). In case of developing countries like Bangladesh travelling long distance has been triggered by traffic congestion and result in longer travel time. Characteristics of child like age, gender also have significant influence on mode choice for school trips (McDonald, 2005; Vovsha and Peterson, 2005, Guo et al., 2005). Household characteristics like presence of multiple number of child at households has a positive influence (McDonald, 2005; Guo et al., 2005; McMillan, 2003) whereas higher income or auto ownership exerts a greater probability of travelling by car (DiGuiseppi et al., 1998; Vovsha and Peterson, 2005, Guo et al., 2005). Some other factors such as the employment status of mother (DiGuiseppi et al., 1998), higher monthly income (McDonald, 2007), adverse weather conditions (Muller et al., 2008) have negative impacts on active commuting to school.

Traditionally, studies used Multinomial Logit (MNL) model for investigating relative influence and tradeoffs among factors of children`s mode choice for school trips (McDonald, 2007). However, problems associated with the unobserved (latent) heterogeneity motivated researchers to consider alternative specifications (McFadden and train, 2000). Assuming that there could be significant heterogeneity in the population group considered in this study, a random parameter logit (RPL) model is used in this study to examine the factors affecting children's mode choice in Dhaka City.

# METHODOLOGY

In modeling mode choice behaviour for school trips, this study considers four types of modes as the choice-set, obtained through a survey conducted in Dhaka City: (1) Private Car, (2) Three wheeled Pedal powered vehicle (TWPV), (3) walk, and (4) bus mode. The choice model was formulated following a random utility-based discrete choice modeling approach. The underlying assumption is that individuals will maximize their utility by choosing an alternative within the choice set, and the utility of choosing an alternative is composed of two components: systematic utility and random utility. Although the MNL model has been widely used for many years in choice modeling, there is a growing body of research exploring alternative formulations for variety of reasons, including addressing problems with latent (unobserved) heterogeneity. The unobserved heterogeneity may exist due to taste variations as well as attitudinal factors, often unknown to the analyst. The effects of taste variations could be incorporated within the MNL model by using observed socio-economic characteristics or via interaction variables. Latent heterogeneity may well remain despite the use of only the observable attributes of individuals (Greene and Hensher, 2003). On the other hand, assessing unobserved attitudinal variations across individuals is challenging, and often ignored in conventional models (Handy et al., 2005). When latent heterogeneity exists and the homogeneity assumption is imposed in choice models, it results in inconsistent estimates of model parameters and even more severe inconsistent estimates of choice probabilities (Bhat, 2000). One approach of dealing with unobserved heterogeneity is to use a random-coefficients specification in which parameters of the household-level logit model are treated as the realization of random variables representing the preferences of households. These random variables are assumed to follow a continuous probability distribution (Gonul and Srinivasan, 1993; Jain et al. 1994). Hence this study examines a Random Parameter Logit (RPL) specification to examine the unobserved heterogeneity among respondents.

Lets assume the systematic utility ($Z_{ijt}$) is linear in the parameter function of covariates ($X_{ijt}$) and corresponding parameters ($\beta$). Assuming that the random utility is independent and identically distributed (IID) with a Gumbel (type I extreme value) distribution, a multinomial logit model (MNL) is given by (McFadden, 1974):

$$P_{ijt} = e^{\beta_j Z_{ijt}} / \sum_{i=1}^{k} e^{\beta_j Z_{ijt}} \qquad (1)$$

Where $P_{ijt}$ represents the probability of individual $j$ choosing alternative mode $i$ in a given choice context. $X_{ijt}$ is a vector of observed attributes of the alternative mode $i$ and individual $j$. $K$ represents the number of alternatives (i.e. walk, car, TWPV and bus) considered in the choice set.

However, to acknowledge the potential existence of random taste heterogeneity this paper has considered a random parameter logit (RPL)formulation where the choice probabilities are obtained through the integrals of standard logit probabilities over a probability density of parameters (Train, 2003). In general, the density function is assumed to be a continuous function. Normal or lognormal distributions are assumed in most applications (Revelt & Train, 1998; Ben-Akiva & Bolduc, 1996). On the other hand, a few applications (Revelt & Train, 2000; Train, 2001) have used triangular and uniform distributions. This paper assumes all random parameters to be normally distributed (i.e. $\beta \sim N(\mu, \nu)$) in the RPL model.

For the RPL, conditional on $\beta_j$, the choice probability of individual $j$ for a single choice occasion choosing mode $i$ (denoting simply as $y_j$) can be written as:

$$g(y_j \mid \beta_j) = e^{\beta_j Z_{ij}} / \sum_{i=1}^{k} e^{\beta_j Z_{ij}} \qquad (2)$$

The unconditional probability is obtained by integrating $g(y_j \mid \beta_j)$ over all values of $\beta_j$ weighted by the density of $\beta_j$ as shown in the equation (3):

$$P_j(y_j \mid \mu, \nu) = \int g(y_j \mid \beta_j) f(\beta_j \mid \mu, \nu) d\nu \qquad (3)$$

where $f(.)$ is the density function assumed to be normal as stated above. Hence the unconditional log likelihood function is given by:

$$L(\mu, \nu) = \sum_{j=1}^{J} \ln \int g(y_j \mid \beta_j) f(\beta_j \mid \mu, \nu) d\nu \qquad (4)$$

Since this likelihood function is a multivariate integral that cannot be evaluated in closed form, the integral of the choice probabilities is approximated by Monte Carlo simulation (Train, 2003). For each decision-maker, taking draws from $f(\beta_j \mid \mu, \nu)$ the conditional choice probability $g(y_j \mid \beta_j)$ is calculated for each draw. This process is repeated for $R$ times (i.e. for this study 150 times). Finally, the integration over $f(\beta_j \mid \mu, \nu)$ is approximated by averaging the $R$ draws. Hence the resulting simulated log-likelihood function can be expressed as:

$$LL_s = \sum_{j=1}^{J} \ln \frac{1}{R} \sum_{r=1}^{R} \widehat{P}_j(y_j \mid \mu, \nu) \qquad (5)$$

where $\hat{P}_j$ is the simulated probability of the children $j$ choosing the mode $i$, and $\mu$ and $\nu$ are parameters to be estimated.

This simulated log-likelihood function is maximized to obtain parameter estimates. Finally, the goodness of fit of the estimated models are evaluated in terms of Rho-square, which is calculated by subtracting ratio of log-likelihood of the full model and the null model (constant only model) from one.

# DATA USED FOR EMPIRICAL APPLICATION

## Activity-based Travel Survey

This study uses data from an activity-based travel survey, which was conducted in 2012 among grades 6-10 students in the Dhaka Metropolitan Area (DMA), Bangladesh. Each student reported all activity engagements in a 24-hour cycle for the surveyed weekday. A stratified random sampling method was used to recruit participants in the survey. First, schools were chosen from two parts of DMA (north and south). Upon approval from administrations of the selected schools, a presentation of the survey was made to students. Then, the participants were recruited with the help of class teachers.

Students completed an activity-based travel diary, mainly reporting various types of structured and non-structured in-home and out-of-home activities for the given weekday. Whereas the structural activities involve a regular participation schedule such as extracurricular pursuits, lessons, enrichment activities, scouting, clubs, and organized games and meets, the non-structural activities include unorganized hobbies and sports, outings, playing, television viewing, and music. The travel diary also collected detailed information about the activity, such as start time, end time, location, mode used, travel time, travel cost, accompanying person, and number of accompanying persons for different types of activities. This questionnaire was completed in the classroom under teachers' supervision. A second questionnaire is designed for parents in order to collect socio-economic and other relevant information, which was distributed to the students. Parents completed the questionnaire at home, and returned those to the class teacher within a specified time period. Information collected through this survey includes age of parent, household income, car ownership, tenure type, household size, employment status, number of children and their associated travel arrangements. Since Geographic Information System (GIS)-based detailed built environment data is currently unavailable for Dhaka City, parents were also asked to report certain built environment attributes, such as the presence of sidewalks around their home, and presence of nearby traffic intersections. In total, 510 surveys were distributed; however, only 276 complete responses were obtained. After cleaning for missing information, responses from 245 participants were found usable for further analysis.

## Data Preparation

For this paper, school trips data was generated using SPSS. Data preparation included several steps, for example, household characteristics were gathered for all 245 respondents, and associated attributes of only school trips were merged into the dataset. As no travel demand forecasting model currently exists for Bangladesh, so travel times and travel costs for non-selected modes are estimated from the relationship between travel time/travel costs and distance of surveyed responses.

### Summary Statistics

The descriptive analysis of the sample reveals that among 245 responses (used in the empirical application) the modal share of private car, TWPV, walk mode and public/school bus are 16.5%, 48.4%, 30.14% and 4.9% respectively. While the average travel time for school trips is approximately 28.25 minutes with a standard deviation of 15.05 minutes (minimum=12minutes and maximum=124minutes). Other socio-economic variable like home ownership among respondents (37.6%) is higher than the national percentage (27.7%). Table 1 shows the summary statistics of the dependent variable considered in empirical models and independent variables (such as alternative specific variable, children's personal attributes, household characteristics, built environment, and escort arrangement) retained in the final model specification.

As explained earlier, random parameter logit model is used to explore determinants of choice of modes. Several types of explanatory variables are tested during model estimation, including children's attributes, household socio-economic characteristics, trip attributes, built environment characteristics, and escort arrangement. Table 1 shows the summary statistics of the independent variables retained in the final model specification. Model results of the multinomial logit model (MNL) and the the random parameter logit (RPL) model are shown in Table 2.

## DISCUSSION

### Multinomial Logit Model (MNL)

The utilities of other modes (private car, TWPV and walk) were modeled relative to bus mode. The travel time variable is assumed to be a generic parameter. The estimated coefficient value of the travel time variable has the expected negative sign (e.g. -.0581), therefore the utility of a mode decreases as the mode becomes slower and is considered as disutility. The expected negative sign of this coefficient, in turn, implies that this will reduce the choice probability of the corresponding mode.

The result suggests that the probability of choosing car as a travel mode increases if the child is female compared to a male child. Among the children's household characteristics, household monthly income has a positive coefficient value indicating the increasing utility of choosing car mode for school trips. It can be related with purchasing power of private car which results from increasing affordability exhibiting from higher monthly income. Thus higher household monthly income is associated with the propensity of using car mode. In contrast, negative sign of the coefficient for the size of the household parameter indicates that car mode choice decreases when the household size is larger. This relates with the presence of multiple children at the household or having the presence of adults who can escort children through other modes. On the contrary, parental escort increases the probability of choosing the car mode. This is arguably because of parents' use of the household car for multiple purposes in the morning and evening. The most significant factor that adds disutility to choose car is the distance between home and school. As expected, the dummy variable of school within 1.00km to home indicates that if the children lives near to school (within 1.00km), it will reduce the choice probability of car.

The model results for non motorized three wheeled vehicle (TWPV) indicate that, older children is more likely to choose TWPV than their younger counterparts. Among the household characteristics, household monthly income has a negative coefficient value implying the decrease in utility for TWPV mode with the increase in monthly income. Similarly, disutility of TWPV mode increases with the increase of home ownership among children's households. Both higher monthly income and home ownership stand for possessing car ownership in the household which replaces the choice probability of other modes. It also reflects the existing scenario of higher income group to use the private car for their daily travel needs. The most important factor which increases the utility of choosing TWPV mode is the parental escorting for school trips. It presumably represents parental decision of choice of mode for school trips over public bus and walking. The built environment factor that affects the choice of non-motorized mode is the presence of intersection nearby home. The coefficient has a negative sign which presumably represents that the high density mixed land uses or busy streets near residence consequently motivates the choice of motorized modes like private car or public bus rather than non-motorized mode TWPV (Sidharthan et al., 2010).

On the other hand, the probability of choosing walk mode is less for the older children than that of younger children. Arguably, older children have to travel long distances than their counterparts for schooling as high school standard varies among schools. Therefore, walk mode might not be feasible. It is also found that an increase in number of children in the household increases utility for choosing walk mode. This may reflect that with the increase in number of children in the household, it is easier for children to choose walking for school trips. Parents can presumably leave the younger child with their older siblings for walking together to school. As expected, in the context of developing countries, household monthly income has a disutility on choosing walk mode for school trips for children. Poor level-of-service for pedestrian walking, and inadequate road safety and personal security make walk mode less desirable. Hence parents with higher purchasing power might prefer to send their children to school through private car or TWPV other than walk. In developing countries, where safety and security are the prime concern of choosing school modes is also strongly related with the home to school distance. Additionally, the dummy variable of distance within 1.00km from school has positive sign indicates the increase in choice probability of walk mode for school trips among children whose trip length is less than 1.00km.

As indicated earlier, built environment attributes exhibit significant influence on choosing walk mode for school trips in Dhaka City. Walking is an incidental physical activity, which depends on the quality of built environment, such as the availability of sidewalks in the residential neighborhood. As expected, the sign of the dummy variable, presence of sidewalk around the home is positive, meaning that children's choice of walk mode for school trips will increase if sidewalks are available near their home. Another aspect of the built environment that decreases the utility of walk mode for school trips is the presence of traffic intersections near the home. This dummy variable is used as a proxy variable to account for traffic interference, given that detailed GIS or transportation network-related information is not available for Dhaka City. As usual, the coefficient value of this variable is negative. Traffic intersections raise road safety issues, and children will need accompaniment arrangements for travelling to school.

The goodness-of-fit statistics of the MNL model (i.e. an adjusted R-square) is 0.50032. On the other hand, the random parameter logit exhibits a higher adjusted R-squared value, 0.51880. It can reasonably be concluded that RPL outperformed the MNL in terms of the model fit. Moreover, the RPL model accounts for latent heterogeneity. Hence, this paper considers random parameter logit as a better model than the conventional MNL model. The following section presents a brief overview of RPL model results.

## Random Parameter Logit

**Table 2** shows the parameter estimates of all the variables retained in the random parameter logit model. The majority of the variables exhibit statistical significance at least at the 95% confidence interval (t - statistic greater than 1.96). In some cases, the *t* -statistic is less than the threshold value; however, those variables are retained in the final model since they offer intuitively important behavioral insights, with an assumption that if a larger dataset were available, these parameters might show statistical significance. However, the majority of the variables show considerable variations both in terms of parametric values and relationships. The generic variable, Travel Time shows higher influence in random parameter logit model along with a statistically significant standard deviation (0.0522).

In case of private car mode choice, gender of the children shows similar positive results along with the increase in significance level. Among household characteristics, household monthly income shows similar positive coefficient value whereas household size similar negative coefficient value. But household size exhibits significant heterogeneity with a standard deviation of 0.185. In contrast parental escort exerts similar positive utility in private car choice probability and dummy variable of distance within 1.00km from home to school offers disutility.

For TWPV mode, all the variables show similar sign while the utility of age of the children decreases and positive utility of parental escort for choosing TWPV increases from 2.11 to 3.23.

Additionally home ownership variable, household monthly income variable and presence of intersection variables have increased disutility which on the other hand reduces the choice probability of TWPV mode. The random parameter estimate of presence of intersection nearby home is assumed to be normally distributed with an estimated standard deviation of 0.285.

In case of walk mode choice, variables exerting disutility such as the presence of intersection around home, household monthly income and age of the children has similar negative coefficient value and sign. Though the variable, age of the children was insignificant in MNL model but found to be statistically significant in random parameter logit model. Variables adding utility in choice probability function, such as the presence of sidewalk for pedestrian, distance from home to school and multiple school going children show similar positive influence on walk mode choice while the coefficient values increased from MNL to mixed logit. Standard deviation of presence of sidewalk variable is 4.4 which implies the high influence of this built environment component over children`s mode choice.

The goodness-of-fit statistics of MNL and RPL model (i.e. an adjusted R-square) is 0.50032 and 0.51880 respectively. It can reasonably be concluded that RPL outperformed the MNL model in terms of the model fit.

# FINDINGS AND CONCLUSION

From mode choice models, it is evident that walk mode choice increases with the increase in number of children in the household, less than 1.00km distance from home to school, and presence of sidewalk around home. Whereas, intersection nearby home, household monthly income and increase in age of the children add disutility in walk mode choice probability. From the discussion in the previous section, it is also evident that random parameter logit model outperforms conventional multinomial logit model, and addresses latent heterogeneity among respondents.

Model results suggest that presence of intersection nearby home reduces walking whereas sidewalk presence increases. Hence, the pedestrian facility and level of service of sidewalks should be improved to promote the choice of walk mode among children to ensure sustainable mode of transport as well as to increase the level of active travel among children. Perhaps, pedestrian zone can be defined around residential neighbourhoods in order to increase the probability of choosing active walk mode. Moreover, the neighbourhoods where there are intersections, there should be pedestrian friendly signal or crossing system so that children can travel alone and safely. As the distance and travel time affect walk mode choice prominently due to the lack of a defined proximal geographic catchment for the school thus regulation of neighbourhood school enrolment system can be introduced to keep home to school distance minimum, reducing travel time for schooling.

It is expected that this research will investigate further the effects of different factors on mode choice of school-going children using alternative modeling techniques. Application of a latent class model application could be interesting. Although this study investigated modes, future research will include modelling mode, school choice and residential location choice in the context of Dhaka City, since residential location and school choice have significant impacts on the choice of mode. Nevertheless, this study offers a first attempt of modelling mode choice behaviour, and useful insights to inform transport policies and programs, including Safe Routes to School (SR2S) in developing countries.

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# REFERENCE

Afroz, R., Hassan M.N., & Ibrahim A.A. (2003) Review of air pollution and health impacts in Malaysia. *Environmental Research*, Vol. 92,pp. 71–77.

Alexander, L. M., Inchley, J., Todd, J., Currie, D., Cooper, A. R., Currie, C. (2005) The broader impact of walking to school among adolescents: Seven day accelerometry based study. *British Medical Journal*.

Ben-Akiva, M., and D. Bolduc. Multinomial Probit with a Logit Kernel and a General Parametric Specification of the Covariance Structure. Working paper, Department of Civil and Environmental Engineering, MIT, 1996.

Bhat, C.R. Incorporating Observed and Unobserved Heterogeneity in Urban Work Mode Choice Modeling. *Transportation Science*, Vol. 34, No. 2, 2000, pp. 228-238.

Black, C., Collins, A., Snell, M. (2001) Encouraging walking: the case of journey-to-school trips in compact urban areas. *Urban Studies*, Vol. 38, pp. 1121–1141.

Boarnet, M. G., C. L. Anderson, K. Day, T. McMillan, and M. Alfonzo. (2005) Evaluation of the California Safe Routes to School legislation: urban form changes and children's active transportation to school. *American Journal of Preventive Medicine*, Vol. 28(2S2), pp. 134-140.

Burgmanis, G. (2012) “Children’s Everyday School Travel and Mode Choice in a Post Socialist city: the case of Riga, Latvia”, 2nd International Conference on Social Science and Humanity, Singapore.

Cao, X., Mokhtarian, P.L., Handy, S.L. (2009) The relationship between the built environment and nonwork travel: a case study of Northern California. *Transportation Research A*, Vol. 43, No. 5, pp. 548–559.

Cervero, R. (2002) Built environments and mode choice: toward a normative framework. *Transportation Research Part D,* Vol. 7, pp. 265– 284.

Choudhury, C. F., Khan, M., & Wang, J. (2010) *Modeling Preference for School Bus Service in Dhaka : An SP based Approach*. Dept. of Civil Engineering, BUET, Dhaka.

Cooper, A.R., Page, A.S., Foster, L.J., Qahwaji, D. (2003) Commuting to school: are children who walk more physically active? *American Journal of Preventive Medicine,* Vol. 25, No. 4, pp. 273–276.

DiGuiseppi, C., Roberts, I., Li, L. (1997) Influence of changing travel patterns on child death rates from injury: trend analysis. *British Medical Journal,* Vol. 314, pp. 710–713.

DiGuiseppi, C., Roberts, I., Li, L. (1998) Determinants of car travel on daily journeys to school: cross sectional survey of primary school children. *British Medical Journal,* Vol. 316, pp. 1426–1428.

Godfrey, D, Mazzella, T, Cabrera, I and Day, S. (1998) "Why Don't Children Walk to School" *Harmonizing Transportation and Community Goals – The Challenge for Today's Transportation Professional*, ITE International Conference, Monterey, CA.

Gonul, F, and Srinivasan, K . (1993) Modeling Unobserved Heterogeneity in Multinomial to Logit Models: Methodological and Managerial Implications, *Marketing Science*, Vol. 12, pp. 213-229.

Greene, W. H. and Hensher, D. A. (2003) A latent class model for discrete choice analysis: contrasts with mixed logit. *Transportation Research Part B: Methodological*, Vol. 37, No. 8, pp. 681-698.

Greene, W.H., and D.A. Hensher. A Latent Class Model for Discrete Choice Analysis Contrasts with Mixed Logit. *Transportation Research Part B*, Vol. 37, No. 8, 2003, pp. 681–698.

Guo, J.Y., Chen, C. (2007) The built environment and travel behaviour: making the connection. *Transportation,* Vol. 34, No. 5, pp. 529–533.

Handy, S., X. Cao, and P. Mokhtarian. (2005) Correlation or Causality between the Built Environment and Travel Behavior? Evidence from Northern California, *Transportation Research Part D.* Vol. 10,No. 6, pp. 427–444.

Hess, S., Ben-Akiva, M., Gopinath, D., Walker, J. (2011) Advantages of latent class over continuous mixture of Logit models.

Hoque, M.M., Debnath, P., Alam, M.D. and Ahmed, S.N.A. (2006) "Metropolitan Street Accidents: The Case of Dhaka", Proceedings of the International Conference on Road Safety in Developing Countries, August 22-24, 2006, Dhaka, Bangladesh.

Jain, D. C., Vilcassim, N. J., and Chintagunta, P. K. (1994) A Random- Coefficients Logit Brand-Choice Model Applied to Panel Data, *Journal of Business & Economic Statistics*, Vol. 12, No. 3, pp. 317-327.

Kamakura, W. A., and Russell, G. J. (1989) A Probabilistic Choice Model for Market Segmentation and Elasticity Structure*, Journal of Marketing Research*, Vol. 26, pp. 379-390.

Kerr J, Rosenberg D, Sallis JF. (2006) Active commuting to school: associations with environment and parental concerns. *Medical Science Sports Exercise*, Vol. 38, pp. 787–94.

Line, T., Chatterjee, K., & Lyons, G. (2010) The Travel Behaviour Intentions of Young People in the Context of Climate Change. *Journal of Transport Geography*, Vol. 18, pp. 238-246.

Loucaides, C. and Jago, R. (2008) Differences in physical activity by gender, weight status and travel mode to school in Cypriot Children. *Preventive Medicine*, Vol. 47, pp. 107-111.

Malone, K. (2001) Children, Youth and Sustainable Cities, *Local Environment,* Vol. 6, No. 1, pp. 5–12.

McDonald, N. (2005) Children's Travel: Patterns and Influences. Ph.D. Thesis, University of California, Berkeley.

McDonald, N. (2007) Active transportation to school: trends among U.S. school children, 1969–2001. *American Journal of Preventive Medicine,* Vol. 32, No. 6, pp. 509–516.

McFadden, D. Conditional Logit Analysis of Qualitative Choice Behavior. In *Frontiers in Econometrics*, P. Zarembka, ed., New York: Academic Press, 1974, pp. 105-142.

McFadden, D., Train, K. (2000) Mixed MNL Models for discrete response. *Journal of Applied Econometrics*, Vol. 15, No. 5, pp. 447-470.

McMillan, T. E. (2007) The Relative Influence of Urban Form on a Child's Travel Mode to School, *Transportation Research Part A*. Vol. 41, No. 1, pp. 69-79.

Morris JM, Wang FS, Lilja L. (2001) School children's travel patterns—A look back and a way forward. 24th Australasian Transport Research Forum, Hobart.

Muller, S., Tscharaktschiew, S., Haase, K. (2008) Travel-to-school mode choice modelling and patterns of school choice in urban areas, *Journal of Transport Geography*, Vol. 16, pp. 342–357.

Pediatrics. (2009) Active Healthy Living: Prevention of Childhood Obesity through Increased Physical Activity. *American Academy of Pediatrics*, Vol. 117, No. 5, pp. 1834-1842.

Revelt, D., and K. Train. (2000) Customer-Specific Taste Parameters and Mixed Logit: Households' Choice of Electricity Supplier. Working Papers E00-274, Department of Economics, University of California at Berkeley.

Revelt, D., and K. Train. (1998) Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level. *Review of Economics and Statistics,* Vol. 80, pp. 1-11.

Rose, G. (2000) Safe Routes to School' Implementation in Australia, *Australia Road and Transport Research,* Vol. 9, No. 3, pp. 3-16.

Schafer, A. (1998) The global demand for motorized mobility. *Transportation Research A*, Vol. 32, No. 6, pp. 455-477.

Schwanen, T., Dijst, M., Dieleman, F.M. (2004) Policies for urban form and their impact on travel: the Netherlands experience. *Urban Studies*, Vol. 41, No. 3, pp. 579–603.

Shin, H.B. (2005) School enrollment—social and economic characteristics of students: October 2003 current population Survey reports, U.S. Census Bureau. http://www.census.gov/prod/2005pubs/p20–554.pdf.

Sidharthan, R., Bhat, C. R., Pendyala, R. M., Goulias, K.G. (2010) A model of children's School travel mode choice Behavior accounting for spatial and social interaction effects.

Timperio A, Ball K, Salmon J, et al. (2006) Personal, family, social, and environmental correlates of active commuting to school. *American Journal of Preventive Medicine*, Vol. 30, pp. 45–51.

Timperio A, Ball K, Salmon J. (2006) Personal, family, social, and environmental correlates of active commuting to school. *American Journal of Preventive Medicine*, Vol. 30, pp. 45–51.

Train, K. A. (2001) Comparison of Hierarchical Bayes and Maximum Simulated Likelihood for Mixed Logit. Working paper, Department of Economics, University of California at Berkeley.

Vance, C., Buchheim, S., Brockfeld, E. (2005) Gender as a determinant of car use: evidence from Germany. *Transportation Research Board*, Vol. 35, pp. 59-67.

Vovsha, P., Petersen, E. (2005) Escorting children to school: statistical analysis and applied modeling approach. *Transportation Research Record*, Vol. 1921, pp. 131–140.

Yarlagadda, A. K. and S. Srinivasan. (2007) Modeling Children's School Travel Mode and Parental Escort Decisions. Presented at the 86th Annual Meeting of the Transportation Research Board, Washington, D.C, 2007.

## List of Tables

**TABLE 1 Summary Statistics of Explanatory Variables used in the Models**

| Variable | Mean/Percent | Stan. Dev. | Min | Max |
|---|---|---|---|---|
| **Dependent Variable** | | | | |
| Private Car | 16.5% | | | |
| TWPV | 48.44% | | | |
| Walking | 30.14% | | | |
| Public/School Bus | 4.9% | | | |
| **Independent Variable** | | | | |
| ***Alternative Specific Characteristics*** | | | | |
| Travel Time | 28.25 | 15.05 | 12 | 124 |
| ***Person and Household Attributes*** | | | | |
| Age of the Children | 14.13 | 1.154 | 11 | 16 |
| Gender of the Children (dummy, 1 if the Child if Female, 0 otherwise) | 50.4% | - | - | - |
| Number of Children at Household | 1.83 | 0.77 | 1 | 4 |
| Monthly Household Income (2012 USD) | 331.39 | 284.14 | 150 | 2800 |
| Total Household Size | 4.33 | 0.86 | 3 | 7 |
| Home Ownership (dummy, 1 if the household is a homeowner, 0 otherwise) | 29.5% | - | - | - |
| ***Built Environment*** | | | | |
| Presence of Sidewalk around Home (dummy, 1 if sidewalk exist adjacent to the home, 0 otherwise) | 43.7% | - | - | - |
| Presence of Intersection nearby Home (dummy, 1 if any intersection exist nearby home, 0 otherwise) | 41.6% | - | - | - |
| Home to School Distance (dummy, 1 if home to school distance is within 1.00Km, 0 otherwise) | 43.3% | - | - | - |
| ***Parental Escort Characteristics*** | | | | |
| Parental Escort (dummy, 1 if the child is accompanied by the parent, 0 otherwise) | 40.2% | - | - | - |

**TABLE 2 Parameter Estimation Results of MNL and Random parameter logit for the Mode Choice Behaviour**

| | MNL<br>Coefficient (*t*-stat) | RPL<br>Coefficient (*t*-stat) |
|---|---|---|
| **Alternative Specific Variable** | | |
| Travel Time | -0.058(-1.618) | -0.143(-2.407) |
| **Car Mode** | | |
| Gender of the Children | 0.262(0.905) | 0.473(1.061) |
| Household Size | -0.908(-3.469) | -1.182(-3.055) |
| Household Income | 0.005(3.137) | 0.006(2.320) |
| Home to School Distance | -2.740(-2.670) | -2.682(-2.299) |
| Parental Escort | 1.909(3.829) | 3.022(3.917) |
| **Non-motorized Three Wheeled (TWPV)** | | |
| Age of the Children | 0.257(1.428) | 0.223(1.045) |
| Household Monthly Income | -0.006(-3.932) | -0.007(-3.087) |
| Home Ownership | -0.687(-2.410) | -0.976(-2.428) |
| Parental Escort | 2.112(6.557) | 3.229(4.918) |
| Presence of Intersection Nearby Home | -1.625(-4.045) | -1.863(-3.694) |
| **Walk Mode** | | |
| Age of the Children | -0.334(-1.512) | -0.640(-1.820) |
| Number of Multiple School going Children | 0.481(2.157) | 1.063(2.104) |
| Household Monthly Income | -0.012(-6.502) | -0.016(-4.462) |
| Distance from home to school | 2.549(6.078) | 5.667(4.378) |
| Presence of Sidewalk Around Home | 2.202(5.815) | 3.437(4.357) |
| Presence of Intersection Nearby Home | -2.195(-4.025) | -2.967(-3.544) |
| **Constants (Reference= Public/School Bus Mode)** | | |
| Car Mode | 0.777(0.577) | -0.333(-0.171) |
| TWPV | -0.542(-0.199) | -1.257(-0.387) |
| Walk Mode | 6.119(1.819) | 7.029(1.316) |
| **Standard Deviation of Parameter Distribution of Random Parameter Logit Model** | | |
| Travel Time | | 0.522 (1.275) |
| Presence of Intersection nearby Home (NMT) | | 0.285 (0.211) |
| Household Size(Car) | | 0.185 (1.068) |
| Presence of Sidewalk around home (Walk) | | 4.409 (3.636) |
| LL (constant only) | -518.7938 | -518.7938 |
| LL (at convergence) | -254.6022 | -245.1877 |
| Adjusted R-sq | 0.50032 | 0.51880 |
| AIC | 1.22590 | 1.20173 |