Do Parental Work Arrangements and Location Influence a Child's Journey to School? The Effect of Intra-Household Scheduling and Spatial Coordination

Sylvia He
Assistant Professor
Department of Geography and Resource Management
The Chinese University of Hong Kong
Shatin, N.T., Hong Kong
Office: (+852) 3943.6646
Email: sylviahe@cuhk.edu.hk

Paper assigned to Session Track **D3 - Travel Demand Models: Understanding Behaviour (SIG 12)**

ABSTRACT

1. Objective

In the United States, the share of children of ages 6 to 12 who travel to school by private vehicle has increased significantly in the past decades. A child's mode to school is influenced by or dependent upon parental choices. Thus an increasing share of auto trips may reflect parental choices and constraints. The intra-household bundling constraints can be defined as the scheduling and spatial constraints that determine whether a household member is able to join another member during an activity. Whether a parent can escort their children to school may depend on their scheduling and spatial constraints, e.g. work schedule and job location in relation to home and school locations. This research aims to understand the effect of household bundling constraints on a child's escort-mode choice.

2. Data/Methodology

In this study, the school trip data are drawn from the 2001 SCAG (Southern California Association of Governments) Post Census Regional Household Travel Survey. The study area is the five-county Los Angeles region. The focus group in this paper is two-parent households, which account for 73.12% of the total households. Although escort decision and mode choice are interrelated, the decisions of escort and travel mode are usually modeled as separate decisions with most studies focused on mode choice. This paper will model these two decisions as a joint decision. The effect of parental work arrangements and locations on children's escort-mode choice will be estimated using multinomial logit and nested logit models.

3. Results/Findings

This essay attempts to model how parents affect the child's means of travel to school using both scheduling and distance variables derived from the household travel diaries. The outcomes demonstrate that the parent's, especially the mother's, increasing work hours and more distant job locations result in an increased likelihood of several alternative escort-mode choices. Mothers who work longer hours and farther away from home are less likely to drive their children. These trips have been substituted by alternative escort choices such as independent travel and escorted by fathers, or alternative mode choices such as active commuting, driving, and busing. The effect of work hours may be offset by the option of flexible work hours, which allows mothers to arrange more escort trips.

4. Implications for Policy

The implications of this research are twofold. First, to better balance a worker's dual roles in work and family life, more childcare facilities need to be located near employment centers and more options of flexible work hours should be provided. Second, the results imply that the parent-child joint trip could be made easier if the child attends a school closer to the parent's workplace. By doing so, he/she may incur a longer travel distance and a different mode choice than children who attend neighborhood schools. This observation helps us understand the increasing travel distance and car use in school trips attributable to women's increasing participation in the labor force.

1. Introduction

In the United States, the share of children age 6 to 12 who travel to school by private vehicle has increased from 15% in 1969 to 50% in 2001. An outcome of increased car dependency is that children are missing an important part of physical exercise outside their classrooms (Tudor-Locke et al. 2001). Much research on school transportation has been conducted to identify what factors influence children's travel-to-school mode choice and how to incorporate the information into urban design and transportation engineering (DiGuiseppi et al. 1998, Ewing et al. 2004, McMillan 2005, McMillan 2007, McDonald 2008a, Müller et al. 2008, Black et al. 2001, Schlossberg et al. 2006, Babey et al. 2009, Zhu and Lee 2008, Davison et al. 2008).

A child's mode to school is influenced by the parent(s). As part of general parental responsibilities, the parent decides whether the child is escorted to school or travels by himself/herself. Thus an increasing share of auto trips may reflect parental choices and constraints. For example, women's increased labor force participation can be a constraint as important as travel distance. Although a child's mode choice depends on parental choice, the decisions of escort and travel mode are usually modeled as separate decisions with most studies focused on mode choice (McMillan 2007, McDonald 2008a, Wilson et al. 2010). In fact, the child's mode and whether the child is escorted by a parent (or other caretaker) are related. For example, children who are escorted to school are most likely to be dropped off or picked up by car, whereas those who travel independently are more likely to use modes such as walking, biking, and bus.

To study the escort-mode joint decision, it is important to consider intra-household bundling constraints. Intra-household bundling constraints can be defined as the scheduling and spatial constraints that determine whether a household member is able to join another member during an activity. Applying this concept to school trips, whether a parent can escort their children to school may depend on the parent's scheduling and spatial constraints, e.g. work schedule and job location. The effects of intra-household bundling have only recently been addressed: parental employment and flexibility of work hours are significant factors in escort and/or mode choice of children's school trips (McDonals, 2008; Vovsha et al. 2004, Vovsha and Petersen 2005, Yarlagadda and Srinivasan 2008). Spatial constraints, which may also affect the joint trip realization, have not been accounted for. The child may attend a non-neighborhood school, increasing trip distance and making walk or bike trips less feasible. Attendance at non-neighborhood schools is increasingly likely due to open enrollment policies. In some cases, students may be able to transfer to districts where their parents work. Therefore, although the student attends a non-neighborhood school that is farther from home than a neighborhood school, it can be closer to the parent's work location, which in turn facilitates parental pickup and drop-off duties. To the author's knowledge, little of the school-work spatial relationship has been studied. This paper will complement previous studies by including the spatial (dis)coordination and time (de)synchronization between parents and children in the model.

The importance of intra-household spatial and temporal coordination on the escort-mode choice may vary across different household structures because of different household structures and unequal chauffeuring responsibility. For this reason, five types of households are defined in this study, including two types of two-parent households (i.e., dual-earner, non dual-earner), two types of single-parent households (i.e., father-headed, mother-headed), and no-parent households (i.e., other-headed). The main focus group of this research is the dual-earner households, because only for this household structure that the father's and mother's employment status and job locations can be identified at the same time, which enables their respective effect on escort-choice decision to be estimated. In the survey data used in this study—2001 SCAG (Southern California Association of Governments) Post Census Regional Household Travel Survey (RHTS)—dual earner households accounted for roughly 73% of the households that participated in the school trips.

This research presents a first attempt in bringing both scheduling and spatial variables that are derived from the parent's work arrangement and workplace to model escort-mode decisions of school trips. The outcomes in this paper demonstrate that the parent's, especially the mother's increasing work hours and distant job location could result in an increased likelihood of several alternative escort-mode choices. Mothers who work longer hours and farther away from home are less likely to escort their children in car. These trips have been substituted by alternative escort choices such as escorted by fathers and by siblings, or alternative mode choices such as active commuting and busing. Moreover, the estimates of the spatial coordination variables suggest that, when the parents would like to escort the child to school, the child may attend a school closer to his/her parent's workplace in order to facilitate the joint-trip realization. This decision may result in a longer travel distance and a different mode choice than those who travel independently.

2. Theoretical Framework and Empirics

2.1 Theoretical framework of time geography

This paper adopts a time geography framework (Hägerstrand 1970), which centers around the spatial and temporal constraints on the movement of individuals. The advantage of this framework lies in its ability to treat both individuals and society as a whole and its focus on "the various types of constraints and finitude which wall-in the action alternatives of individuals" (Pred 1977, pp. 210). According to this theory, the constraints can be categorized into three types: individual, bundling, and societal constraints. Individual constraints refer to biological, physiological necessities; bundling constraints refer to when, where, and how long must an individual join others; and societal constraints refer to accessibility to specific domains at specific times determined by rules, laws, economic barriers (Hägerstrand 1970; Pred 1977). Although the joint school trips involve all three types of constraints, its realization depends heavily on the *bundling* and *societal* constraints. Bundling constraints emphasize both temporal synchronization and spatial coordination between the parent and the student whereas societal constraints address the institutional cooperation. It is possible that societal changes such as the provision of childcare or having flexible start time at school can relax the time and space constraints of the parents. However, institutions are usually more resistant to change as it is a collective effort of the interconnected social systems. For this reason, this study will focus on *bundling* constraints such as parental work arrangement and workplace location, which are likely to affect the space and time restrictions more easily within the household. It is worthy to note that in this research the space and time constraints are modeled in a global way, as explanatory variables of parental work arrangement and location, which is not the same as the space-time prism approach (Scott and He 2012).

2.2 Empirics of temporal synchronization and spatial coordination

Previous studies on household interactions have focused mainly on household heads until recently. Vovsha and Petersen (2005) examined household interactions between adults and children regarding their joint trip decision makings. Using data from the Atlanta region, they combined both to and from school trips and defined three escorting decisions (i.e., ridesharing with a household member who is on the way for a mandatory activity, pure escorting by a household member who has no mandatory activity on the tour, and no escort) each way. The estimation results showed that part-time workers and non-workers were significantly more likely to escort their children but for inbound trips only. The authors suggested that their model would be enhanced by explicitly including an additional variable—flexible work hours. One drawback of Vovsha and Petersen's (2005) model is that they only accounted for auto trips and ignored other transportation mode choices, especially for the active commuting modes.

With a focus on walking and biking mode choice, McDonald (2008a) tested whether parent's work schedule can affect children's mode choice to school. With a national sample in the United States, McDonald's work revealed that the mother's work status and departure time increased the likelihood that elementary and middle schoolers' active commuting, but the association was not found in the father's work status. It was found that mothers who traveled to work in the morning were associated with a 7.7%

decrease in children's walking or biking to school. In contrast, fathers who traveled to work in the morning were found to increase children's non-motorized travel by 7%. While the findings are interesting, the decision is limited at the mode choice level and does not link mode choice with escort choice.

Yarlagadda and Srinivasan (2008) used an escort-mode choice model to study the effect of household interactions. For some modes (i.e., bike and drive, school bus, and transit), the escorting decisions are not differentiated. Only walking and being a passenger were split by the escorting arrangement (i.e., walked alone, walked by mother, driven by mother, driven by father, and driven by other). They found that the father and mother's employment status and work schedule had a significant impact on children's private vehicle use. Working mothers were more likely to drop off the children, whereas working fathers were less likely to drop off their children. The association between parent's work commitment and children being chauffeured were not found in pick up trips, suggesting less temporal overlaps between work-school end times than the overlaps for start times.

One caveat of the aforementioned escort and/or mode choice studies (Vovsha and Petersen 2005, McDonald 2008a, Yarlagadda and Srinivasan 2008) is that, despite their attempts to include parents' work schedule in school trips, the focus still remained on time synchronization whereas spatial coordination among household members (i.e. the distance from parent's work place to school) has largely been missing. We know that scheduling and joint trip decisions are influenced by factors along both the time and space dimension (Hägerstrand 1970). The distance from the parental work place to the school is expected to decrease parents' involvement in school trips; hence, this spatial variable will likely affect the escort and mode choice. This paper will fill this gap by including both space and time constraints in the escort-mode choice models.

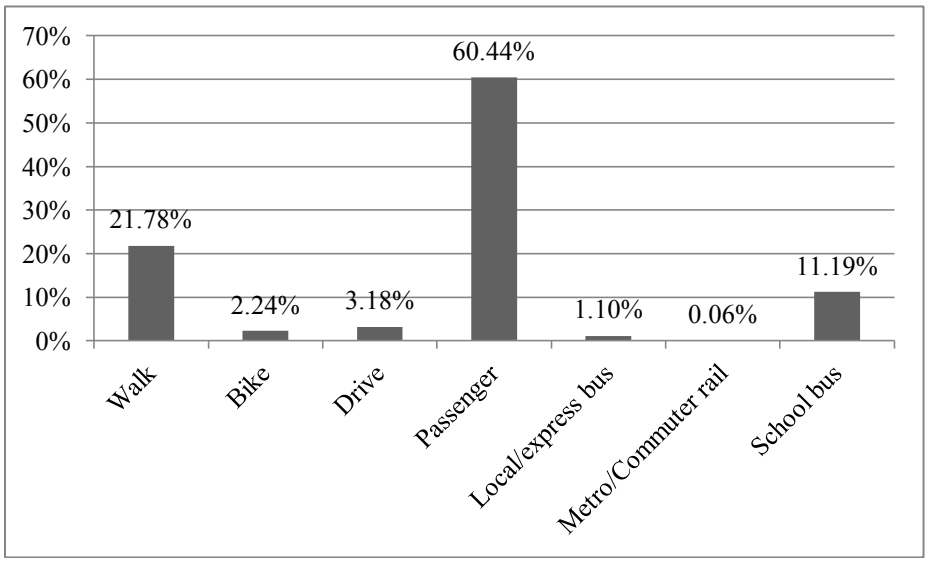
3. Methodology

3.1 Study area and data

In this study, the trip data came from the 2001 SCAG (Southern California Association of Governments) Post Census Regional Household Travel Survey (RHTS), covering six counties in the region: Los Angeles, Orange, Riverside, San Bernardino, Ventura, and Imperial. Because it is a rural county, Imperial County was excluded from further analysis, leaving 16,024 households in the sample of the five-county Los Angeles Region. My sample of school trips is selected based on age (5-18) and the trip purpose indicated in the survey. A trip is selected if and only if the primary or secondary trip purpose is going to school (attending classes) and the age of the traveler is 5-18, a normal age for K-12 schoolers.

Statistical analysis of this travel survey shows that students in the Southern California Region had high car dependency and low usage of alternative modes. Among this age group of travelers, more than 60% travel to school by private vehicle, roughly 24% on foot or by bicycle, and slightly more than 11% by school bus; few students travel by transit bus or by subway (Figure 1). Because trips undertaken by rail and express bus have a very small share by students in the region (3 trips accounting for 0.09%), they are removed from further analysis rather than combined with bus trips (to become transit trips). The rest of the transportation mode choices are combined into four: walking and biking (active commuting modes or non-motorized modes), bus (school bus and local bus), being a passenger, as well as driving.

Figure 1: Mode choice summary (N=3,172)



Different types of households view and share the escort responsibility differently. Therefore, household structure is expected to play an important role in the escort decision. The focus group in this paper is two-parent households, which account for 73.12% of the households. There are also a substantial proportion of the households that are single-earner households: mother-headed households account for over 20.55% and father-headed households take up 5.64%. Table 1 shows that, in general, slightly over half of the trips are escorted by parents: mothers share roughly 40% of the escort responsibility and fathers share a much smaller fraction of the escorts at 12%. Trips of students from single-parent households exhibit significantly different patterns. For example, students from these families are more independent on their journeys to school. The share of their independent trips is 2%-8% higher than general households. Students from father-headed households are nearly three times more likely to be escorted by the father (35.47% vs. 13.08%), almost twice more likely to travel with their siblings (28.49% vs. 14.78%), and over seven times more likely to be escorted by other household members (6.40% vs. 0.21%). By contrast, students who live with a single mother have escort patterns similar to the general households except that more trips are undertaken independently (30.63% vs. 20.49%). Although it is known that single parents need to balance both childcare and work and they may be more likely to receive help from their family to share some childcare responsibilities, the statistics here show that single mothers do not receive as much escort assistance from other household members as single fathers do (1.94% vs. 6.40%). Lastly, notwithstanding the small sample sizes of students from non parent-headed households, they exhibit very different travel patterns as well compared to traditional household types.

Table 1: Escort decision by household structure

Escort Decision		**All Households**	**By Household Structure**			
Travel companion			Two parent	Father headed	Mother headed	Child or other household member headed
Parent(s)	Father & Mother	1.61%	2.16%	N/A	N/A	N/A
	Father	11.68%	13.08%	35.47%	0%	0%
	Mother	40.64%	43.10%	0%	43.76%	0%
Others	Sibling(s)	15.94%	14.78%	28.49%	16.53%	27.78%
	Other household member(s)	0.88%	0.21%	6.40%	1.94%	0%
	Non-household member(s)	6.37%	6.18%	4.65%	7.13%	22.22%
Independent	Self	22.88%	20.49%	25%	30.63%	50%
Total number of trips		3169	2362	172	617	18
Percentage		100%	74.53%	5.43%	19.47%	0.57%

3.2 Defining escort-mode (EM) choices

After linking transportation mode and removing trips with unknown travel companions and travel modes, the preliminary data set of households is reduced to 3,169 trips. Table 2 shows that walking is more frequently seen during trips undertaken alone or accompanied by siblings. When trips are escorted by parents, they are predominantly undertaken by car. Similar car dependence level is observed when trips are escorted or accompanied by other household members or non-household members. An interesting difference is found again between trips escorted by fathers and by mothers. It appears that women have continued their traditional role in childcare; the number of trips escorted by mothers is over three times as many as trips escorted by fathers. In addition, when the father escorts school trips, over 95% of the students are passengers and only 3% of them walk; whereas when the trips are escorted by mothers, more students walk (11.96%).

Table 2: Escort-mode decision analysis (row percentage in brackets)

Escort Type	Relationship		Travel companion	N	Walk	Bike	Drive	Passenger	Local/Express bus	School bus
Independent			Self	725 (100)	333 (45.93)	52 (7.17)	74 (10.21)		28 (3.86)	238 (32.83)
Dependent	With household member	Escorted by parent(s)	Father & Mother	51 (100)	4 (7.84)			47 (92.16)		
			Father	370 (100)	11 (2.97)	2 (0.54)	1 (0.27)	356 (96.22)		
			Mother	1,288 (100)	154 (11.96)	3 (0.23)	2 (0.16)	1,124 (87.27)	4 (0.31)	1 (0.08)
		Not escorted by parent	Sibling(s)	505 (100)	183 (36.24)	14 (2.77)	16 (3.17)	176 (34.85)	2 (0.40)	114 (22.57)
			Other household member(s)	28 (100)	6 (21.43)			21 (75.00)		1 (3.57)
	No household member		Non-household member(s)	202 (100)			8 (3.96)	193 (95.54)		1 (0.50)
Total				3,169 (100)	691 (21.80)	71 (2.24)	101 (3.19)	1,917 (60.47)	35 (1.10)	355 (11.20)

Note: The dominant transportation mode for each escort type is underlined.

Suppose for each transportation mode we have five escort decisions: travel alone, escorted by mom, escorted by dad, accompanied by siblings, escorted/accompanied by others. Meanwhile suppose we have five transportation modes (i.e., walking, biking, bus, driving, being driven), then this exhaustive set of escort-mode choices would contain a total of 25 (5 x 5 = 25) alternatives. It would be difficult to estimate for such a large of choice set with the given dataset because many alternatives account for a very low percentage of the total trips. To avoid the potential collinearity problem that may be introduced by a small number of observations for certain alternatives, it is necessary to redefine/reduce the alternatives.

For trips chauffeured by both fathers and mothers, given the traditional household relationship where men are more often the decision makers than women, the father is more likely to be the decision maker during these trips. Hence, for trips when both parents are present, these trips are considered similar to trips escorted by father and thus grouped together (EM1). Trips driven by the mother is the most frequent escort-mode alternative among the seven choices; hence it is chosen as the reference group (EM2). Trips chauffeured by others make up a significant proportion of the total trips and therefore are categorized as a separate choice (EM3). Walking or biking trips are only observed in three escort choices: either independent travel or with siblings or parents. In other words, active commuting is rarely accompanied by other household members or non-household members. Furthermore, walking or biking trips escorted by parents are infrequent. To ensure that the model converges in the estimation, walking/biking trips escorted by parents are combined with walking/biking trips escorted by siblings. Therefore, there are two alternatives for active commuting trips, either with a companion (EM4) or independently (EM5). Lastly, driving and busing trips are conducted predominantly alone or with minimal participation of parents. Therefore, under the categories of driving (EM6) and busing (EM7) there are no escorting decision differentiations.

Table 3 lists the seven escort-mode alternatives to be modeled for all general households and dual-earner households. Driven by mother (EM2) is the dominant escort-mode choice for all households (35.47%). It also dominates the escort-mode choice for two-parent households (37.47%) and mother – headed households (38.74%). In fact, students from two-parent families have shares of each escort-mode alternative similar to the shares observed in mother-headed households (except for the higher share of bus trips), suggesting mothers take up the main escort responsibility. By contrast, students from father-headed households are much more likely to be driven by the father and others. In households without parents, students are significantly more likely to be chauffeured by other household members, drive, or go to school by bus. This result is not unexpected; when the parent is not present in a household, the involvement of other caretakers or the independency of the student during school trips increases as a response. However, given the small number of observations in other-headed households, these trips will be removed from further analysis.

Table 3: Escort-mode choice alternatives, by household type

Mode	Escort Party	Escort-Mode Decision	Choice	All Households		Two-parent Households		Mother-headed Households		Father-headed Households		Other-headed Households	
				Obs.	Col. Pct	Obs.	Col. Pct	Obs.	Col. Pct	Obs.	Col. Pct	Obs.	Col. Pct
Passenger	Father & mother, or father only	Driven by both parents or by fathers only	**EM1**	403	12.72%	344	14.56%	0	0.00%	59	34.30%	0	0.00%
	Mother	Driven by mother only	**EM2**	1,124	35.47%	885	37.47%	239	38.74%	0	0.00%	0	0.00%
	Siblings, other household or non-household members	Driven by others	**EM3**	390	12.31%	246	10.41%	87	14.10%	48	27.91%	9	50.00%
Walk or bike	Parent, siblings, other household or non-household members	Active commuting with a companion	**EM4**	377	11.90%	294	12.45%	66	10.70%	17	9.88%	0	0.00%
	Self	Active commuting independently	**EM5**	385	12.15%	265	11.22%	96	15.56%	22	12.79%	2	11.11%
Drive	Any type	Drive	**EM6**	101	3.19%	72	3.05%	20	3.24%	6	3.49%	3	16.67%
School bus or local bus	Any type	Bus	**EM7**	389	12.28%	256	10.84%	109	17.67%	20	11.63%	4	22.22%
Total				3,169	100%	2,362	100%	617	100%	172	100%	18	100%

Note: The dominant escort mode for each household type is underlined.

4. Modeling and Results

4.1 MNL model

The escort and mode choice decisions can be assumed simultaneous and thus they can be considered as a joint choice decision (Yarlagadda and Srinivasan 2008). The escort-mode choice is estimated using the multinomial logit model (MNL). The multinomial logit regression fits the model by using the method of maximum likelihood estimation. Coefficient estimates on the probability of each of the outcomes compared to the reference group are reported. The utility accounts for factors that influence not only mode choice but also escorting decision. The utility function used in this analysis is the sum of the utility of individual *n* choosing option *i* to school:

$$U_{jn} = V_{jn} + \varepsilon_{jn} \tag{1}$$

$$V_{jn} = \alpha_j + \beta_j X_n \qquad \forall j \in C \tag{2}$$

$$\beta X = \beta_1 S + \beta_2 H + \beta_3 R + \beta_4 E + \beta_5 D \tag{3}$$

where

α is the alternative specific constant;
β is the vector of coefficients for the utilities;
ε is the disturbance term for individual *n*;
S is student's attributes (i.e., age, gender, ethnicity);
H is household variables (i.e., car ownership, income);
R is residential built environment variables (i.e., density, median house value, land use);
E is parents' employment status (i.e., work status, flexibility of work hours,); and
D is distance variables (i.e., distance from home to school, distance from school to the parents work place)

An individual will choose *j* if and only if

$$U_{jn} \geq U_{\ln} \qquad \forall j, l \in C \tag{4}$$

The probability that an individual chooses (*i*, *j*) is:

$$P_n(i,j) = \frac{\exp(V_{ij}^n)}{\sum_{(p,q)\in C} \exp(V_{pq}^n)} \tag{5}$$

As defined in the utility function, the explanatory variables are individual specific. The popularity of the alternatives is reflected by the constant α and the coefficient β. The reasons why there are no alternative attributes in the utility function are twofold. First, alternative attributes are not directly measured in the travel survey (i.e., travel cost); hence, any assumptions and the measures generated thereby can introduce errors in variables. The constant term α is in fact a function of the unmeasured alternative variables *Z*, which can be expressed as:

$$\alpha_j = \gamma Z_j$$

Therefore, α captures the sum information of the alternative attributes. Second, the focus of this research is on how attributes of the individual *n* (i.e., work arrangements, distance from the school) may affect their choice, rather than the attributes of the alternatives. As a matter of fact, the alternative attributes are often not included in escort and/or mode choice studies in school transportation (Yarlagadda and Srinivasan 2008, McMillan 2007, McDonald 2008a).

Also, it should be noted that, the escort-mode choice is a short-term choice conditional upon previous long-term choices such as home, work, and school location. These prior decisions and the resulting relatively fixed location of home, work, and school is indeed the reason why spatial coordination of parents and children needs to be included in the escort-mode choice decision.

4.2 Selection of Variables

The main contribution of this research is to consider both parent's time and space constraints related to children's school trip. These constraints are reflected in the parents' employment and distance variables, also defined as the temporal and spatial intra-household coordination, respectively. Other factors that influence the escort and mode choice decision are also included in the model. Overall, the explanatory variables entered the model can be grouped into five categories: student's individual attributes (S), household characteristics (H), neighborhood build environment (R), parents' employment status (E) and distance variables (D) (Equation 3). Definitions of these variables are listed in Table 4.

Table 4: Definition of variables

Intra-household Coordination	Category	Variable	Definition/Value
N/A	Student traveler's personal attributes (S)	Age	Age of the student
		Female	1 if the student is female, 0 otherwise
	Household attributes (H)	Number of siblings	Number of siblings of the student
		Total vehicle	Total number of vehicle in the household
		Household income	Low income (less than $35,000); middle income ($35,000-$75,000); high income (over $75,000)
		Ethnicity	White/Not Hispanic; Hispanic; African American; Asian/Pacific Islander; Other
	Residential neighborhood built environment (R)	Population density	Population density per square mile of the census tract
		Median house value ($)	Median house value of the census tract
		Land use	Single family residential; multi-family residential; other land use
Temporal	Parent employment status and work arrangement (E)	Father employment status	Full time; part time; unemployed
		Father's work hours	Total number of hours worked per week at main job (answered if employed)
		Father with Flexitime	Work hours not fixed (answered if employed)
		Mother employment status	Full time; part time; unemployed (answered if employed)
		Mother's work hours	Total number of hours worked per week at main job (answered if employed)
		Mother with Flexitime	Work hours not fixed
Spatial	Distance derived from the location information of home, school, and the parent's workplace (D)	Home-School	Distance from home to school
		Home-Father's job	Distance from home to father's workplace
		Home-Mother's job	Distance from home to mother's workplace
		School-Father's job	Distance from school to father's workplace
		School-Mother's job	Distance from school to mother's workplace

The two most interesting explanatory factors in this study are parent employment status and work arrangement (Vovsha and Peterson 2005, Yarlagadda and Srinivasan 2008, McDonald 2008a) and the proximity of the parent's workplace to school. These factors are proxy for intra-household temporal and spatial coordination. The total number of work hours is expected to lower the probability of escorted trips by the parent, while the option of flexible hours may counteract the negative impact of long work hours. Likewise, the distance between work place and school is an impedance to joint trip. Although the distance between home and school has been shown to be influential in mode choice decisions, the distance

involving the workplace is rarely considered. It should be noted that childcare is traditionally considered the mother's responsibility in a household. Thus, even though both fathers' and mothers' work status and location are estimated, the results of the mother may be more intuitive since the mother is usually the caretaker and her work-related variable is expected to have a more direct impact on the escort-mode decisions. The descriptive summary of the explanatory variables is shown in Table 5.

The control variables are selected for the following reasons. Children's independent travel is associated with their demographic and the family's socioeconomic status. Age is a critical factor as younger children are more likely to be escorted to school (Vovsha and Peterson 2005, Yarlagadda and Srinivasan 2008), which is probably due to personal and traffic safety concerns. Additionally, older students have a stronger desire for and a higher chance of being granted the freedom to travel independently. The age effect can be prevalent across all transportation modes such as walking, biking, driving, and take the bus (Yarlagadda and Srinivasan 2008). As for the gender variable, it can affect travel independence as well (Vovsha and Peterson 2005, Yarlagadda and Srinivasan 2008). Parents are likely to be more concerned about personal safety for female than male children. Thus female students are less often allowed to travel outside the parent's guardianship, not to mention travel alone.

The reasons for selecting household characteristics (i.e., the number of siblings, car availability, household income, and ethnicity) are as follows. Children with siblings are usually more likely to travel and conduct activities with their siblings, including going to school. It is also likely that having more siblings will increase children's active commuting (McDonald 2008a). The number of private vehicles is likely to reduce the propensity of using alternative transportation modes (McMillan 2005). Both income (Vovsha and Peterson 2005) and ethnicity (Yarlagadda and Srinivasan 2008) categories are shown to affect escort-mode choices. In terms of mode choice decisions, high income households have higher mobility and thus can travel farther; hence, they are expected to have a higher percentage of auto trips and lower percentage of non-motorized trips. In other words, high income groups (i.e., over $75,000, accounting for 28% in the final sample) are expected to chauffeur or drive alone more often whereas low income group (i.e., below $35,000, accounting for 37% in the final sample) are more likely to walk or bike or take bus (He 2011). In terms of ethnicity, a higher rate of Hispanic students' active commuting has been observed nationwide (McDonald 2008a). Given the large number of Hispanics in the Southern California region, it will not be surprising to observe a distinctively different travel behavior pattern when compared to Whites. In fact, it has been documented that Hispanics are more likely to take bus or commute on foot or bike to school (He 2011).

As another control variable, built environment is a component in which urban planners have a keen interest. The neighborhood level built environment is indicated by population density, the median house value of the census tract, and land use of the residential area (McDonald 2008a, He 2011, Mackett et al. 2007, Yarlagadda and Srinivasan 2008). There has been a number of empirical studies have shown the positive effects of residential density on active commuting (McDonald 2008a, He 2011). A higher population density is likely to be associated with more activity opportunities and street mutual monitoring, thus creating more livable and safer neighborhoods, which may facilitate children's independent travel. The relationship between density and children's active commuting, however, is still under debate and requires further examination. In addition, the variables of median house values and land use are used to proximate various neighborhood amenities and walkability that affect children's independent travel.

Table 5: Descriptive statistics, by household structures

	All households (N=3151)		Two-parent households				Mother-headed households (N= 617)		Father-headed households (N=172)	
			Dual-earner households (N= 1320)		Non Dual-earner households (N= 1042)					
Continuous variable	**Mean**	**Std**	**Mean**	**Std**	**Mean**	**Std**	**Mean**	**Std**	**Mean**	**Std**
Discrete variable	**Percent**		**Percent**		**Percent**		**Percent**		**Percent**	
Demographics										
Age	10.700	3.597	10.948	3.603	10.252	3.578	10.781	3.581	11.209	3.471
Female	46.68%		45.63%		47.22%		48.20%		45.93%	
Household Structure										
Number of siblings	1.471	1.113	1.341	.960	1.722	1.158	1.418	1.263	1.140	1.078
Car Availability										
Total vehicle	1.974	1.016	2.336	.892	1.900	.974	1.368	1.011	1.820	1.007
Income Category										
Low income (<35k)	36.81%		18.20%		46.88%		60.83%		34.39%	
Middle income (35k-75k)	35.57%		41.99%		30.47%		27.90%		43.95%	
High income (>=75k)	27.62%		39.81%		22.65%		11.27%		21.65%	
Ethnicity										
White/Not Hispanic	45.42%		55.49%		40.00%		32.04%		42.42%	
Hispanic	39.34%		29.91%		49.37%		43.50%		36.36%	
African American	6.89%		4.79%		3.51%		17.48%		12.12%	
Asian/Pacific Islander	3.36%		4.63%		2.34%		2.52%		2.27%	
Other	4.99%		5.18%		4.78%		4.47%		6.82%	
Neighborhood BE										
Population density	8159.273	8387.814	7213.962	7453.887	8364.926	9083.438	9995.221	9115.964	7582.175	6793.919
Median house value ($)	193857.5	119298.8	206543.9	121120.8	192391.3	124572.6	171261.1	103770.5	186436.6	112241.5
Single-family residential	59.19%		65.68%		57.20%		49.59%		55.81%	
Multi-family residential	11.81%		9.62%		11.52%		15.88%		15.70%	
Other land use	29.01%		24.70%		31.29%		34.52%		28.49%	
Parents Employment										
Father worked FT	89.84%		96.23%		83.09%		--		81.05%	
Father worked PT	3.67%		3.77%		3.30%		--		5.50%	
Father unemployed	6.49%		0%		13.61%		--		13.45%	
Father's work hours[a]	44.93	11.049	45.158	11.063	44.796	10.965	--		43.336	11.509
Father with Flexitime[b]	40.49%		41.89%		47.04%		--		35.14%	
Mother worked FT	47.02%		73.79%		7.83%		55.74%		--	
Mother worked PT	14.66%		26.21%		2.19%		10.45%		--	
Mother unemployed	38.32%		0%		89.98%		34.21%		--	
Mother's work hours[a]	35.823	13.341	35.175	13.783	36.430	11.452	38.046	11.883	--	

Mother with Flexitime[b]	36.16%		36.36%	63.64%	33.01%		36.32%		--	
Distance (mile)										
Home-School	2.663	7.507	2.900	6.900	2.644	9.947	2.185	3.671	2.700	4.156
Home-Father's job	13.081	19.927	13.316	17.781	13.112	23.391	--	--	10.799	15.965
Home-Mother's job	7.849	10.490	7.677	9.809	9.465	14.439	8.010	11.432	--	--
School-Father's job	13.586	20.404	13.675	18.183	13.867	24.046	--	--	11.067	15.252
School-Mother's job	8.010	10.667	7.754	9.976	9.922	14.399	8.357	11.656	--	--

Note: a. Work hours is available for employed father or mother only. b. Percent of father or mother with Flexitime is available for employed father or mother only.

4.3 Results from MNL model

Seven escort-mode choices (defined earlier in Table 3) form the choice set. Mother's escorted trip by car is chosen as the reference choice due to its highest frequency in the observations. As the main variables in this research, the variables that measure the intra-household temporal synchronization and spatial coordination have a significant impact on the escort-mode decisions. It should be noted that some employment and location information (i.e., work hours, access to flexible work hours, workplace location) is only available for employed parents. Therefore, only *dual-earner* households have adequate information to estimate the full model, in which the hypothesized relationship of intra-household temporal and spatial coordination can be fully tested and presented. Employment status is dropped in the full model because there are no unemployed parents and inadequate observations of part-time fathers in this subset of sample. However, the inclusion of the total number of work hours can to some extent account for the parent's employment status since full-time workers normally work longer hours than part-time workers. The estimation results are summarized in Table 6.

With respect to temporal variables, parents exhibit time wise synchronization in their escort-mode choice decisions. Both work hours and the option of flexible time affect considerably on the probability of a student's escort-mode choice, compared to the referenced choice (i.e., chauffeured by the mother). The results confirm the temporal effects: working longer work hours reduces the parent's chauffeuring activities whereas working with flexible work schedules allows a better childcare as reflected through an increase in the chauffeuring trips. The observations are twofold. First, when the mother works with flexible hours, the student has a lower probability of being chauffeured by others; when the father works with this option, the student is more likely to be chauffeured by the father. This finding suggests that the flexible hour program improves the parent's childcare option. Second, the mother's longer work hours increase several alternative mode choices: children are more likely to commute actively, drive, or take the bus. This outcome suggests the mother's escort responsibility is shifted to other household members or the children themselves when their participation in the labor market increases.

The spatial dimension of the intra-household coordination is reflected through estimates of the distance variables. The distance from home to school, as previous studies have shown (Waygood and Kitamura 2009, McDonald 2008b, He 2011), considerably reduces the likelihood of walking or biking trips over escorted trips. The distance between school and parent's work place, has highly significant effects on escort-mode choice decisions as well. The farther away the parent works from school, the less likely it is that they will drive their children to school. In addition, when the mother works farther from and/or the father works closer to the school, the children are more likely to be chauffeured by the father than by the mother, indicating an intra-household sharing of childcare responsibility. Moreover, when the distance between mother's work place and school increases, children are more likely to walk to school alone. These findings along the spatial axis suggest that the parent-child joint trip can be made easier if the child attend a school closer to the parent's workplace. This decision may facilitate the escorting trip and childcare outside school hours but at the same time may cause a longer travel distance for the child should he/she forgoes the neighborhood school.

Among the explanatory variables, demographic variables have strong effects across all the three household types. Age in general has a positive effect on the likelihood of most alternatives. Older students have a higher probability of being chauffeured by others, commuting actively alone, driving, and taking the bus. This variable estimate reflects that, as the children get older, they gain more independence from their parents. In addition, the age variable has an economically large effect on student's driving, reflected by its large coefficient. When it comes to gender, this variable has a relatively weak effect, although previous findings suggested that female students tend to be less likely to conduct their journeys on foot or by bicycle than males (Black et al. 2001, He 2011, Sirard and Slater 2008, Timperio et al. 2004).

Regarding the household structure variables, the number of siblings increases non-motorized joint trips with parents and reduces independent trips: students with more siblings are more likely to walk or to bike to school with the parent/siblings and less likely to commute actively alone. This result is in alignment with a previous study (McDonald 2008a), which shows that having siblings is associated with a higher likelihood of non-motorized travel for high school students. Because many siblings attend the same school, the sibling(s) are likely to be the travel companion(s), reducing the perceived duration and safety concerns associated with walking and biking trips.

Car availability is often considered to be influential on mode choice (McMillan 2005, He 2011). The outcomes here show that the number of vehicles reduces active commute regardless whether the trips are undertaken with a companion or alone[1]. Vehicle availability also contributes to a student's driving because easy access to cars can considerably reduce the relative attractiveness of alternative modes. Income has a strong impact on alternative transportation mode choices. Students from low income households have a greater tendency to take the bus and/or to walk or bike. Ethnicity effect is found to be insignificant, although an earlier study suggested that students from the ethnic minority groups have a higher probability of taking the bus or commuting actively than Whites (He 2011).

The last control variables are the neighborhood built environment variables. Population density is shown to have a positive effect on a student's commute on foot or by bike. The result echoes previous tests with respect to the effect of density on active commuting (McDonald 2008a, He 2011). A higher density is likely to be associated with shorter trip distances and hence a lower likelihood of driving or taking the bus. The median house value is used to proximate neighborhood amenities. It is expected that families from wealthy neighborhoods may have a high car ownership and thus an infrequent use of public transit. However, this variable has an insignificant impact in most models. As for the land use variables, children living in residential areas of other land use types are more likely to take the bus, compared to those from single family residential area.

[1] The impact on alone walking or biking trips is in fact only marginally significant as the p value is 0.101; hence, no * is indicated next to this estimate in Table 6.

Table 6: Estimation results for dual-earner households (Reference group: driven by mother, EM2)

Mode Choice	**Passenger**				**Walk or Bike**				**Drive**		**Bus**	
Escort Choice	**Both or Father (EM1)**		**Others (EM3)**		**Parents or Siblings (EM4)**		**Alone (EM5)**		**Any (EM6)**		**Any (EM7)**	
	Coef	Std Err	Coef	Std Err	Coef	Std Err	Coef	Std Err	Coef	Std Err	Coef	Std Err
Constant	-.821	.769	-4.988***	.880	-1.775	1.159	-4.534***	.959	-45.582***	8.110	-4.622***	.982
Demographics												
Age	.013	.032	.162***	.036	-.018	.050	.247***	.039	2.362***	.433	.187***	.039
Female	-.001	.205	.147	.229	-.407	.296	-.213	.248	.892	.546	-.158	.252
Household Structure												
Number of siblings	-.203*	.121	-.043	.129	.619***	.165	-.338**	.144	-.379	.313	.112	.144
Car Availability												
Total vehicle	-.114	.133	.230	.140	-.906***	.246	-.279	.171	1.177***	.311	-.182	.160
Income Category												
Low income	.108	.372	1.317***	.398	.996*	.521	1.445***	.434	.909	1.445	1.449***	.431
Middle income	-.077	.238	-.059	.277	.800**	.401	.644**	.299	.184	.589	.652**	.318
Ethnicity												
Hispanic	.135	.273	.133	.312	.152	.374	-.346	.341	.204	.741	.273	.324
Non White nor Hispanic	-.285	.316	-.377	.363	-.276	.460	.020	.337	-.488	.974	.126	.385
Neighborhood BE												
Population density	.004	.017	-.004	.022	.024	.020	.034*	.017	-.064	.065	-.040*	.023
Median house value	.000	.001	.002**	.001	.002	.002	.000	.001	.000	.002	.000	.001
Multi-family residential	.481	.371	.027	.480	.224	.481	.569	.406	1.100	1.048	.418	.488
Other land use	.210	.256	-.230	.306	.394	.377	-.085	.325	-.803	.793	.844***	.286
Parents Employment												
Father's work hours	-.010	.008	.011	.009	-.014	.012	.006	.010	.047*	.025	-.012	.011
Father with flexitime	.373*	.210	-.368	.247	.271	.297	-.320	.262	-1.078*	.616	-.090	.262
Mother's work hours	.010	.007	.006	.008	.026***	.008	.023***	.008	.033*	.020	.025***	.008
Mother with flexitime	-.019	.213	-.733***	.262	-.103	.317	-.154	.262	-.313	.561	.301	.261
Distance												
Home-School	-.048	.030	-.012	.021	-.589***	.163	-.201***	.071	-.143	.115	.041**	.021
School-Father's job	-.025***	.010	.010*	.006	.015**	.006	-.022*	.012	.015	.013	-.004	.008
School-Mother's job	.053***	.013	.050***	.013	.019	.020	.068***	.015	.040	.037	.029*	.015
SUMMARY STATISTICS	N=933											
Log likelihood							Pseudo R^2			0.1935		
Null model	-1590.3718						LR Chi^2			615.50		
Full model	-1282.6226						p			0.0000		

Note: *** indicates significance at 99% level, ** indicates significance at 95% level, * indicates significance at 90% level.

5. Hierarchical Structure of Escort and Mode decisions

Whilst the MNL model assumes that the error terms are irrelevant independent distributed (IID) (McFadden, 1978), this assumption will be relaxed in the nested structure of the alternative. A nested logit (NL) model will be estimated with escort decision at the first level and mode choice decision at the second (lower) level (Figure 2). The escort choices consist of independent and accompanied, and the mode choices consist of private vehicle, active commuting (i.e., walk or bike), and bus. The mode choice of private vehicle is termed differently under the two escort decisions, as driver and passenger respectively, to reverberate the different degrees of travel independence. Please note that alternative 1 refers to the student drove to school either independently or with passengers. In either case, being able to drive sends a strong signal that the individual has independent mobility. If this nested structure is supported by the model, the close relationship between escort and mode choice decisions will be again confirmed. Furthermore, the effect of parental work arrangement and location on escort choice can be directly presented.

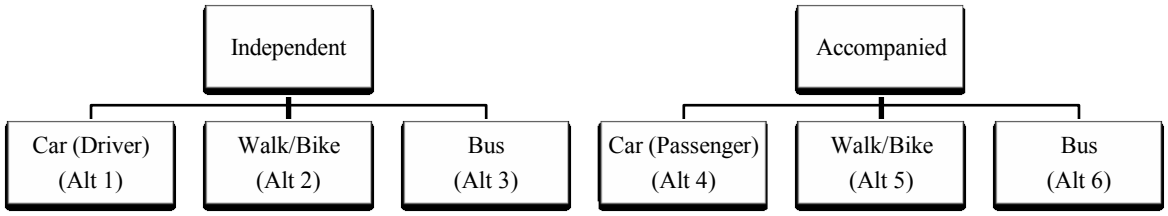


Figure 2: Escort and mode choice alternatives in a hierarchical structure

At the escort decision level, both age and the number of siblings have a very strong influence in a child's independent travel (Table 7). Older children and fewer siblings encourage independent mobility. Mother's employment arrangement and distance between workplace and school also turn out to have significant impact on the joint trip decision. Longer work hours and being farther away from the child's school location reduce the likelihood of escort trips. Unlike the results from the MNL estimation, the option of flexitime shows no significant effect on escort decision. In the MNL model, father working with flexitime is more likely to escort the child and mother with this option reduces escort trips by others, compared to the reference group (i.e., escorted by the mother). In either case, the flexitime option does not encourage independent travel, which is actually consistent with the implications from the NL model. In other words, the result from the NL reflects intra-household coordination of childcare, in which the inflexibility of mother's work schedule is translated to father's more frequent escort trip. Such childcare sharing responsibility within the household does not lead to the child's higher chance of travel independently.

At the mode choice level, the travel mode is shown to be affected by car availability, household income, population density, land use, and distance from home to school. Interestingly, the degree of impacts on travel modes differs following different escort decisions. For instance, household income plays an important role: children from low and middle income households are more likely to walk or bike independently compared to those being the passenger. However, for children walking or biking with a companion, the income factor does not seem to be significant compared to the passenger group. Another example is the density variable. While density has been argued to be crucial for facilitating active communing, the outcome here shows that density

is crucial in encouraging unsupervised travel. When it comes to escorted trips, density may not remain the same level of importance.

The differentiation of the impact of potential factors on mode choice depending on the escort choice is rarely revealed in the current school transportation literature because mode choice has been the main and sole focus. The results from the hierarchical model estimation again confirm that the escort and mode choice decisions are highly related. Both parental employment and distance variables are critical in determining whether the child will travel under supervision or independently. The influence of the spatial and temporal constraints of parental employment as well as other variables in the escort equation is carried down to the alternative equation where more variables significantly affect mode choice for independent travel than for accompanied travel.

Table 7: Estimation results for dual-earner households (Reference group: Level 1: Independent; Level 2: Passenger, Alternative 4)

Escort Choice	**Independent**		**Accompanied**	
ESCORT EQUATION	Coef	Std Err	Coef	Std Err
Demographics				
Age			-.264***	.029
Female			.107	.183
Household Structure				
Number of siblings			.468***	.110
Neighborhood BE				
Median house value			-.000	.001
Parents Employment				
Father's work hours			-.006	.007
Father with flexitime			.241	.193
Mother's work hours			-.015**	.006
Mother with flexitime			-.056	.193
Distance				
School-Father's job			.004	.006
School-Mother's job			-.020*	.010

Mode Choice	**Car (Driver)**		**Walk/Bike**		**Bus**		**Car (Passenger)**		**Walk/Bike**		**Bus**	
Alternative	**Alt 1**		**Alt 2**		**Alt 3**		**Alt 4**		**Alt 5**		**Alt 6**	
ALTERNATIVE EQUATION	Coef	Std err	Coef	Std err	Coef	Std err	Coef	Std err	Coef	Std err	Coef	Std err
Constant	-14.849***	3.768	-7.132***	2.089	-9.680***	2.618			-2.356	2.934	-6.704	6.073
Car Availability												
Total vehicle	2.227***	.656	-.727*	.418	-1.265**	.599			-2.369*	1.384	-1.541	1.189
Income Category												
Low income	-9.492	6.479	3.128**	1.287	2.796**	1.150			2.361	1.982	3.187	2.895
Middle income	-3.943*	2.020	2.340**	.947	1.824*	.960			2.238	1.607	1.849	2.062
Ethnicity												
Hispanic	1.682	1.146	-.630	.709	.287	.850			.501	.960	1.219	1.766
Non White nor Hispanic	-.492	1.507	.919	.798	-.629	1.305			-.031	1.219	.563	2.102
Neighborhood BE												
Population density	-.197	.132	.110*	.065	-.042	.059			.125	.109	-.265	.207
Multi-family residential	1.244	1.577	.163	.969	.625	1.999			.065	1.193	1.024	2.641
Other land use	-3.566**	1.638	-1.569	1.327	4.019**	1.705			.882	1.211	1.895	1.996
Distance												
Home-School	-.0282	.081	-.568**	.234	.168***	.059			-1.627*	.938	-.569	.586
SUMMARY STATISTICS	N=933											
Dissimilarity Parameters (tau)		Est.		Std Err								
Level 1		4.9202		1.9489								
Level 2		3.0332		2.0712								

LR test for IIA (tau = 1):	Chi^2 (2) = 9.38	p= 0.0092				
Log likelihood						
Null model	-1047.6236					
Full model	-863.3664					
Pseudo R^2	0.1759					

Note: *** indicates significance at 99% level, ** indicates significance at 95% level, * indicates significance at 90% level.

6. Conclusion

Compared to the studies on adults' activity-travel patterns, "the activity-travel field is in its infancy in its understanding of children-adult activity-travel and decision-making interactions" (Paleti et al. 2011, p. 277). That said, more empirics are needed for a better understanding of the parents-children joint trip. School trips of K-12 students perhaps are the most representative joint trips between parents and children since they are mandatory trips where the majority of them (e.g., over 50 percent as shown in Table 2) are escorted by the parent. The research on joint-trip decision accounting for temporal and spatial coordination is especially needed because women's increasing participation in the work force may cause scheduling constraints for escorted trips and consequentially lead to changes in children's travel mode. In this paper, joint escort-mode choice of journeys to school is modeled for K-12 students in the Los Angeles region. This paper reveals a strong effect of parental, especially women's work arrangements and location on children's travel behavior.

The main interesting variables fall into two categories: the parent employment status and the job location in relation to the school location. The results show that the parent's longer work hours increase the likelihood of the alternative modes such as active commuting, driving, and busing. It also implies that the effect of work hours on escort-mode choice may be offset by the option of flexible work hours, which reduces the probability that a trip is escorted by others. In addition, the closer is the mother's workplace relative to the school, the more likely that the mother will chauffeur their students to school. As this distance measure goes up, the school trip is more likely to be escorted by the father or others, and more likely to be undertaken by active commuting, or by bus. To make the parental escorting trip possible and childcare before/after school hours more manageable, a short distance between the parent's workplace and the school is important, especially in dual-earner household. When the parent chooses a school closer to his/her workplace instead of the neighborhood school, the child's travel distance is likely to increase and the child is more likely to be escorted in car. Since most escorting trips are carried out by the mother, the distance between the mother's workplace and the school influences more on the escort decision than the father's. This situation would be very different if the mother is a (full-time) housewife. Because the housewife stays at home, she would prefer the child to attend the neighborhood school so that the distance between the mother and the child can be minimized. Such a short distance from home to school would facilitate the non-motorized travel modes. However, women's increasing participation in the labor market makes their role as the housewife less relevant.

The results of this research are also useful for us to understand the working mother's dual responsibilities. Traditionally mothers undertake more childcare responsibilities and undertake more chauffeuring trips than men. Nowadays working mothers devote more time to their career. Their longer work hours and farther work location away from home and/or school would inevitably change the child's means of travel to school. This dual role in the labor market and in the family may cause considerable amount of stress for working mothers (Staines and Pleck 1983) because childcare responsibility in a household is still primarily remained on the mother's shoulder (Peterson and Gerson 1992, Ozer 1995, Scarr 1996). From within the household, the contribution from the father over the years is increasing (Peterson and Gerson 1992), and the help from the spouse for childcare has been a robust predictor of the mother's psychological well-being and distress (Ozer 1995). From the society's perspective, certain labor policies and programs have been created to address this issue. For example, in Nordic countries, family-friendly government policies grant mothers paid maternity and parental leaves, child allowances and part-time work (Scarr 1998). However, these types of policies have their own disadvantages as it may cause women's loss of experience and discontinuity in the labor force (Cherlin 1992). In comparison, there are more working women in the United States. The continuous work experience in most cases is a condition to "career advancement, higher incomes, retirement benefits, and other markers of gender equality" (Scarr

1998, p. 100). More importantly, women's labor force participation can lead to "higher family income, greater personal satisfaction, and more social support" (Scarr 1998, p. 100).

Conflict and stress can arise when women need to carry dual responsibility. To address this issue, government and private employers can create more family friendly policies and programs to improvement the family-work balance and help reduce workers' stress induced by fixed work hours and job location. Since the option of flexible time and proximity of the mother's workplace to school increases the likelihood of mother-children joint school trips, programs (e.g., Flexitime, school choice policy) that can relax the mother's temporal and spatial constraints may improve the mother's childcare option.

The outcomes of this paper help us better understand children's travel behavior in journeys to school. School trips escorted by the mother (or the father) do not necessarily lead to a better active commuting outcome; rather, these trips are likely to be motorized trips. This change stems from the changing societal roles of women, leading to fewer full-time mothers who would devote their time to walk or bike to school with their children. Therefore, children's journeys to schools are frequently embedded in commute trips, which are likely to be undertaken by car.

References

Angel R.D., Caudle W.L., Noonan R., and Whinston A. 1972, Computer-assisted school bus scheduling. *Management Science*, 18, B279-B288.

Babey S.H., Hastert T.A., Huang W., and Brown E.R. 2009, Sociodemographic, family, and environmental factors associated with active commuting to school among US adolescents. *Journal of Public Health Policy*, 30, 203-220.

Black C., Collins A., and Snell M. 2001, Encouraging walking: The case of journey-to-school trips in compact urban areas. *Urban Studies*, 38, 1121-1141.

Bradley M. and Vovsha P. 2005, A model for joint choice of daily activity pattern types of household members. *Transportation*, 32, 545-571.

Bradshaw R. 1995, Why do parents drive their children to school?. *Traffic Engineering and Control*, 36, 16-19.

Bureau of Labor Statistics 2005, *Workers on Flexible and Shift Schedules in 2004 Summary*. http://www.bls.gov/news.release/flex.nr0.htm. Last accessed June 23, 2011.

Cherlin A. 1992, Infant care and full-time employment. In A. Booth (ed.), *Child Care in the 1990s: Trends and Consequences*, pp. 209-214. Hillsdale, NJ: Erlbaum.

Combs S. 2010, Analysis of Alternative work schedules, Texas Comptroller of Public Accounts. http://www.window.state.tx.us/specialrpt/altschedule/Alternative_Wrk_Sched.pdf. Last accessed June 23, 2011.

Davison K.K., Werder J.L., and Lawson C.T. 2008, Children's active commuting to school: Current knowledge and future directions. *Preventing Chronic Disease*, 5, 1-11.

DiGuiseppi C., Roberts I., Li L., and Allen D. 1998, Determinants of car travel on daily journeys to schools: Cross sectional survey of primary school children. *British Medical Journal*, 316, 1426-1428.

Ewing R., Schroeer W., and Greene W. 2004, School location and student travel: Analysis of factors affecting mode choice. *Transportation Research Record: Journal of the Transportation Research Board*, 1895, 55-63.

Fast J.E. and Frederick J.A. 1996, Working arrangements and time stress. *Canadian Social Trends*, Winter, 14-19.

Golden L. 2001, Flexible work schedules: what are we trading off to get them?. *Monthly Labor Review*, 124, 50-67.

Hägerstrand T. 1970, What about people in regional science?. *Papers of the Regional Science Association*, 24, 7-21.

He S. 2011, The effect of school quality and residential environment on mode choice of school trips. *Transportation Research Record: Journal of the Transportation Research Board*, 2213, 96-104.

Marchetti C. 1994, Anthropological invariants in travel behavior. *Technological Forecasting and Social Change*, 47, 75-88.

McDonald N.C. 2008a, Household interactions and children's school travel: The effect of parental work patterns on walking and biking to school. *Journal of Transport Geography*, 16, 324-331.

McDonald N.C. 2008b, Children's mode choice for the school trips: The role of distance and school location in walking to school. *Transportation*, 35, 23-35.

McMillan T.E. 2005, Urban form and a child's trip to school: The current literature and a framework for future research. *Journal of Planning Literature*, 19, 440-456.

McMillan T.E. 2007, The relative influence of urban form on a child's travel mode to distance. *Transportation Research Part A*, 41, 69-79.

Müller S., Tscharaktschiew S., and Haase K. 2008, Travel-to-school mode choice modeling and patterns of school choice in urban areas. *Journal of Transport Geography*, 16, 342-357.

NHTS Brief 2008, *Travel to school: The distance factor*. Available at < http://nhts.ornl.gov/briefs/Travel%20To%20School.pdf>

Ozer E.M. 1995, The impact of childcare responsibility and self-efficacy on the psychological health of professional working mothers. *Psychology of Women Quarterly*, 19, 315-335.
Paleti R., Copperman R.B., and Bhat C.R. 2011, An empirical analysis of children's after school out-of-home activity-location engagement patterns and time allocation. *Transportation*, 38, 273-303.
Peterson R.R. and Gerson K. 1992, Determinants of responsibility for child care arrangements among dual-earner couples. *Journal of Marriage and Family*, 54, 527-536.
Pierce J.L. and Newstrom J.W. 1980, Toward a conceptual clarification of employee responses to flexible working hours: A work adjustment approach. *Journal of Management*, 6, 117-134.
Pred A. 1977, The choreography of existence: comments on hagerstrand's time-geography and its usefulness. *Economic Geography*, 53, 207-221.
Scarr S. 1996, Family policy dilemmas in contemporary nation-states: Are women benefited by family-friendly governments? In S. Gustavsson & L. Lewin (eds.), *The Future of The National State: Essays on Cultural Pluralism and Political Integration*, pp. 107-129. London: Routledge.
Scarr S. 1998, American child care today. *American Psychologist*, 53, 95-108.
Schlossberg M., Greene J., Phillips P.P., Johnson B., and Parker B. 2006, School trips: Effects of urban form and distance on travel mode. *Journal of the American Planning Association*, 72, 337-346.
Scott D.M. and He S.Y. 2012, Modeling constrained destination choice for shopping: a GIS-based, time-geographic approach, *Journal of Transport Geography*, 23, 60-71.
Tausig M. and Fenwick R. 2001, Unbinding time: Alternative work schedules and work-life balance. *Journal of Family and Economic Issues*, 22, 101-119.
Timperio A., Crawford D., Telford A., and Salmon J. 2004, Perceptions about the local neighborhood and walking and cycling among children. *Preventive Medicine*, 38, 39-47.
Tudor-Locke C., Ainsworth B.E., and Popkin B.M. 2001, Active commute to school: An overlooked source of childrens' physical activity. *Sports Medicine*, 31, 309-313.
Vovsha P., Peterson E., and Donnelly R. 2004, Impact of intrahousehold interactions on individual daily activity-travel patterns. *Transportation Research Record: Journal of the Transportation Research Board*, 1898, 87–97.
Vovsha P. and Peterson E. 2005, Escorting children to school: Statistical analysis and applied modeling approach. *Transportation Research Record: Journal of the Transportation Research Board*, 1921, 131-140.
Waygood E.O.D. and Kitamura R. 2009, Children in a rail-based developed area of Japan: Travel patterns, independence, and exercise. *Transportation Research Record: Journal of the Transportation Research Board*, 2125, 36-43.
Wilson E.J., Marshall J., Wilson R., and Krizek K.J. 2010, By foot, bus or car: Children's school travel and school choice policy. *Environment and Planning A*, 42, 2168-2185.
Yarlagadda A.K. and Srinivasan S. 2008, Modeling children's school travel mode and parental escort decisions. *Transportation*, 35, 201-218.
Zhu X. and Lee C. 2008, Walkability and safety around elementary schools: Economic and ethnic disparities. *American Journal of Preventive Medicine*, 34, 282-290.