How Are Children Accompanied to School?

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Abstract: A growing number of parents accompany their children to and from school, to make sure they travel with the best care and minimum stress. Policies that aim at promoting nonmotorized modes of transportation or at least discouraging 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 the tendency toward the use of active modes of travel, complicates intrahousehold activities that need to be considered in travel demand models, and increases externalities (e.g., safety, energy, and environmental risks) of the transportation systems. Two separate three-level nested logit models are developed to explore escort decisions in trips to and from school. In addition to addressing escort model misspecification, the authors' models encompass a wide range of parental reservations such as safety and comfort that are typically ignored in previous research. A few policy sensitive variables, including commute distance, car ownership, income, and safety, were explicitly looked into and their influence on student 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 elasticities of the nested logit are 16 times more than that of multinomial logit. Commute distance to school, which has a fundamental role in land-use decisions, for instance, is found to be sensitive to the model specification. **DOI: 10.1061/(ASCE)UP.1943-5444.0000315.**

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Introduction

Policymakers throughout various disciplines have focused on analyzing school trip behaviors. Public health officials look at school trips as an opportunity to embed a regular physical activity in children's daily routines (Cooper et al. 2006). City officials, on the other hand, struggle to find policies that change the travel attitudes of students and parents toward carpooling, walking, or biking. Although city planners strive to promote active modes of transportation and health officials advocate active modes of travel, parents have understandable reservations regarding their children's travel modes (McDonald and Aalborg 2009). Policies that aim at promoting nonmotorized modes of travel or at least discouraging 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 from 94 to 54% in the share of 10-year-old students who were allowed to walk alone to schools in London from 1971 to 1990.

Students' escorting behaviors need to be investigated for three primary reasons. First, school trips are a part of the daily routine of both children and parents who regularly accompany their kids to school. About 46% of American students are accompanied by an adult driver to school (McDonald and Aalborg 2009), while this share is around 53% in Auckland (ARTA 2007), 43% in Belgium (Zwerts et al. 2010), and 19% in Tehran (the current study). Therefore, considerable improvements in traffic congestion, environmental risk, and road safety are 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, intrahousehold 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 for their children (Jones 1979). If a child is not escorted to school, for instance, the parent may take public 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 nonmotorized travel modes in school trips is deemed as a routine method of physical activity. Because parents who accompany their kids to school do not usually have enough time to regularly walk to school, they fail to use active modes of transportation in school trips (Faulkner et al. 2009). According to McDonald (2007), the use of active modes among American students from 1969 to 2001 diminished from 40.7 to 12.9%. A study conducted in Toronto also indicated that using the mode of walking in school trips during 1986–2001 decreased from 53 to 42% among students aged 11–13, and from 39 to 31% among students aged 14–15 (Buliung et al. 2009). Although the influence of physical activity as a preventive health precaution is receiving more attention, a global declining trend in physical activity among children is occurring, which can eventually lead to the development of obesity, Type II diabetes, hypertension, and cardiovascular disease, to name only a few health side effects (Ebbeling et al. 2002; Andersen et al. 2006). Furthermore, the use

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of nonmotorized travel modes leads to an overall decrease in children's independence, which negatively affects students' maturity level and qualifications (Fyhri and Hjorthol 2009).

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

Background

Escorting students in 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 of studies that are supported by a robust modeling approach (Ermagun et al. 2014). Zwerts et al. (2010) studied escorting behavior of students aged 11–13 years in Belgium. A descriptive statistical analysis was performed to demonstrate the effect of gender and age of the students on parental escort decisions. Further, McDonald et al. (2009) and Fyhri et al. (2011) found that travel safety and convenience urge 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 nonmandatory tour, and having no escort. Quality and availability of transit service, and distance to school, along with certain 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 the 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 was 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. Although this was a pioneer study in simultaneous modeling of travel mode and escort decisions, supposition of independently and identically distributed (IID) error terms seems a very strong assumption, because for example, driving with mother and driving with father are very much likely to have common unobserved factors. Therefore, independence of irrelevant alternatives (IIA) property of the MNL formulation leaves the conclusions open to serious questions.

Explanatory variables that are found influential on 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 driving students to school and income, car ownership, and distance is unanimously confirmed in the previous studies (Ewing et al. 2004; Vovsha and Peterson 2005; Zwerts and Wets 2006; Ermagun et al. 2015). Age is also shown to have a negative association with the likelihood of dependent travel to school (Ermagun et al. 2014). Female students are also more likely to be driven to school (Zwerts and Wets 2006). However, 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 (2008) 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. Hence, the role of intrahousehold connections in students' escort behaviors deserves more investigation. Moreover, full-time workers, in contrast to part-time workers, are less likely to accompany their kids to school (Yarlagadda and Srinivasan 2008). Working status of mothers, in contrast to fathers, is more influential, as DiGuiseppi et al. (1998) found that a working mother favors the chance of students being driven.

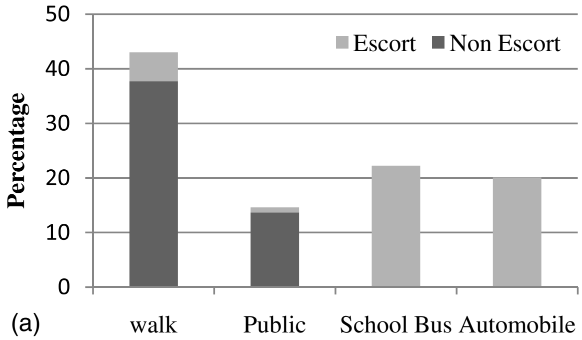
There are four limitations in the literature of parents' tendency to escort kids in school trips that are addressed to a certain extent in this study. First, MNL model specification is predominantly used, which comes with the IIA property and thus questions the final findings and misinforms policy recommendations. Allowing for correlated and heteroskedastic error terms is essential for more reliable estimates. A nested logit (NL) structure, for instance, seems more appropriate because the IIA property is relaxed to independence of irrelevant nests (IIN). 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 yet received adequate attention. Third, school busing is not considered as a form of escort, although the students are accompanied on their trip not only by other students but also with a driver who is trusted by the parents. Fourth, interactive variables are hardly used in previous studies, and therefore, an implicit assumption that the 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. The city of Tehran spans more than 700 km^2, has a population of more than 7.5 million, and is the 16th most densely populated city in the world. In the city of Tehran more than 15 million daily trips are taken, among which more than 25% are school trips (Tehran Census 2011).

There were 5,352 schools and 1,119,571 registered kindergarten through 12th grade (k–12) students in Tehran in 2010 (Statistics of Minister of Education 2012). Elementary schoolers are not included in this study because their travel behavior heavily depends on their parents, and also safety reservations are more serious. Further, they usually go to neighborhood schools that are very close to their residence. Such fundamental differences lead the authors to concentrate on students attending middle school and high school.

The entire population was stratified by gender, age, and municipality zones to secure the consistency of geographic and gender distributions in the sample and population. However, k–12 schools are fully segregated by gender in Iran, and travel behaviors are expected to be substantially different not just for physiologic reasons but for cultural considerations. Questionnaires were distributed among 4,700 students in middle school and high school in a random sample, and parents were asked to fill out the survey. Of the 4,700 envelopes that were distributed in 94 schools, 76% were returned. An initial screening resulted in excluding 150 envelopes from two schools because evidence was found that they were



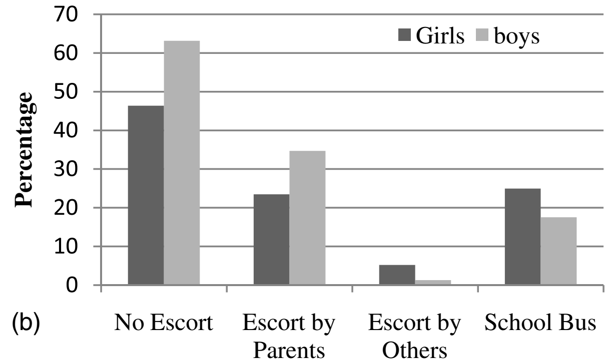


Fig. 1. Children's mode choice and escort behavior

not filled out by the parents. A minimum response rate of 64% was obtained from the remaining 3,441 questionnaires. This rate of response is deemed satisfactory for this type of study. Sixty percent of the collected forms came from the public schools, which is fairly compatible with the actual share of 59% for the public middle and high schools in Tehran. All-girls schools, however, have a share of 59.7 and 50.5%, respectively, in the sample and population. Moreover, high schools have a share of 40.5%, of which 58% are from the all-girls schools.

Information was collected on five areas of study: (1) households' socio-demographics (e.g., household size, income, education, vehicle ownership, working status of parents); (2) students' characteristics (e.g., age, gender, grade); (3) built-environment attributes (e.g., walk time to school, access to public transit, commuting to or from a restricted traffic zone); (4) school trip behaviors (e.g., escort pattern, primary mode of travel, travel cost, and trip chain); and (5) parental reservations about school trips (e.g., safety, reliability, access, and comfort). The lowest rate of response was observed for the occupation question, which 10% of the parents refused to answer. The questions about household income and number of cars in the household were refused by only 43 and 24 individuals, respectively.

Four modes of transportation were considered for school trips: walking, school busing, taking public transit, and using private automobiles. As shown in Fig. 1(a), around 43% of students walk to school, whereas use of private automobiles and school buses constitute 20 and 22% of daily school trips, respectively. A point worthy of attention is that when parents wish to accompany their kids to school, they tend toward the use of private automobiles. According to Fig. 1(a), 88% of students who walk to school are unaccompanied. Therefore, correctly identifying factors that influence the accompanying of students can affect the promotion of active modes of transportation.

Four choice situations are considered for escorting students to school, namely: *no escort*, *escort by parents*, *escort by others* including siblings or friends, and *school bus*. Fig. 1(b) shows the proportion of the use of each choice separately for girls and boys. The data revealed that parents play a dominant role regarding the transportation of their children. While only 10% of parents accompany their children to school on their way to work, 12% of parents travel solely for the purpose of taking their kids to school. Table 1 provides a summary of variables that are used to explain school trip escort behaviors. According to Table 1, it is worth noting that *WALKTIM* and *INCOME* are scale variables, although they look like ordinals. The main reason for considering these variables as interval scale is rooted deeply in two basic facts: (1) the both variables have meaningful zero values, and (2) equal numerical differences between the magnitudes represent equal quantities of the

Table 1. Description of the Explanatory Variables

Variable	Description	Average	SD
WALKTIM	1: <10; 2: 10–20; 3: 20–30; 4: 30–40; 5: 40–50; 6: >50 min walk time to school	2.67	1.55
INCOME	1: <5; 2: 5–10; 3: 10–15; 4: 15–20; 5: 20–25; 6: >25 million Iranian rials[a] household income	2.11	1.23
LOW_INC	1: if household income is <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 (ages 7–18)	1.57	0.67
AGE	Age of children 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 nonworker parents are in household; 0: otherwise	0.05	0.21
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 min; 0: otherwise	0.60	0.50
D_GENSAFE	1: if safety is important for parent of male students; 0: otherwise	0.12	0.32

[a]11,800 Iranian rials was equivalent to 1 USD in May 2011.

characteristic. De facto, *WALKTIM* is the floor function of (walk time to school in minutes divided by 10) + 1 if walk time is less than an hour, and 6 otherwise. The same applies to the *INCOME* variable. Concretely speaking, someone with *INCOME* = 4 is twice as wealthy as someone with *INCOME* = 2. Hence, these are treated as scale variables in the model.

Method

Logit models are widely used to explain different choice situations, as their closed-form formula eases the estimation procedure and makes the results easy to interpret (Train 2009). Multinomial logit, however, is widely criticized for the IIA property, which implies characteristics of a third alternative do not change the relative odds between the two alternatives (McFadden 1978). This is an inappropriate assumption in the choice situations for escorting students because IIA of the MNL model indicates that if for some reason the parents cannot take their kid to school, the likelihood of taking a school bus and having the child travel alone would increase proportionally. This is intuitively not true as parents who want to take their children 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.

The NL relaxes the IIA property and retains most of the advantages of an MNL, by clustering subsets of alternatives with a higher degree of similarity in a nest. The 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.

Model

Four aforementioned choice situations for escorting students to school were modeled. Contrary to 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 latter is then classified into *escort by parents* and *escort by others* (Fig. 2). Other possible nest structures and model specifications were investigated, with Fig. 2 presenting the best structure. The best structure was determined based on the model selection criteria that include goodness-of-fit measures, inclusive value (IV) parameters, and significance and rationality of the estimates. 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 (Train 2009). The other IV parameters are determined in the estimation process.

A full information 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% confidence interval. Moreover, the likelihood ratio test is conducted to evaluate the overall goodness of fit for each model.

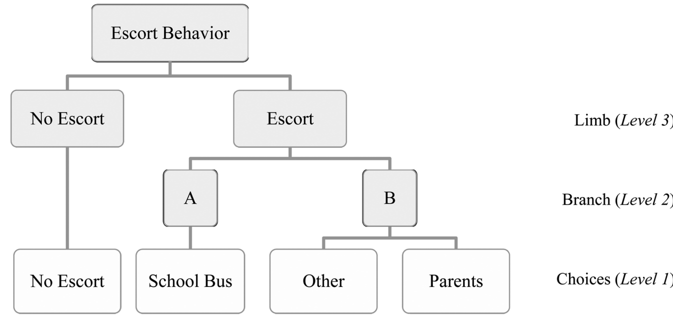


Fig. 2. Tree structure for the nested logit model

Likelihood ratio index, also known as McFadden's pseudo R^2, fluctuates between zero and one, and has a similar interpretation as R^2 in the linear regression models. The 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%, conveying that there is a broader range of missing variables affecting this decision. Generally, the 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 on the MNL model. Misspecification consequences along with a broader analysis of results are provided in the following sections.

General Discussion

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

The results show boys are less likely 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 girls' independent travel, particularly in Eastern culture (Samimi and Ermagun 2013b). 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 lifestyle and parents are less concerned about their safety. This tendency is higher in trips from school to home, because students have a more flexible schedule in the afternoon.

Household income is a strong determinant of escort patterns. 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 safe and convenient travel for their children, and (2) high-income families have easier access to personal vehicles and therefore there is a higher chance for their children 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 cannot afford the associated fees. Moreover, similar to previous studies (Vovsha and Petersen 2005;

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[a]	21.66	2.79[a]	19.99
TRF_LIMIT		1.37[a]	6.39	1.22[a]	6.65
LOW_EDU		0.32[a]	2.71	0.33[a]	2.86
RELIABL		−0.47[a]	−3.17	−0.43[a]	−2.66
INCOME		−0.13[a]	−2.69	−0.16[a]	−2.87
COMFRT		−0.48[a]	−3.37	−0.50[a]	−3.26
Constant	Escort other	−1.17[a]	−3.49	0.19	0.25
GENDER		−2.40[a]	−8.4	−4.73[a]	−6.21
COST		−0.54[b]	−2.3	−1.88[a]	−3.36
TRF_LIMIT		0.49	1.33	0.55	1.43
CHILD_7		0.53[a]	4.08	0.62[a]	4.2
LEVEL		−0.59[a]	−2.79	−1.29[a]	−3.28
Constant	Escort parent	3.65[a]	4.2	4.73[a]	−3.28
GENDER		−1.35[a]	−10.47	−3.64[a]	−5.19
AUTO		0.27[a]	3.46	0.33[a]	2.73
LIC_0		−0.57[b]	−2.12	−0.87[b]	−2.47
COST		−0.68[a]	−5.32	−2.01[a]	−3.89
NON_WRK		0.49[b]	2.31	0.63[b]	2
Constant	School bus	4.95[a]	5.65	4.72[a]	3.2
GENDER		−2.28[a]	−13.1	−3.13[a]	−4.71
COST		−1.84[a]	−10.69	−2.43[a]	−5.27
D_WALKTIM		−1.39[a]	−11.65	−1.22[a]	−7.49
TRF_LIMIT		0.75[a]	3.41	0.70[a]	3.09
D_GENSAFE		1.34[a]	6.93	1.21[a]	5.13
LOW_INC		−0.93[a]	−6.25	−0.94[a]	−5.75
AGE	Escort parent and school bus	−0.19[a]	−3.06	−0.18[c]	−1.86
LEVEL		−0.31	−1.41	−0.96[b]	−2.33
SAFE		0.21[c]	1.81	0.66[a]	3.55
WALKTIM	All escort choices	−0.04	−0.96	0.24[b]	2.16
Inclusive value parameters					
Escort	—	—	—	0.64[a]	4.01
No escort	—	—	—	1.0 (fixed)	—
A	—	—	—	1.0 (fixed)	—
B	—	—	—	0.62[a]	5.79
Log-likelihood at zero		−3,389.15	—	−3,389.15	—
Log-likelihood at convergence		−2,338.52	—	−2,169.05	—
McFadden's pseudo R^2		0.31	—	0.36	—
Sample size		3,013	—	3,013	—

[a]Significance level at 1%.
[b]Significance level at 5%.
[c]Significance level at 10%.

Ermagun and Samimi 2015), the authors found that parents with driver's licenses and easy access to personal vehicles are more likely to drive their children to school, whereas students from low-income families have a greater chance of walking alone to school. In addition, if there are more school-going kids in the family, students are more likely to be accompanied by 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 2012, 2013a; McMillan et al. 2006) also show a decline in the tendency to walk and bike as the commute distance increases. Students who live more than one mile from their school are more likely to ride in a school bus. The authors 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; and (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. The results showed that parents who are concerned about the safety of their children in their school trips have a higher tendency to accompany their kids to school or have them use school buses. A noteworthy point is that the concern of parents regarding the safety of their children is much higher on the trips back from school rather than on the way to school. This could be attributed to the fact that there is no particular time constraint on the way back from school, whereas in the mornings children must get to school at a fixed time. Thus, children tend to spend more time on their return trips, during which they are more exposed to society and parents are more worried about possible risks. Another important finding was the varying safety concerns parents had toward male and female

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[a]	13.84	1.58[a]	13.51
TRF_LIMIT		0.71[a]	3.42	0.57[a]	3.45
LOW_EDU		0.32[a]	2.99	0.33[a]	3.10
RELIABL		−0.72[a]	−5.24	−0.73[a]	−5.05
INCOME		−0.08[a]	−1.93	−0.10[a]	−2.23
COMFRT		−0.37[a]	−2.91	−0.39[a]	−2.92
Constant	Escort other	−1.23[a]	−4.69	−0.87	−1.60
GENDER		−1.60[a]	−8.72	−4.10[a]	−6.25
COST		−0.38[b]	−2.21	−1.36[a]	−3.23
TRF_LIMIT		0.44	1.59	0.42	1.46
CHILD_7		0.32[a]	3.08	0.40[a]	3.25
LEVEL		−0.71[a]	−4.39	−2.04[a]	−5.29
Constant	Escort parent	3.97[a]	4.58	6.33[a]	4.27
GENDER		−1.56[a]	−11.27	−4.09[a]	−6.27
AUTO		0.29[a]	3.26	0.36[a]	2.81
LIC_0		0.15	0.62	0.02	0.07
COST		−0.22[c]	−1.65	−1.16[a]	−2.86
NON_WRK		0.52[b]	2.27	0.57[c]	1.75
AGE	—	−0.34[a]	−5.22	−0.49[a]	−4.97
Constant	School bus	5.12[a]	5.87	2.75[a]	2.00
GENDER		−1.83[a]	−11.54	−2.52[a]	−4.72
COST		−1.76[a]	−10.19	−2.13[a]	−6.55
D_WALKTIM		−1.50[a]	−12.11	−1.12[a]	−5.93
TRF_LIMIT		0.21	0.92	0.10	0.44
D_GENSAFE		0.98[a]	5.09	1.00[a]	4.06
LOW_INC		−1.04[a]	−6.89	−1.07[a]	−6.34
AGE	—	−0.28[a]	−4.48	−0.15	−1.60
LEVEL	Escort parent and school bus	−0.08	−0.4	−0.97[b]	−2.69
SAFE		0.63[a]	5.87	0.95[a]	5.71
WALKTIM	All escort choices	0.04	1.14	0.35[a]	3.18
Inclusive value parameters					
Escort	—	—	—	0.64[a]	4.48
No escort	—	—	—	1.0 (fixed)	—
A	—	—	—	1.0 (fixed)	—
B	—	—	—	0.55[a]	4.77
Log-likelihood at zero		−3,375.67	—	−3,375.67	—
Log-likelihood at convergence		−2,521.80	—	−2,464.23	—
McFadden's pseudo R^2		0.25	—	0.27	—
Sample size		3,002	—	3,002	—

[a]Significance level at 1%.
[b]Significance level at 5%.
[c]Significance level at 10%.

children. *D_GENSAFE*, an interactive dummy variable, indicates such parents have a higher chance of choosing a school bus for their female students. This was particularly expected in Iranian society. Families who are more concerned about the 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 from driving their kids to school, as they need to purchase a special sticker to enter the zone with their personal vehicle.

Policy Implication

The entire purpose and objective of this study is to provide a better understanding of some influential variables that affect escort decisions in school trips for policymakers and urban planners. Moreover, this study attempts to show that using inappropriate models can produce irreversible results in short-term and long-term policy analyses. To demonstrate this, elasticities of some policy sensitive variables in the MNL and NL models are estimated, compared, and discussed in this section. Elasticities are a typical way of reporting the magnitude of effect that an explanatory variable has on the endogenous variable. This is simply defined as the percentage of change in the dependent variable caused by a 1% increase in an independent variable. Tables 4 and 5 show elasticities of age, travel time, number of students in a household, family income, and vehicle ownership for NL and MNL models, which are calculated using sample enumeration. There are integer variables for which a 1% increases looks nonsense. However, elasticities become less accurate as the percentage of change increases. In short, there is a trade-off between a 1% increase and a one unit increase. The first provides a more accurate elasticity, whereas the second makes more sense. Because elasticities are compared to approximate the magnitude of effect for each explanatory variable on the decision variable, the first approach is adopted. Both approaches, however, are easily converted to each other with basic calculations. For instance,

Table 4. 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*	−0.02	***0.01***	***−0.06***	−0.10	*0.06*	*0.01*	−0.02
	Escort parent	***0.02***	***−0.06***	***−0.84***	***0.32***	***0.02***	***−0.35***	***0.02***	***−0.13***
	School bus	***0.03***	***−0.14***	***0.03***	***−0.24***	***0.03***	***−0.24***	***−0.07***	***0.42***
CHILD_7	Escort other	−0.04	−0.02	**−0.04**	**−0.11**	0.81	0.87	−0.04	−0.05
AUTO	Escort parent	**−0.07**	**−0.03**	0.21	0.15	**−0.07**	**−0.19**	−0.07	−0.08
AGE	Escort parent	**0.61**	**0.22**	−2.21	−1.20	**0.61**	**1.346**	0.61	0.54
	School bus	0.64	0.37	0.64	0.69	0.64	0.69	−2.18	−1.86
INCOME	No escort	−0.16	−0.19	0.13	0.15	0.13	0.15	0.13	0.15

Note: Elasticity value is the percentage change in probability of selecting an alternative, when the value of an interest variable is increased by 1%. Italic text shows elasticities with opposite signs in MNL and NL models. Bold text represents the cases in which MNL model either overestimates or underestimates the elasticities more than two times the NL model. Both italic and bold text represents the both conditions.

Table 5. 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	−0.02	**−0.01**	**−0.20**	**0.11**	**0.76**	**−0.01**	**−0.05**
	Escort parent	**−0.01**	**−0.05**	**0.10**	**0.57**	**−0.01**	**−0.39**	**−0.01**	**−0.10**
	School bus	**−0.03**	**−0.21**	**−0.03**	**−0.37**	**−0.03**	**−0.37**	**0.08**	**0.59**
CHILD_7	Escort other	**−0.03**	**−0.01**	**−0.03**	**−0.15**	0.46	0.48	−0.03	−0.04
AUTO	Escort parent	−0.04	−0.02	0.25	0.21	**−0.04**	**−0.16**	−0.04	−0.04
AGE	Escort parent	0.66	0.35	−4.16	−4.14	**0.66**	**2.82**	0.66	0.83
	School bus	**0.94**	**0.34**	0.94	0.62	0.94	0.62	−3.15	−1.56
INCOME	No escort	−0.09	−0.11	0.09	0.11	0.09	0.11	0.09	0.11

Note: Bold text represents the cases in which MNL model either overestimates or underestimates the elasticities more than two times the NL model.

increasing the level of income from 2 to 3 for a household means a 50% increase in the *INCOME* variable. The corresponding elasticity in this example is then arrived at by multiplying the 1% elasticity by 50%.

As stated earlier, a significant inclusive value in the NL model conveys a specification bias in the MNL model. However, most policymakers are unaware of the consequences of such a misspecification. A comparison is made between NL and MNL elasticities to make the differences tangible. The ratio of NL to MNL elasticities is 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 plotted in Fig. 3(a). According to this figure, NL and MNL elasticities are of opposite signs in more than 40% of cases. In many other cases, MNL and NL elasticities have the same sign but different magnitudes. The frequency bar for the ratios that is depicted in Fig. 3(b) indicates that NL elasticities are as large as 16 times more than that of the MNL model in some cases. The dark portion of each bar in Fig. 3(b) belongs to the cases with a NL elasticity in the numerator.

The opposite sign of elasticities belongs to *WALKTIM*, a scale 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 schools alleviates the general transportation costs (e.g., safety, fuel, etc.), whereas 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 modes 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 school of thought, but rather aims to provide an example of how model misspecification may misguide a policymaker. However, this study demonstrates that an increase in distance dramatically decreases the probability of utilizing independent travel modes. Therefore, those policymakers who wish to promote independent travel modes such as walking or biking are expected to support neighborhood schools. Because larger schools require more land, decision makers tend to construct these schools on the outskirts of cities to save on costs. This leads to an increase in average distance between schools and residential areas and thereby a decrease in independent modes of travel. On the other hand, relying on misspecified models can lead to irreversible consequences in the application of long-term policies. For example, the results of the MNL model show that with the increase of 1% in travel distance, the probability of parental accompaniment decreases by 0.84% and the probability of other escort behaviors and nonescort behaviors increases by 0.02%. However, the results of the NL model show that in such cases, not only do parents have a higher propensity to accompany their children, but the probability of choosing other escort choices also decreases significantly.

The age of students is among other policy-sensitive variables that have been the focus of attention of policymakers in recent years. It has long been a maxim that students of different age groups exhibit different travel behaviors. For instance, parents are more concerned about the safety of younger children and are thus more willing to accompany them to school. Therefore, the identification and specification of these differences with regard to age and behavior can lead to a better implementation of policies. This study showed that the probability of middle school children being accompanied by their parents in MNL and NL models, respectively,

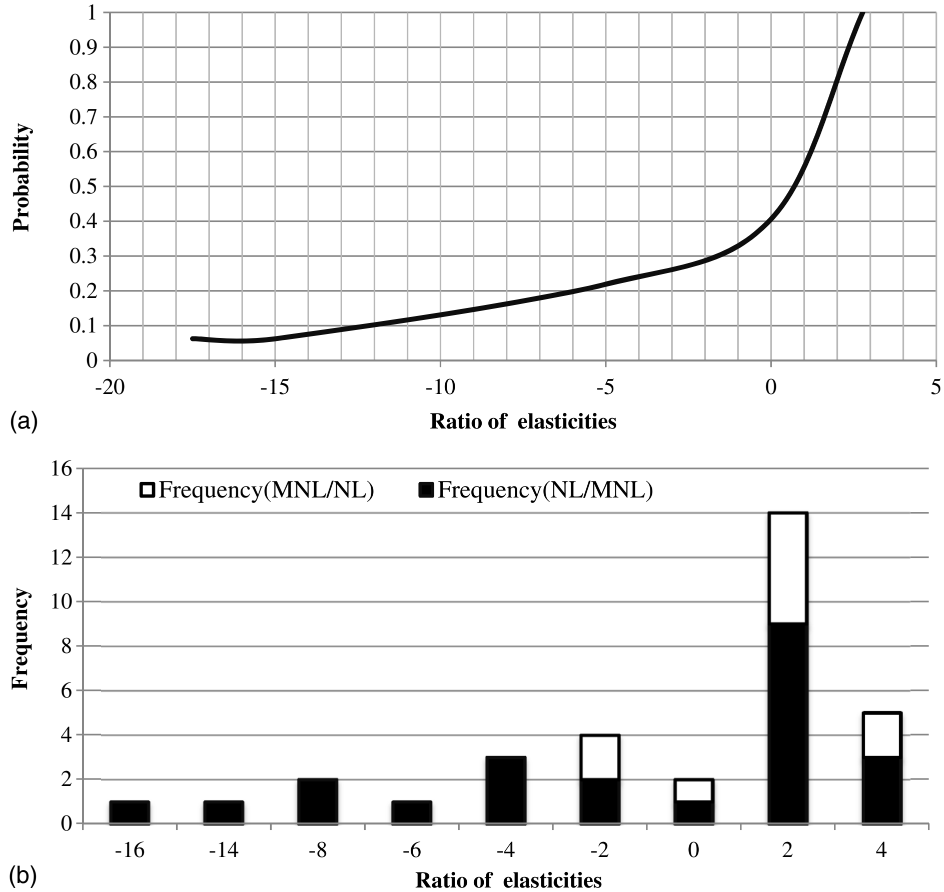


Fig. 3. (a) Cumulative density function of ratio of NL to MNL elasticities; (b) frequency chart for ratio of elasticities

is 27.7 and 51% greater compared to children in high school. Thus, the use of MNL modeling in this case results in a nearly double overestimation, which can lead to incorrect policy recommendations.

Income-direct elasticity of around −0.19 was obtained in choosing the no-escort option, and cross elasticity of 0.15 in other choices. In other words, a 1% increase in household income increases the probability of accompaniment by 0.15% and decreases nonaccompaniment by 0.19%, whereas the rate of decrease in nonaccompaniment in the MNL model is 0.16%. This is a direct consequence of model misspecification that leads to an underestimation of probability of no escort when household income increases. This finding helps policymakers address different segments of society to properly utilize independent modes of transportation such as walking.

Although the surveyed data showed 61% of families have only one vehicle in the household, 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 children on the way to school as they acquire a second car. Therefore, policymakers need to be alerted to a possible growing trend of family intrahousehold tours that may worsen the traffic congestion in the morning peak hours. Improving safety measures could mitigate this effect and encourage independent school trips, particularly for high-school students.

To give readers a flavor for understanding the effect of parental reservations on escorting decisions, the pseudo-elasticity of dummy variables was measured. Table 6 outlines the percentage of variation in probability of escort when each parental reservation becomes one, having all the continuous variables at mean, discrete variables at mode, and other parental reservations at zero. As shown, safety concerns significantly increase the probability of accompaniment to school. An important point here is the difference witnessed among different student age and gender groups. For instance, results show safety concerns increases the probability of accompaniment of middle-school and high-school girls by respectively 35 and 26%. Actions such as *Safe Routes To School* and *Walk School Bus* are examples of such effective policies. However, these strategies need to be specifically studied in context before implementation. Such findings enable policymakers to apply varying policies to differing social and age groups. In addition to safety, comfort and reliability are influential on the decision to escort children in school trips. For example, comfort and reliability concerns lead to an increase of accompanying students by at most 36 and 30%, respectively.

Table 6. Percentage of Variation in Probability of Escort by Changing Parental Reservations

		Parental reservations			
Gender	Level	Safety	Reliability	Comfort	Traffic limit
Female	Middle school	35	30	36	−117
	High school	26	29	34	−107
Male	Middle school	25	22	26	−57
	High school	23	19	23	−44

Sensitivity of the model estimates to model specification indicates that reliance on the MNL model when the assumptions are not met could result in poor policy evaluations. For instance, if the need for school bus service were based on the MNL model rather than a generalized extreme value (GEV) model, the service could break even financially due to the biased estimate. Therefore, model specification could significantly change policy assessment outcomes.

Conclusion

Travel behavior of students, mode choice, and escorting pattern have been part of a heated debate among various research disciplines. Although a host of research has been conducted to explore mode choice decisions for school travel, the literature is scant in understanding the escorting behavior of schoolchildren. As a result, an interest in scrutinizing the escorting pattern of schoolers is gaining momentum in the travel-behavior arena. Few studies, however, have investigated the schoolchildren's escorting decisions explicitly in an econometric modeling framework. This research therefore contributed toward understanding behavioral aspects of 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. The results of the models also fairly compared with the results of the multinomial logit models that are predominantly used by the scholars of this field. The authors demonstrated how an incremental advance in methodology provides outcomes with substantially different policy implications. Contributions of this study may be summarized as follows:

- The empirical results underscored the significance of model specification for realistic policy evaluations. MNL and NL elasticities were different in both magnitude and the sign of the parameters. In some cases, NL elasticities were up to 16 times larger than those of the MNL model. For instance, walk time to school, which has a fundamental role in land-use decisions, was found sensitive to the model specification;
- A few policy-sensitive explanatory variables were explicitly looked into and their influence on students' escort behavior was explained in an Eastern culture. The critical roles of commute distance, car ownership, income, and safety were discussed in this regard; and
- Reservations of parents in terms of safety, comfort, reliability, and cost of travel are accounted for in analyzing escort behaviors. This prevents model misspecification in terms of the omitted variable, and also shows potential ways of promoting independent travel among students. For example, it was found that parents who are primarily concerned about their kids' travel safety are more likely to opt for a school bus for their girls. Such findings are studied in the Iranian context and should not be applied to other cities and contexts before appropriate transferability analysis.

Generally, the findings of this research give policymakers and practitioners an insight into not only the impacts of wide range of variables on escorting patterns, but the pitfall of model misspecification for both long-term and short-term policy assessments. This study, nevertheless, has certain limitations that could be possible avenues for future research:

- Land-use and built environment variables were only available at a semiaggregate level, and therefore, using zonal data could improve the model power. The more aggregate data are unfortunately unavailable in the place of study, while availability of land-use and built environment parameters enables researchers to explore the effect of them and thereby boost the model;
- Elementary-school students are not taken into account in this study because their escorting patterns need to be explored in a separate framework. Hence, the age gap between school children for escorting patterns might be interesting to investigate in further research;
- 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 more detailed data and a more complex specification for the choice model; and
- Although the use of MNL is theoretically called into question versus GEV models, external validity of the policy recommendations could be an interesting improvement in future research.

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