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How are Children Accompanied to School?

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ABSTRACT

A growing number of parents accompany their kids to and from school, to make sure they travel with the best care and minimum stress. Policies that aim at promoting non-motorized modes of transportation or at least admonishing auto driving solely for the purpose of picking up or dropping off the kids may not be successful in practice, unless primary concerns of parents are treated appropriately. School escorting decisions need to be investigated, as a decreasing trend in students' travel freedom also decreases tendency toward the use of active modes of travel, complicates intra-household activities that need to be considered in travel demand models, and increase externalities (e.g. safety, energy, and environmental risks) of the transportation systems. Two separate three level nested logit models are developed to explore school escort decisions in trips to and from school. In addition to addressing escort model misspecification, our models encompass a wide range of parental reservations such as safety and comfort that are typically ignored. A few policy sensitive variables, including commute distance, car ownership, income, and safety, were explicitly looked into and their influence on students escort behaviors was explained. Elasticities of the nested and multinomial logit models are compared to elaborate the consequences of model misspecification in terms of general conclusions and policy assessments. In some cases, the elasticities are even different in sign, and in some other cases nested logit elasticities are 16 times more than that of multinomial logit. Commute distance to school that has a fundamental role in land-use decisions, for instance, is found to be very sensitive to the model specification.

Keywords: school trip, escort decisions, three level nested logit, Tehran.

INTRODUCTION

Policy-makers, throughout various disciplines, have focused on analyzing school trip behaviors. Public health officials, on one hand, look at school trips as an opportunity to embed a regular physical activity in children's daily routine. City officials, on the other hand, struggle to find policies that change travel attitude of students and parents toward carpooling, walking, or biking. Although city planners strive to promote "green" modes of transportation and health officials advocate active modes of travel, parents have understandable reservations regarding their children's travel methods. Policies that aim at promoting non-motorized modes of transportation or at least admonishing auto driving solely for the purpose of picking up or dropping off the kids may not be successful in practice, unless primary concerns of parents are treated appropriately. A growing number of parents accompany their kids to and from school, to make sure they travel with the best care and minimum stress. Hillman et al. (1990), for instance, reported a significant reduction of 94 to 54 percent in the share of 10-year-old students who were allowed to walk alone to schools in London during 1971 to 1990.

Students' escorting behaviors need to be investigated for three primary reasons. First, school trip is part of the daily routine of both children and parents who regularly accompany their kids to school. 46 percent of American students are accompanied by an adult driver to school

(McDonald and Aalborg, 2009), while this share is about 53 percent in Auckland (ARTA, 2007), 43 percent in Belgium (Zwerts et al., 2009), and 19 percent in Tehran. Therefore, considerable improvements in traffic congestion, environmental risk, and road safety is expected, should a portion of these trips be shifted to green modes of transportation which are dominantly made independently by the kids (Koushki et al., 2002; Wilson et al., 2007). Second, intra-household activities place a strong constraint on activities of other family members. Parents accompanying their kids to school should adapt their daily plans to provide appropriate service to their children (Jones, 1979). If a child is not escorted to school, for instance, the parent may take transit to work. Therefore, household interactions have to be considered in travel demand models for a more realistic forecast (Gliebe and Koppelman, 2005). This area, however, is receiving more attention among activity-based travel modelers (Copperman and Bhat, 2007; Sener and Bhat, 2007). Lastly, use of non-motorized travel modes in school trips is deemed as a routine method of physical activity. Since parents who accompany their kids to school do not usually have enough time to regularly walk to school, they fail to utilize active modes of transportation in school trips (Faulkner et al., 2009). For instance, share of walking, as the habitual mode of travel to school in Toronto, decreased from 53% to 42% for students aged 11 to 13, during 1986 to 2001(Buliung et al., 2009). Although the influence of physical activity as a preventive medicine is receiving more attention, a global declining trend in physical activity among children is noticed which eventually leads to the development of obesity, type II diabetes, hypertension, and cardiovascular disease, to name only a few (Ebbeling et al., 2002; Andersen et al., 2006). Furthermore, it leads to an overall decrease in children's independence which negatively affects students' maturity level and qualifications (Fyhri and Randi, 2009).

Most parents are concerned about traffic safety and the risk of abduction or harassment (Martin and Carlson, 2005) that has lead to a notable decline in independent school travel. Whatever the reason, this decrease in travel freedom may be associated with several motives that need to be carefully investigated. This study is an effort to examine the behavioral aspects of escorting children to and from school, in Tehran, the capital of Iran. A critical review of the literature, followed by an overview of the data is provided in the following sections. Then, two three level nested logit models are proposed to explain escorting decisions in trips to and from school. The paper concludes with an analysis of results.

BACKGROUND

Escorting students on school trips has not been widely investigated, but there is a growing interest in the subject. Most of the past works suffer from a weak methodology, and there are a handful number of studies that are supported by a robust modeling approach. Zwerts et al.(2009) studied escorting behavior of a group of 10 to 13 years old students in Belgium. A descriptive statistical analysis was performed to demonstrate the effect of gender and age of the students on the parental escort decision. Further, McDonald et al. (2009) and Fyhri et al. (2011) found that travel safety and convenience urge the parents to drive their kids to school, rather than letting them walk alone. Vovsha and Petersen (2005) considered three situations for escorting students to school: ridesharing with a household driver on a mandatory tour, escorting by a household driver on a non-mandatory tour, and having no escort. Quality and availability of transit service, and distance to school, along with some demographics such as gender, car ownership, work status, and age turned out to have a meaningful effect in the final model. Yarlagadda and Srinivasan (2008) studied interdependencies among the travel patterns of parents and children in San Francisco Bay Area. A multinomial logit (MNL) model was proposed to simultaneously determine the travel mode and the escorting behaviors in school trips. A wide variety of explanatory variables are considered, including age, ethnicity, and gender of the students, employment status of parents, vehicle ownership, income, distance to school, along with some built-environment characteristics such as length of road and bike lanes. Nine choice situations were considered, namely: biking, driving, walking alone, walking with mother, riding a school bus, taking transit, driving with mother, driving with father, and driving with a non-parent driver. Although this was a pioneer study in simultaneous modeling of travel mode and escort decisions, supposition of IID (independently and identically distributed) error terms seems a very strong assumption, since, for example, driving with mother and driving with father have common unobserved factors. Therefore, IIA (independence of irrelevant alternatives) property of the MNL formulation leaves the conclusions open to serious questions.

Explanatory variables that are found to be influential on the escort decisions include age and gender of the students, working status of parents, having siblings, vehicle ownership, family income, and distance to school. A positive correlation between the propensity of riding students to school and income, car ownership, and distance is unanimously confirmed in previous studies (Vovsha and Peterson, 2005; Zwerts and Wets, 2006; Ewing et al., 2004). Age is also shown to have a negative association with the likelihood of dependent travel to school (Guo et al., 2005). Further, female students are more likely to be driven to school (Zwerts and Wets, 2006). Contradictory findings are reported about the role of having siblings on the escort behaviors. Yarlagadda and Srinivasan (2008), for example, found an increase in the odds of children being driven to school with the presence of multiple students in a household. Contrastingly, McDonald (2008a) noted an increase in the propensity of walking to school and a decrease in the likelihood of a student being driven, with the presence of multiple school going children. Therefore, role of intra-household connections in students' escort behaviors deserve more investigation. Moreover, fulltime workers are less likely to accompany their kids to school (Yarlagadda and Srinivasan, 2008). Working status of mothers is more influential, as DiGuiseppi et al. (1998) found that a working mother favors the chance of students being driven.

There are four limitations in the literature of parents' tendency to escort kids in school trips that are addressed to a possible extent in this study. First, MNL model specification is predominantly used, which comes with the IIA property and thus questions the final findings. Allowing for correlated and heteroskedastic error terms is essential for more reliable estimates. A nested logit (NL) structure, for instance, seems more appropriate, since IIA property is relaxed to IIN (independence of irrelevant nests). Interested readers may refer to Train (2009) for a more detailed discussion on the limitations of MNL. Second, safety is the primary concern of parents who accompany their kids to school. Although safety, along with other family reservations such as comfort and reliability play a determining role in escort behaviors, such variables have not received adequate attention so far. Third, school bus is not considered as a form of escort, although the students are accompanied on their way, not only by other students but also with a driver who is trusted by parents. Fourth, interactive variables are hardly used in previous studies, and therefore, an implicit assumption that effect of each variable is independent from other variables is made in most studies. For instance, age influences propensity of independent travel, but the magnitude of this effect could be different among males and females.

DATA

A school travel data collection effort was carried out in Tehran, in May of 2011. Questionnaires were distributed among more than 4700 middle and high school students in a random sample, and parents were asked to fill out the survey. As Iranian schools are gender-segregated, a stratified sample was taken to ensure male and female schools have similar percentage to what they actually have in the city. Eventually, 3441 forms were returned, making a response rate of 72%. A separate study on selectivity analysis and response bias, along with the survey method and a preliminary analysis of data is provided elsewhere (Samimi and Ermagun, 2011). Information was collected on five folds: household socio demographics (e.g. household size, income, education, vehicle ownership, working status of parents), student characteristics (e.g. age, gender, grade), built-environment attributes (e.g. walk time to school, access to public transit, commuting to or from a restricted traffic zone), school trip behaviors (e.g. escort pattern, primary mode of travel, travel cost, and trip chain), and parental reservations about school trips (e.g. safety, reliability, access, and comfort). Table 1 provides a summary of variables that are utilized to explain school trip escort behaviors. The data revealed that parents play a dominant role regarding the transportation of their children. While only 10 percent of parents accompany their children to school on their way to work, 12 percent of parents travel solely for the purpose of taking their kids to school.

MODEL

This section elaborates the methodology and final results of the escort models. Trips to and from school are separately modeled, as the explanatory variables and their magnitude of effect are expected to be different.

Method

Logit models are widely used to explain different choice situations, as their closed-form formula ease the estimation procedure and make the results easy-to-interpret. Multinomial logit, however, is widely criticized for the IIA property that implies characteristics of a third alternative does not change the relative odds between the two alternatives. This is an inappropriate assumption in the choice situations for escorting students, since IIA of the MNL model indicates that if for some reason the parents cannot take their kid to school, likelihood of taking a school bus and having the kid travel alone would increase proportionally. This is, intuitively, not true, as parents who want to take their kids to school are usually concerned about convenience and safety of their children and taking a school bus seems more probable when they cannot drive them to school.

Table 1 - Description of the explanatory variables

Variable	Description	Average	Std. Dev.
WALKTIM	1: less than 10 / 2: 10-20 / 3: 20-30 / 4: 30-40 / 5: 40-50 / 6:more than 50 minutes walk time to school	2.67	1.55
LOW_INC	1:If household income is less than 5 million Iranian Rials* / 0: Otherwise	0.33	0.47
LEVEL	1:High school / 0:Middle school	0.41	0.49
AMT_TO	1:If students choose AMT to school / 0: Otherwise	0.43	0.49
LOW_EDU	1: Parents have less than a high school diploma / 0: Otherwise	0.33	0.47
GENDER	1:Male / 0:Female	0.40	0.49
CHILD_7	Number of school children in household (ages7-18)	1.57	0.67
AGE	Age of children between 12-17 years old	14.13	1.62
LIC_0	1: If no license in household / 0: Otherwise	0.07	0.26
AUTO	Number of cars in a household	1.01	0.68
NON_WRK	1: If non worker parents are in household / 0: Otherwise	0.05	0.21
INCOME	1: less than 5/ 2: 5-10 / 3: 10-15 / 4: 15-20 / 5: 20-25/ 6:more than 25 million Iranian Rials* household income	2.11	1.23
COST	1: If cost of trip is important for parents / 0: Otherwise	0.30	0.46
SAFE	1: If children safety is important for parents / 0: Otherwise	0.31	0.46
RELIABL	1: If reliability of trip is important for parents / 0: Otherwise	0.18	0.39
COMFRT	1: If comfort of trip is important for parents / 0: Otherwise	0.18	0.39
TRF_LIMIT	1: If traffic zone is special / 0: Otherwise	0.11	0.31
D_WALKTIM	1: If walk time to school is less than 20 minutes / 0: Otherwise	0.60	0.50
D_GENSAFE	1: If safety is important for parent of male students / 0: Otherwise	0.12	0.32

*Note: 11800 Iranian Rails was equivalent to 1 USD in May 2011.

NL relaxes IIA property and retains most of the advantages of a MNL, by clustering subsets of alternatives with a higher degree of similarity in a nest. Coldren and Koppelman (2005) formulated the choice probability of a three level NL model as in Eq. 1. Denoting the alternative, lower-level nest, and upper-level nest, respectively, by i, n, and m; probability of choosing i is obtained by multiplying the probability of choosing the alterative given the lower-level nest ($P_{i|n}$), times the probability of choosing the lower-level nest given the upper-level nest ($P_{n|m}$), times the probability of choosing the upper-level nest (P_m). μ is the inverse logsum parameter, τ_n and τ_m are, respectively, given by Eqs. 2 and 3.

$$P_i = P_m \times P_{n|m} \times P_{i|n} = \frac{exp(\frac{1}{\mu_m}\tau_m)}{\sum_{m'\in M} exp(\frac{1}{\mu_{m'}}\tau_{m'})} \times \frac{exp(\frac{\mu_m}{\mu_n}\tau_n)}{\sum_{n'\in N} exp(\frac{\mu_m}{\mu_{n'}}\tau_{n'})} \times \frac{exp(\mu_n V_i)}{\sum_{i'\in n} exp(\mu_n V_{i'})} \quad (1)$$

$$\tau_n = ln\left(\sum\nolimits_{i' \in N_j} exp(\mu_n V_{i'})\right) \tag{2}$$

$$\tau_m = ln\left(\sum\nolimits_{n' \in N_m} exp(\frac{\mu_m}{\mu_{n'}} \tau_{n'})\right) \tag{3}$$

Coefficient of the inclusive value (logsum parameter) which is the expected utility of the nest is estimated to show the level of correlation in unobserved components of the alternatives in that nest. McFadden (1978) proved that coefficients of the inclusive values (IV) that lay between zero and one are consistent with the global utility maximization behavior in two level nested structures. In a three level nested logit, it is also required that the lower-level IV parameter be less than the upper-level IV parameter. While a value of zero indicates complete correlation among unobserved components of the alternatives in a nest, a value of one indicates absolute independence and makes the estimates similar to MNL. Therefore, a significantly less-than-one IV parameter conveys invalidity of the IIA property from a theoretical view. MNL and NL models are developed in this study to explain the choice situation and to also underscore the consequences of model misspecification in terms of general conclusions and policy assessments.

Estimation results

The purpose is to model four choice situations for escorting students to school, namely *no escort*, *escort by parents*, *escort by others* including siblings or friends, and *school bus*. Contrary to some previous studies, school bus riders who are indeed accompanied by the bus driver and friends are considered to be escorted in this study. The three level NL model classifies students into those who travel alone and those who are accompanied on their way to school. The *escort* nest is further broken down into *school bus* and *no school bus* nests, and the later is then classified into *escort by parents* and *escort by others* (Figure 1). The IV parameters of *no escort* branch and limb *A* in the *escort* branch are normalized to one, as there is only one alternative in each. The other IV parameters are determined in the estimation process.

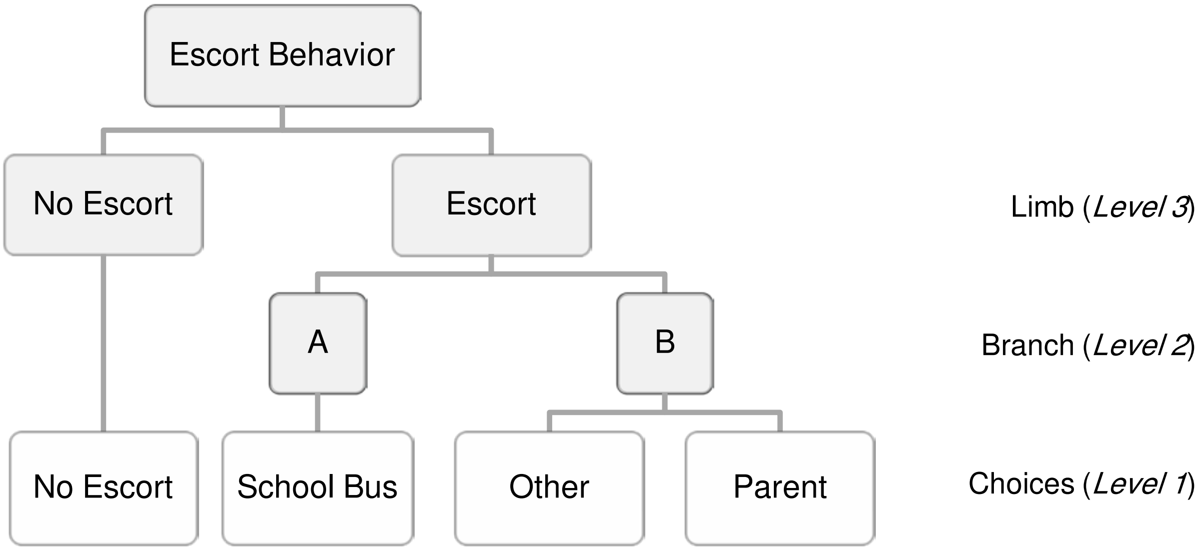


Figure 1 - Tree structure for the nested logit model

A maximum likelihood estimation method is adopted to determine the systematic utility of each alternative. Estimation results for MNL and NL models for trips to and from school are provided in Tables 2 and 3.In Table 2, IV parameters of the *escort* and *no school bus* nests are 0.63 and 0.62, respectively, and both are statistically different from zero and one. A significant effect of each explanatory variable on the choice variable is verified with the conventional statistical t-test. As shown in Table 2, all the estimates are statistically significant and of the right sign. The lowest absolute t-statistic value is 1.43 for a dummy variable that distinguishes students who must travel to or from a restricted traffic zone. Most variables, however, are statistically significant with a 99 percent confidence interval. Moreover, likelihood ratio test is conducted to evaluate the overall goodness of fit for each model. Likelihood ratio index, also known as McFadden pseudo-rho-squared, fluctuates between zero and one, and has a similar interpretation as R-squared in the linear regression models. NL and MNL models have a likelihood ratio index of 0.36 and 0.31, respectively, in Table 2. The NL model for escorting decisions on the way back home (Table 3) has an explanatory power of 27 percent, conveying that there is a broader range of missing variables affecting this decision. Generally, NL model not only has a higher explanatory power, but it also includes some key exogenous variables such as walk time to school with a more meaningful coefficient. Most importantly, significant IV parameters for the nests convey misspecification of the MNL model. This results in erroneous interpretations of the findings and leads to misdirecting policy assessments that are based upon the MNL model. Misspecification consequences along with a broader analysis of results are provided in the next section.

Table 2 - Escort models for trips to school

Variables	Alternatives	*Multinomial logit*		*Nested logit*	
		Coefficient	t-statistic	Coefficient	t-statistic
AMT_TO	No escort	2.95***	21.66	2.79***	19.99
TRF_LIMIT		1.37***	6.39	1.22***	6.65
LOW_EDU		0.32***	2.71	0.33***	2.86
RELIABL		-0.47***	-3.17	-0.43***	-2.66
INCOME		-0.13***	-2.69	-0.16***	-2.87
COMFRT		-0.48***	-3.37	-0.50***	-3.26
Constant	Escort other	-1.17***	-3.49	0.19	0.25
GENDER		-2.40***	-8.4	-4.73***	-6.21
COST		-0.54**	-2.3	-1.88***	-3.36
TRF_LIMIT		0.49	1.33	0.55	1.43
CHILD_7		0.53***	4.08	0.62***	4.2
LEVEL		-0.59***	-2.79	-1.29***	-3.28
Constant	Escort parent	3.65***	4.2	4.73***	-3.28
GENDER		-1.35***	-10.47	-3.64***	-5.19
AUTO		0.27***	3.46	0.33***	2.73
LIC_0		-0.57**	-2.12	-0.87**	-2.47
COST		-0.68***	-5.32	-2.01***	-3.89
NON_WRK		0.49**	2.31	0.63**	2
Constant	School bus	4.95***	5.65	4.72***	3.2
GENDER		-2.28***	-13.1	-3.13***	-4.71
COST		-1.84***	-10.69	-2.43***	-5.27
D_WALKTIM		-1.39***	-11.65	-1.22***	-7.49
TRF_LIMIT		0.75***	3.41	0.70***	3.09
D_GENSAFE		1.34***	6.93	1.21***	5.13
LOW_INC		-0.93***	-6.25	-0.94***	-5.75
AGE	Escort parent and school bus	-0.19***	-3.06	-0.18*	-1.86
LEVEL		-0.31	-1.41	-0.96**	-2.33
SAFE		0.21*	1.81	0.66***	3.55
WALKTIM	All escort choices	-0.04	-0.96	0.24**	2.16
Inclusive value parameters:					
Escort				0.64***	4.01
No escort				1.0(fixed)	
A				1.0(fixed)	
B				0.62***	5.79
Log-likelihood at zero		-4176.91		-4176.91	
Log-likelihood at convergence		-2338.52		-2328.39	
McFadden pseudo-rho-squared		0.31		0.36	
Sample size		3013		3013	

Note: ***, **, * means significance at 1%, 5%, 10% level.

Table 3 - Escort models for trips from school

Variables	*Alternatives*	*Multinomial logit* Coefficient	*Multinomial logit* t-statistic	*Nested logit* Coefficient	*Nested logit* t-statistic
AMT_TO	No escort	1.60***	13.84	1.58***	13.51
TRF_LIMIT		0.71***	3.42	0.57***	3.45
LOW_EDU		0.32***	2.99	0.33***	3.10
RELIABL		-0.72***	-5.24	-0.73***	-5.05
INCOME		-0.08***	-1.93	-0.10***	-2.23
COMFRT		-0.37***	-2.91	-0.39***	-2.92
Constant	Escort other	-1.23***	-4.69	-0.87	-1.60
GENDER		-1.60***	-8.72	-4.10***	-6.25
COST		-0.38**	-2.21	-1.36***	-3.23
TRF_LIMIT		0.44	1.59	0.42	1.46
CHILD_7		0.32***	3.08	0.40***	3.25
LEVEL		-0.71***	-4.39	-2.04***	-5.29
Constant	Escort parent	3.97***	4.58	6.33***	4.27
GENDER		-1.56***	-11.27	-4.09***	-6.27
AUTO		0.29***	3.26	0.36***	2.81
LIC_0		0.15	0.62	0.02	0.07
COST		-0.22*	-1.65	-1.16***	-2.86
NON_WRK		0.52**	2.27	0.57*	1.75
AGE		-0.34***	-5.22	-0.49***	-4.97
Constant	School bus	5.12***	5.87	2.75***	2.00
GENDER		-1.83***	-11.54	-2.52***	-4.72
COST		-1.76***	-10.19	-2.13***	-6.55
D_WALKTIM		-1.50***	-12.11	-1.12***	-5.93
TRF_LIMIT		0.21	0.92	0.10	0.44
D_GENSAFE		0.98***	5.09	1.00***	4.06
LOW_INC		-1.04***	-6.89	-1.07***	-6.34
AGE		-0.28***	-4.48	-0.15	-1.60
LEVEL	Escort parent and school bus	-0.08	-0.4	-0.97**	-2.69
SAFE		0.63***	5.87	0.95***	5.71
WALKTIM	All escort choices	0.04	1.14	0.35***	3.18
Inclusive value parameters:					
Escort				0.64***	4.48
No escort				1.0(fixed)	
A				1.0(fixed)	
B				0.55***	4.77
Log-likelihood at zero		-3375.67		-3375.67	
Log-likelihood at convergence		-2521.80		-2507.99	
McFadden Pseudo R-squared		0.25		0.27	
Sample size		3002		3002	

Note: ***, **, * means significance at 1%, 5%, 10% level.

ANALYSIS OF RESULTS

This section is structured in three parts. A general discussion on the explanatory variables is followed by an argument on the consequences of model misspecification, and finally an analysis of elasticities.

Influential Factors

The model contains many significant variables, including distance, gender, age, number of siblings, income, vehicle ownership, parental education, and their work status, along with their reservations on safety, convenience, reliability, and cost of the trip.

Boys are more reluctant to be accompanied on their way to school, and have a higher propensity for going with siblings or friends compared to other types of escorting. This is in line with previous findings (Yarlagadda and Srinivasan, 2008), and could be attributed to the boys' relative self-determining mindset and the fact that parents are more concerned about their girl's independent travel, particularly in the eastern culture (Samimi and Ermagun, 2012a). Age of the students is another determinant that negatively affects the likelihood of escorting. Younger students are likely to either be accompanied by their parents or ride a school bus, as senior students desire a more independent life style and parents are less concerned about their safety. This tendency is higher in trips from school to home, since students have a more flexible schedule in the afternoon.

Household income is a strong determinant of escort pattern. Students from low income families are typically found to travel alone to and from school. There are two possible reasons for this behavior: 1) high income parents are more willing to pay for a school bus in order to ensure a safe and convenient travel for their kids, 2) high income families have easier access to personal vehicle and, therefore, there is a higher chance for their kid to be driven to and from school. There is a dummy for low income households in the utility of school bus alternative that indicates a significant reduction in their tendency to use this method of travel, as they generally do not afford the associated fees. Moreover, similar to previous studies (Vovsha and Petersen, 2005), we found that parents with a driving license and easy access to personal vehicles are more likely to drive their kids to school, whereas students from low-income families have a greater chance of walking alone to school. In addition, if there is more school going kids in family, students are likely to be accompanied with others. This could be explained by the students' willingness to commute together, as shown by McDonald and Aalborg (2009). This propensity is higher in the trips to school, which is understandable considering that high schools and middle schools have similar start times but different end times. Also, part-time workers are more willing to accompany their kids just to drop them off.

Distance to school is another important determinant of escort decisions, such that parents are more likely to drive their kids or have them driven in long distance commutes. Previous studies (Samimi and Ermagun, 2012b; McDonald, 2008b; McMillan et al., 2006) also show a decline in tendency to walk and bike, as the commute distance increases. Students who live more than one mile from their school are likely to ride in a school bus. We found a higher tendency to escort students in longer distances for trips to home compared to trips to school. This behavior could have three possible explanations: 1) students are tired in the afternoon and prefer not to walk back home, 2) parents want to prevent their kids from hanging around with their friends, as they have a more flexible schedule after school time, 3) parents are likely to be free after school and are willing to spend some time with their kids.

Reservations of parents in terms of safety, comfort, reliability, and cost of travel are accounted for analyzing escort behaviors. 32 percent of parents, who consider travel safety as the primary determinant in their decisions, are more likely to drive their kids to school or take a school bus. Percentage of variation in probability of no escort by changing parental reservations is presented in Table 4. According to this table, a 25 percent reduction in the likelihood of escorting is expected, should the parents become primarily concerned about their kid safety. This percentage is calculated, setting the continuous explanatory variables at the average and the other dummy variables at their mode. Further, *D_GENSAFE*, an interactive dummy variable, indicates such parents have a higher chance of taking a school bus for their female student. This was particularly expected in Iranian society. Families who are more concerned about cost of the travel, on the other hand, are unwilling to accompany their kids. This reluctance is more apparent for the school bus mode, which is considerably more costly. Parents, who are concerned about comfort and reliability of the trip, prefer to escort their kids to school. Moreover, living in a restricted traffic zone discourages parents to drive their kids to school, as they need to purchase a special sticker to enter the zone with their personal vehicle.

Table 4 - Percentage of variation in probability of no escort by changing parental reservations

Gender	Level	Parental Reservations				
		Cost	Safety	Reliability	Comfort	Traffic limit
Female	Middle School	106	-25	-30	-36	117
	High School	88	-23	-29	-34	107
Male	Middle School	45	-35	-22	-26	57
	High School	33	-26	-19	-23	44

Misspecification Consequences

As stated earlier, a significant inclusive value in the NL model conveys a specification bias in the MNL model. However, most policy-makers are unaware of the consequences of such a misspecification. A comparison is made between NL and MNL elasticities to make the differences tangible. Elasticities of age, travel time, number of students in a household, family income, and vehicle ownership for NL and MNL models are calculated using sample enumeration (Tables5 and 6). Ratio of NL and MNL elasticities are calculated to observe the magnitude of difference between the two models. To calculate the ratio, either MNL or NL elasticity with a larger absolute value is divided by the other, and the cumulative distribution function of this ratio is illustrated in Figure 2.a.

According to Figure 2.a, NL and MNL elasticities are of opposite signs in more than 40 percent of cases. Opposite sign of elasticities belongs to *WALKTIM*, an ordinal variable for the walk time to school that is a critical policy variable affecting different school-siting policies. There are challenges in urban design studies among central school advocates and those who support neighborhood schools. Neighborhood school supporters argue that easy access to school alleviate the transportation general costs (e.g. safety, fuel, etc), while central school proponents are more concerned about cultural segregation and minorities. Distance to school plays a critical role in escort decisions. Decentralization of schools encourages independent school trips and use of active models of travel. This could have external costs (e.g. cultural segregation, lower quality of education, higher operational costs) that must be quantified in some way, in order to make a robust cost-benefit analysis possible. This paper does not aim to support either viewpoint, rather to provide an example of how model misspecification may misguide a policy-maker. In many other cases, MNL and NL elasticities have the same sign but different magnitudes. Frequency bar for the ratios that are plotted in Figure 2.b indicates that NL elasticities are even 16 times more than that of MNL model, in some cases. Dark portion of each bar in Figure 2.b belongs to the cases with a NL elasticity in the numerator.

Elasticities

Ample explanatory variables turned out to have a significant effect in the NL and MNL models. Some of the variables are policy sensitive, and are appealing to the city officials, as they can change travel attitudes, generally, at a low cost. Elasticities are a typical way of reporting magnitude of effect that an explanatory variable has on the endogenous variable. This is simply defined as the percentage of change in an independent variable that leads to one percent increase in the dependent variable. We obtained income direct elasticity of around -0.19 in choosing no escort option, and indirect elasticity of 0.15 in other choices. Age has a direct elasticity of -1.86 and -1.20, respectively, in the school bus and escort parent alternatives. Direct elasticities of walk time to school, on the other hand, were positive but less than one in all the escorting situations.

Although the surveyed data showed 61 percent of families have only one vehicle in the household, the city officials expect a growing car ownership per capita in Tehran. A direct elasticity of 0.15 for vehicle ownership, on the other hand, indicates families are more likely to accompany their kids on their way to school, as they acquire a second car. Therefore, policy-makers need to be alerted on a possible growing trend of family intra-household tours that may worsen the traffic congestion in the AM peak. Improving safety measures could mitigate this effect and encourage independent school trips, particularly for high school students.

Table 5 - Elasticities for escort models for trips to school

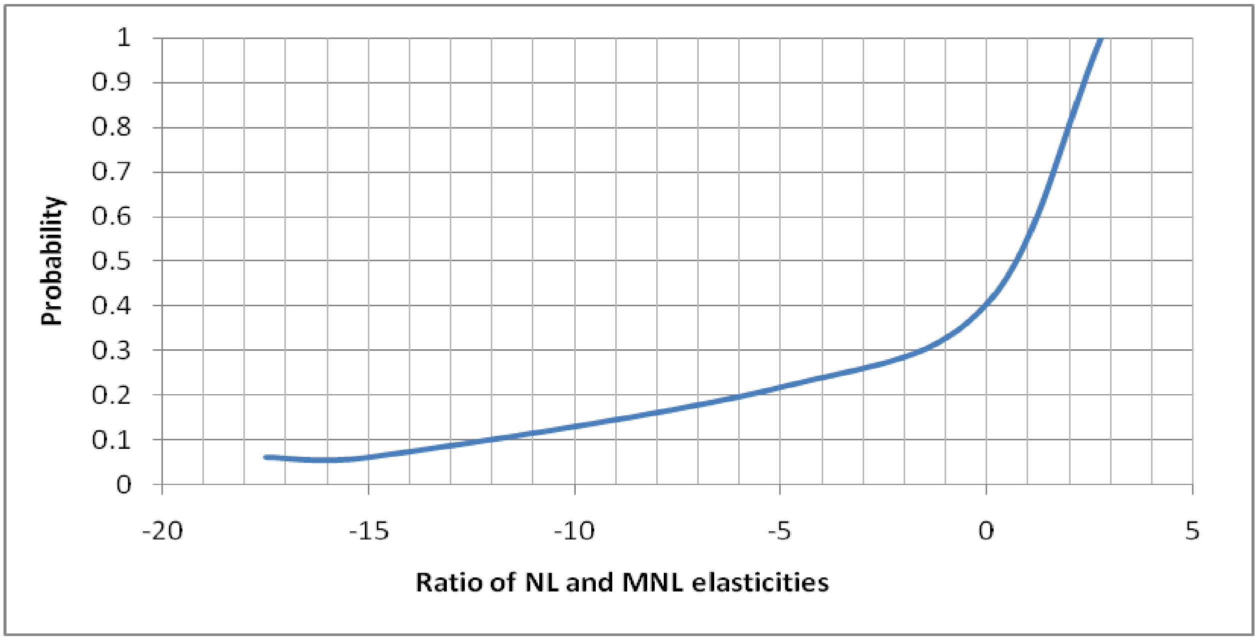
Attribute	Primary Alternative	No escort		Escort parent		Escort other		School bus	
		MNL	NL	MNL	NL	MNL	NL	MNL	NL
WALKTIM	Escort other	0.01 (0.01)	-0.02 (0.01)	0.01 (0.01)	-0.06 (0.05)	-0.10 (0.06)	0.06 (0.36)	0.01 (0.01)	-0.02 (0.02)
	Escort parent	0.02 (0.02)	-0.06 (0.05)	-0.84 (0.05)	0.32 (0.20)	0.02 (0.02)	-0.35 (0.20)	0.02 (0.02)	-0.13 (0.08)
	School bus	0.03 (0.05)	-0.14 (0.19)	0.03 (0.05)	-0.24 (0.31)	0.03 (0.05)	-0.24 (0.31)	-0.07 (0.04)	0.42 (0.20)
CHILD_7	Escort other	-0.04 (0.06)	-0.02 (0.03)	-0.04 (0.06)	-0.11 (0.14)	0.81 (0.33)	0.87 (0.32)	-0.04 (0.06)	-0.05 (0.06)
AUTO	Escort parent	-0.07 (0.08)	-0.03 (0.04)	0.21 (0.14)	0.15 (0.10)	-0.07 (0.08)	-0.19 (0.14)	-0.07 (0.08)	-0.08 (0.07)
AGE	Escort parent	0.61 (0.46)	0.22 (0.17)	-2.21 (0.57)	-1.20 (0.30)	0.61 (0.46)	1.346 (0.31)	0.61 (0.46)	0.54 (0.22)
	School bus	0.64 (0.68)	0.37 (0.40)	0.64 (0.68)	0.69 (0.60)	0.64 (0.68)	0.69 (0.60)	-2.18 (0.73)	-1.86 (0.67)
INCOME	No escort	-0.16 (0.18)	-0.19 (0.21)	0.13 (0.11)	0.15 (0.13)	0.13 (0.11)	0.15 (0.13)	0.13 (0.11)	0.15 (0.13)

Note I: Standard deviation for each elasticity is reported in the parenthesis.
Note II: Elasticity value is the percentage of change in the choice probability of the decision variable in the first row, when the attribute in the utility function of the primary alternative increases by one percent.

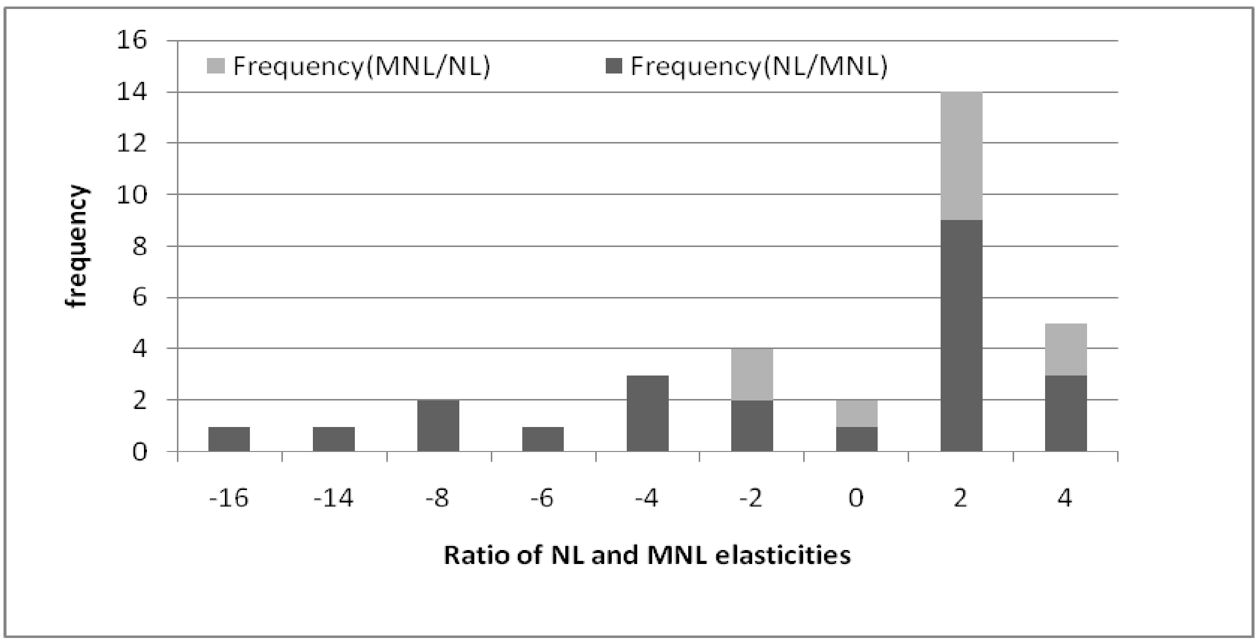
Table 6 - Elasticities for escort models for trips from school

Attribute	Primary Alternative	No escort		Escort parent		Escort other		School bus	
		MNL	NL	MNL	NL	MNL	NL	MNL	NL
WALKTIM	Escort other	-0.01 (0.01)	-0.02 (0.02)	-0.01 (0.01)	-0.20 (0.13)	0.11 (0.06)	0.76 (0.48)	-0.01 (0.01)	-0.05 (0.04)
	Escort parent	-0.01 (0.01)	-0.05 (0.04)	0.10 (0.06)	0.57 (0.35)	-0.01 (0.01)	-0.39 (0.23)	-0.01 (0.01)	-0.10 (0.06)
	School bus	-0.03 (0.05)	-0.21 (0.31)	-0.03 (0.05)	-0.37 (0.48)	-0.03 (0.05)	-0.37 (0.48)	0.08 (0.04)	0.59 (0.28)
CHILD_7	Escort other	-0.03 (0.03)	-0.01 (0.02)	-0.03 (0.03)	-0.15 (0.12)	0.46 (0.18)	0.48 (0.18)	-0.03 (0.03)	-0.04 (0.04)
AUTO	Escort parent	-0.04 (0.05)	-0.02 (0.02)	0.25 (0.16)	0.21 (0.14)	-0.04 (0.05)	-0.16 (0.12)	-0.04 (0.05)	-0.04 (0.04)
AGE	Escort parent	0.66 (0.48)	0.35 (0.25)	-4.16 (0.81)	-4.14 (1.05)	0.66 (0.48)	2.82 (0.65)	0.66 (0.48)	0.83 (0.36)
	School bus	0.94 (1.00)	0.34 (0.37)	0.94 (1.00)	0.62 (0.54)	0.94 (1.00)	0.62 (0.54)	-3.15 (1.09)	-1.56 (0.58)
INCOME	No escort	-0.09 (0.10)	-0.11 (0.12)	0.09 (0.06)	0.11 (0.08)	0.09 (0.06)	0.11 (0.08)	0.09 (0.06)	0.11 (0.08)

Note I: Standard deviation for each elasticity is reported in the parenthesis.
Note II: Elasticity value is the percentage of change in the choice probability of the decision variable in the first row, when the attribute in the utility function of the primary alternative increases by one percent.



(a) Cumulative density function of ratio of NL and MNL elasticities



(b) Frequency table for ratio of NL and MNL elasticities

Figure 2 - Differences in NL and MNL elasticities

SUMMARY AND CONCLUSION

This research contributed toward understanding behavioral aspects of school trip escort decisions for trips to and from school. Two separate three level nested logit models were developed along with a comprehensive analysis of the empirical results, based on a surveyed data in Tehran. Contributions of this study may be summarized as follow:

- MNL formulation is predominantly used in the literature of students' escort decisions. The empirical results underscored the significance of model specification for realistic policy evaluations. MNL and NL elasticities were not only different in magnitude but in the sign as well. In some cases, NL elasticities were even 16 times more than that of MNL model. For instance, walk time to school that has a fundamental role in land-use decisions was very sensitive to the model specification.
- A few policy sensitive explanatory variables were explicitly looked into and their influence on students escort behaviors was explained in an eastern culture. Critical role of commute distance, car ownership, income, and safety was discussed in this regard.
- Reservations of parents in terms of safety, comfort, reliability, and cost of travel are accounted for analyzing escort behaviors. This prevents model misspecification in terms of omitted variable, and also shows potential ways of promoting independent travel among students. For example, we found parents who are primarily concerned about their kid's travel safety are more likely to take a school bus for their girls.

This study has certain limitations that could be possible avenues for future research.

- Although a three level nested logit model is presented by the research team (Samimi and Ermagun, 2013) that elaborates choice of "walk", "auto drive", "school bus", and "public transportation" on the collected data, however, students escort decisions and mode choice should be simultaneously modeled, as they have similar unobserved factors.
- Land-use and built environment variables was only available at a semi-aggregate level, and therefore, using zonal data could improve the model power.
- Elementary school students are not regarded in this study.
- Escort alternatives could be expanded. For example, escorting by siblings could be considered separately from escorting by friends. Similarly, escorting by parents can be broken down into escorting by father and escorting by mother. This requires a more complex specification for the choice model.
- Some information such as ethnicity and start and end time of mothers' work could also improve the model.

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