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16. Abstract

This report provides a comprehensive review of previous research on children's activity engagement and travel by focusing on the dimensions characterizing children's activity-travel patterns and the factors affecting these dimensions. In addition, an empirical analysis is undertaken of the post-school out-of-home activity-location engagement patterns of children aged 5 to 17 years. Specifically, this research effort utilizes a multinomial logit model to analyze children's post-school location patterns, and employs a multiple discrete-continuous extreme value (MDCEV) model to study the propensity of children to participate in, and allocate time to, multiple activity episode purpose-location types during the after-school period. Finally, the paper identifies the need and opportunities for further research in the field of children's travel behavior analysis.

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A COMPREHENSIVE ASSESSMENT OF CHILDREN'S ACTIVITY-TRAVEL PATTERNS

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ABSTRACT

Children are an often overlooked and understudied population group, whose travel needs are responsible for a significant number of trips made by a household. In addition, children's travel and activity participation have direct implication for adults' activity-travel patterns. A better understanding of children's activity-travel patterns and the linkages between parents and children's activity-travel needs is necessary for accurate prediction and forecasting of activity-based travel demand modeling systems. In contrast to the need to examine and model children's activity-travel patterns, existing activity-based research and modeling systems have almost exclusively focused their attention on the activity-travel patterns of adults. Therefore, the goal of this research effort is to contribute to the area of activity-based travel demand analysis by comprehensively examining children's activity-travel patterns.

This report provides a comprehensive review of previous research on children's activity engagement and travel by focusing on the dimensions characterizing children's activity-travel patterns and the factors affecting these dimensions. In addition, an empirical analysis is undertaken of the post-school out-of-home activity-location engagement patterns of children aged 5 to 17 years. Specifically, this research effort utilizes a multinomial logit model to analyze children's post-school location patterns, and employs a multiple discrete-continuous extreme value (MDCEV) model to study the propensity of children to participate in, and allocate time to, multiple activity episode purpose-location types during the after-school period. Finally, the paper identifies the need and opportunities for further research in the field of children's travel behavior analysis.

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EXECUTIVE SUMMARY

This report begins by assessing the state-of-the-research on children's activity-travel patterns. The first part of the assessment provides a comprehensive review of previous research on children's activity engagement and travel by focusing on the dimensions characterizing children's activity-travel patterns, including the (1) decision to participate in an activity (generation dimension), (2) activity participation duration and time of day of participation (temporal dimension), (3) activity episode location (spatial dimension), (4) episode sequencing, (5) mode, duration/distance of travel to episodes, and activity and location chaining (travel dimension), and (6) accompanying individuals (with-whom dimension). The second part of the assessment identifies the factors that shape and influence the dimensions of children's activity-travel patterns. The study develops a conceptual framework of the factors affecting children's activity-travel patterns and presents a review of previous research on each factor. These factors may be grouped into four categories: the demographics of the child and the child's social contacts (including household and non-household members), the attitudes of the child and his/her social contacts, the activity-travel patterns of the child's social contacts, and the child's environment.

In addition, data from the 2002 Child Development Supplement (CDS) of the Panel Study of Income Dynamics (PSID) is used to undertake a comprehensive assessment of the post-school out-of-home activity-location engagement patterns of school-aged children. Specifically, this research effort utilizes a multinomial logit model to analyze children's post-school location patterns, and employs a multiple discrete-continuous extreme value (MDCEV) model to study the propensity of children to participate in, and allocate time to, multiple activity episode purpose-location types during the after-school period. Overall, the study represents the first formulation and application of a comprehensive econometric framework to consider children's post-school location patterns and participation, and levels of participation, in joint activity and location combinations.

There are several important findings from our study. First, children have activity-travel characteristics that are unique and different than adults. For instance, they participate in higher levels of structured/organized activities and participate in unique activity purposes such as daycare and studying. They also depend on adults to escort them to/from out-of-home activities. These distinctive dimensions of children's activity-travel patterns should be considered and

directly modeled within activity-based travel demand modeling systems. Second, while not unique to children, activities take place both within and outside the home and at various activity locations. What is unique to children is the role school plays as a significant location for out-of-home activity participation for both school and non-school activities. In addition, participation and time-allocation to episodes of different activity purposes are affected by different factors, depending on the location of participation. Third, in addition to demographic characteristics, attitudinal and environmental attributes, and other individuals' activity-travel pattern variables, impact children's activity engagement patterns. These results confirm the importance of going beyond simple analyses of age, gender, and household income level when examining travel behavior, and support the collection of detailed geospatial information and the inclusion of questions on perceptions and attitudes in travel surveys. Finally, a child's activity-travel pattern is impacted by not only household members, but also friends and other non-household members. Children mostly participate with other individuals (rather than alone) in out-of-home activity episodes, and a significant proportion of these joint participations are with individuals who are not family members. In addition, a significant number of out-of-home activities take place at someone else's home. These results highlight the need to examine children's inter-household interactions, as well as children's intra-household interactions, within a joint framework.

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CHAPTER 1:
INTRODUCTION

1.1 Introduction

More daily trips in the United States are undertaken during the 3-4 pm hour of the day than during any other hour, and 43.1% of all daily trips are made between 2-8 pm (USDOT, 2001). This peak in trips during the afternoon period can be attributed in part to children's after school activity and travel patterns, suggesting that children's travel needs play a role in the congestion that plagues many of our nation's cities. In fact, a study examining data from the 1995 National Personal Travel Survey found that approximately 30% of children do not go directly home after school, and instead travel from school to participate in other activities. In addition, approximately 40% of children make an additional trip after returning home from school (Clifton, 2003).

Children's travel needs affect the travel patterns of other family members. Children depend, to a large extent, on household adults or other adults to drive them to activities. Such serve-passenger activities constrain adults' activity-travel patterns in important ways. For instance, a parent driving a child from school during the afternoon peak is unlikely to shift away from this time because of a congestion pricing strategy, even if the parent has a flexible work schedule. Similarly, in the case of a parent dropping a child off at soccer practice, it is not the parent's activity but the child's activity, and its location, that determines the temporal and spatial dimensions of the trip (see Kitamura, 1983). Further, the dimension of *who* is responsible for serving the trip for the child's activity determines which adult's activity-travel pattern is affected. Of course, in addition to serve-passenger activities, children can also have an impact on adults' activity-travel patterns in the form of joint activity participation in such activities as shopping, going to the park, walking together, and other social-recreational activities.

The intricate interactions and effects of children's activity-travel patterns on adults' activity-travel patterns can be captured in limited ways by the commonly used approach of including "exogenous" variables representing the number, presence, and age distribution of children. Such a limited approach is not as behaviorally interesting or appropriate as considering the activity-travel patterns of children, and explicitly inter-linking these with those of adults' activity-travel patterns. In addition, the consideration of children's activity-travel patterns is

important in its own right. Specifically, children's activity-travel patterns contribute directly to travel by non-drive alone modes of transportation. However, until recently the focus of analysis in existing activity-based research has almost exclusively been on the activity-travel patterns of adults (16-18 years of age and older; for instance, see Bhat and Srinivasan, 2005; Koppelman and Gliebe, 2002; Bhat and Misra, 2002). Thus, many activity-based travel demand modeling systems currently in practice or in development take a limited approach to modeling the patterns of children and make many simplifying assumptions (see Section 1.2.2 for further details on this point).

Also, understanding the overall time-use patterns of children, and the context of their travel, is important for promoting the health of children. Children's non-motorized travel and physical activity participation is an issue that is gaining increasing attention at the interface of the transportation and public health fields, because of the positive correlation between physically active lifestyles and the development of strong, healthy, and intelligent children (CDC, 2006; Transportation Research Board and Institute of Medicine, 2005). In addition, understanding children's participation levels in after school activities is important to psychologists and sociologists who are concerned with promoting children's participation in developmentally beneficial after-school activities and programs.

The next section positions the study of children's activity and travel patterns within the current state of the activity-based travel demand analysis movement. Sections 1.3 and 1.4 expand on the importance of studying children's activities and travel within other disciplines.

1.2 Activity-based Travel Demand Modeling Systems and Children

1.2.1 Activity-based Travel Demand Modeling

It is currently well recognized, among transportation planning professionals, that activity-based travel demand modeling is conceptually more appealing compared to the traditional trip-based (four-step) approach to travel demand analysis (see Bhat and Koppelman, 1999; Jones *et al*., 1983; Kitamura, 1988; Jones *et al.,* 1990; Axhausen and Garling, 1992). The activity-based approach treats travel as a demand derived from the desire and need to participate in activities. Therefore, the activity-based approach attempts to capture the behavioral basis behind households' and individuals' decisions to participate in specific activities at certain times and places.

An individual's decision regarding participation in an activity is not made independently of other activities and other people's activity-travel patterns. Therefore, the activity-based approach recognizes the need to capture the sequencing or patterns of activity behavior, over an entire day or longer, while also taking into account other household members' activity-travel patterns. The activity-based approach to travel analysis adopts a holistic framework which views individuals and households as the decision-making unit, focuses on the sequences of behavior, examines the timing and duration of activities and travel, incorporates spatial, temporal and inter-personal constraints, and recognizes the interdependence of activities and individuals.

This holistic approach to modeling activity-travel behavior is well suited to capture the results of congestion management policies, such as HOV lanes, congestion pricing, telecommuting, and flexible work schedules, as well as to more accurately model the choice of individuals to travel via specific modes of transportation. For example, an individual is less likely to use transit to reach a desired activity, and s/he is less likely to take advantage of travel demand management programs, such as carpooling, if s/he needs to make a stop on the way to the activity (Strathman *et al*., 1995; Rosenbloom and Burns, 1993). However, more than 7 million households contain working parents who drop off or pick up their children on the way to or from work, and, therefore, make a stop on the way to work (McGuckin and Nakamoto, 2004). If the linkages between parents' and children's activity-travel needs are not taken into account, then travel demand models may inaccurately predict the number of transit or HOV trips. The above example highlights the importance of explicitly modeling children's activity-travel patterns within activity-based travel demand models.

1.2.2 Children's Scheduling in Activity-Based Travel Demand Modeling Systems

While the benefits of activity-based analysis are well known, the development and implementation of comprehensive activity-based travel demand modeling systems are still ongoing efforts. Within the last ten years, various activity-based modeling systems have been designed for metropolitan planning organizations within the United States. These micro-simulation systems attempt to replicate the decision mechanisms underlying activity engagement and travel of every individual and household within an entire metropolitan area.

Since most previous research in the area of activity-based analysis has focused on the patterns of adult workers and non-workers, many of these modeling systems take a limited approach to modeling the patterns of children and make many simplifying assumptions. For

instance, the earliest versions of activity-based modeling systems did not model children at all, including the Portland METRO system formerly in implementation (see Bowman *et al.*, 1999). Even the modeling systems that do model children make many assumptions and simplifications. One of the most common simplifications within current modeling systems is the lack of inter-household linkages related to serve-passenger or escort trips (Bradley and Bowman, 2006). For example, if a household adult is scheduled to make a serve-passenger trip (*i.e.,* the main purpose of the trip is to drop off a passenger), it is unknown who s/he is escorting. In addition, in most modeling systems, if a child is scheduled to be driven to an activity, it is not known whether or not s/he is taken by a household member or a non-household member. An exception to this, found in the systems developed for Atlanta, Columbus, South Florida, the Bay Area, and Dallas, is the case of drop-off and pick-up from school and fully joint trips where all trips within the tour are made together (see Bradley and Bowman, 2006).

Current activity-based travel demand modeling systems are also designed without acknowledging the differences between children's and adults' activity-travel patterns. These modeling systems divide activities into categories that fit with the activity engagements and desired priorities of adult household members, while ignoring the fact that the salient attributes characterizing children's activity types and activity dimensions do not fit easily into these classifications. For instance, some modeling systems classify activity types into three main activity categories: mandatory activities, maintenance activities, and discretionary activities (see Vovsha *et al*., 2003). These activity categories are assigned a scheduling priority with mandatory activities taking precedence over maintenance activities and maintenance activities taking precedence over discretionary activities. In most activity-travel surveys and current activity-travel demand models, extracurricular activities would be considered a recreational activity and, therefore, a discretionary activity, according to the above classification scheme. However, it can be argued that, for a child, an extracurricular activity will take precedence over maintenance activities such as running errands and grocery shopping.

In addition, current activity-based travel demand modeling systems contain an activity type that groups all recreational pursuits into one group, labeled a discretionary activity or recreational activity. In these systems, extracurricular activities are classified as a recreational activity, even though they have spatial and temporal fixities that more closely resemble a mandatory activity. This category becomes very broad and diverse when it is applied to children. For example, the social/recreational category would include attending music lessons, going to a friend's house after school, and free-time playing at the park. All of these activities

vary quite differently in their priority-level, intra-household needs, durations, and spatial and temporal flexibility.

1.3 Public Health Perspective

Public health professionals are interested in understanding children's activity engagement patterns in physical activity due to concerns surrounding rising childhood obesity, cardiovascular diseases, and diabetes. The Centers for Disease Control (CDC, 2003) reports that more than 60% of children aged 9-13 years do not participate in any organized physical activity during their non-school hours and more than 20% do not engage in any free-time physical activity. Only 36% of students meet recommended levels of physical activity (CDC, 2006). About one-third of teenagers do not engage in adequate physical activity for health (CDC, 2002).

In recent years, there has been considerable debate regarding the impacts of the design of the transportation infrastructure (and built environment in general) on participation in physical activity (see Transportation Research Board and Institute of Medicine, 2005). It has been argued that suburban sprawl, low density, and segregated land use configurations, and the highly automobile-oriented transport infrastructure (with limited sidewalks and bicycle paths), make it extremely difficult for individuals of all ages to use non-motorized modes of transportation and engage in physically active pursuits (see Frank *et al*., 2003).

Within the realm of children's travel, mode choice to school has received the most substantial attention. Children are walking and biking to school at a much lower rate than forty years ago. Walking and biking to school made up 42% of school trips in 1969 compared to only 13% of school trips in 2001 (McDonald, 2005). This dramatic decrease in walking and biking to school has resulted in the federally mandated Safe Routes to School Program. This program gives funding for transportation construction projects near schools, with the intent of making it safer for children to walk and bike to school (Boarnet *et al*., 2005).

As a result of the potential link between transportation and public health, transportation and public health professionals are interested in understanding the attributes (such as demographic characteristics, built environmental attributes, *etc.*) that have an impact on physical activity participation to promote healthy lifestyles, particularly in children (see Sallis *et al.*, 2000, for a review of studies examining factors affecting physical activity levels).

1.4 Sociology and Child Psychology Perspective

From a sociological perspective, child development experts have been lamenting the decreasing level of participation of children in extracurricular activities that broaden young minds and sharpen life skills, while also promoting healthy social interactions. Sociologists believe that participation in structured leisure activities helps reduce anti-social behavior by structuring youth's time and providing opportunities to interact with competent adults and role models (Mahoney and Stattin, 2000). Such activities teach children independence and responsibility and help them learn social skills including conflict resolution (Carnegie Corporation of New York, 1992). Studies have found that participation in extra-curricular activities is associated with higher test scores, grades, and educational outcomes, higher self-esteem, and less anti-social behavior including truancy and drug use (Huebner and Mancini, 2003; Darling, 2005).

On the other hand, participation in unsupervised and unstructured leisure activities has been found to be correlated with high levels of anti-social behavior and poor educational performance (Mahoney and Stattin, 2000; Osgood et al., 1996; Posner and Vandell, 1994). Sociologists are concerned that children's unstructured free time is increasingly spent watching television rather than in beneficial physically and mentally active free play such as hobbies and unorganized sports (Hofferth and Jankuniene, 2001; see Cole-Hamilton *et al*., 2002 for a review of the benefits of free play). Watching television is generally associated with lower cognitive test scores (Timmer *et al*., 1985) and less time spent in reading and studying (Koolstra and van der Voort, 1996). Thus, from a sociological perspective, professionals are interested in understanding the factors that would promote healthy out-of-home extra-curricular activity participation and time use, and discourage passive television viewing.

1.5 Research Objectives

The analysis of children's activity-travel patterns and time-use has been gaining increasing attention in a variety of fields, driven primarily by three main considerations: 1) Understanding children's activity-travel behavior and its implications for the accurate forecasting of the overall travel patterns of individuals in a household, within the context of an activity-based approach to travel modeling; 2) Promoting the health of children by increasing participation in physically active activities and non-motorized travel; and 3) Encouraging children's participation in developmentally beneficial activities. While the results of this report will contribute knowledge to all three aspects, the focus of this research is on the first aspect, which is to examine children's

activity participation behavior in the context of accurate travel forecasting. The goal of this research effort is to contribute to the area of activity-based travel demand analysis by comprehensively examining children's activity-travel patterns.

Activity-based travel demand micro-simulation systems attempt to replicate the activity engagement and travel patterns of each individual in the study region over the course of a day. Therefore, the first objective of this research effort is to undertake an assessment of the dimensions of children's daily activity-travel patterns (*i.e.,* generation, temporal, spatial, sequencing, travel, and with-whom dimensions). The assessment includes a review of previous research findings on each dimension and an in-depth empirical analysis of several dimensions.

To facilitate the accurate modeling of an individual's activity-travel patterns, the activity-based approach attempts to capture the behavioral basis behind households' and individuals' decisions to participate in specific activities at certain times and places. Thus, the second goal of this research effort is to contribute to an understanding of households' and individuals' decisions, by identifying the factors that shape and influence the dimensions of children's activity-travel patterns. This study develops a conceptual framework of the factors affecting children's activity-travel patterns and presents a review of previous research on each factor. In addition, the research explicitly models several dimensions of children's activity-travel patterns to further identify the factors affecting these dimensions.

1.6 Structure of the Report

The rest of this report is organized as follows. Chapter 2 reviews previous research on the dimensions characterizing children's activity-travel patterns and discusses areas that warrant further research. Chapter 3 presents a conceptual framework of the factors affecting children's activity-travel pattern dimensions and reviews previous research findings on these factors. Chapter 4 analyzes children's post-school location sequencing and the propensity of children to participate in, and allocate time to, multiple activity-location types during the after-school period through an empirical analysis. Finally, Chapter 5 concludes the paper by discussing the major findings of this research effort and their implications for activity-based travel demand modeling and travel survey improvements, and by identifying the need and opportunities for further research in the field of children's travel behavior analysis.

CHAPTER 2:
DIMENSIONS OF CHILDREN'S ACTIVITY-TRAVEL PATTERNS

2.1 Introduction

The daily activity-travel pattern of a child is defined as the set of all in-home and out-of-home activity episodes, and travel to reach these activity episodes, undertaken by a child during the course of a day. There are many dimensions that comprise a child's daily activity-travel pattern, including the (1) decision to participate in an activity and the number of episodes of participation (generation dimension), (2) activity participation duration and time of day of participation (temporal dimension), (3) activity episode location (spatial dimension), (4) episode sequencing, (5) mode, route, and duration of travel to episodes (travel dimension), and (6) accompanying individuals (with-whom dimension).

In the rest of this section, we first discuss the earlier research related to the generation and temporal dimensions of a school-aged child's activity patterns (Section 2.2), followed by a presentation of research on the spatial (Section 2.3), episode sequencing (Section 2.4), travel (Section 2.5), and with-whom (Section 2.6) dimensions. Section 2.7 presents a summary of the findings and discusses areas that warrant further research.

2.2 Generation and Temporal Dimensions

The generation and temporal dimensions of a child's activity-travel pattern are discussed by activity purpose in this section. The activity purposes include habitual and mandatory activities that take place on a regular basis and have a relatively set time period of participation (i.e. personal care, sleep, and school on weekdays), and non-mandatory activities whose participation rates and duration levels show more variation by day and by child.

2.2.1 Habitual and Mandatory Activities

2.2.1.1 Personal Care and Sleep

All children invest time in some form of personal care and sleep (Hofferth and Sandberg, 2001). Children spend, on average, an hour per day in personal care (Copperman and Bhat, 2007b; Hofferth and Sandberg, 2001). The amount of time children spend sleeping varies substantially

by age. A survey conducted by the National Sleep Foundation (2004) found that elementary aged children spend, on average, 9-10 hours per night sleeping, while Wolfson and Carskadon (1998) report that adolescents sleep, on average, for 7 ½ hours per weeknight and 9 hours per weekend night. Personal care and sleep are activities that predominantly take place within a child's own home (Copperman and Bhat, 2007b). After accounting for time spent in personal care and sleep, children have between 13 and 15 1/2 hours, on average, on weekdays to invest in other in-home and out-of-home activities and travel to reach the out-of-home activities, and 13 to 14 hours on weekend days.

2.2.1.2 School

Similar to work for working adults, school-aged children participate in school during the work week. School is a highly obligatory (or mandatory) activity, occurs regularly every weekday, and has a fixed duration, start and end time, and location. Therefore, for most children, school is a rigidly constrained activity around which all other weekday activities must be scheduled.

On a normal weekday, approximately 87% of children attend school. The time at school comprises the highest percentage of a child's waking hours, averaging 7 hours per day (Copperman and Bhat, 2007b). Ninety percent of school-going children start school between 7 and 9 am, and 90% of school-going children end school between 1 and 4 pm[1]. Thus, school tends to occur during the morning and early afternoon, leaving the late-afternoon and evening to pursue a variety of other activities. Therefore, it is not surprising that children participate in all non-school activities, with the exception of personal care, at a much higher rate and for longer durations during the after-school period than the before-school period (Copperman and Bhat, 2007b).

2.2.2 Non-mandatory Activities

After accounting for school participation, the amount of time children have to invest in non-school in-home and out-of-home activities, and time traveling to reach the out-of-home activities, drops to between 6-8.5 hours on weekdays. Since children do not attend school on weekend days, but tend to sleep longer, children have 6-7 hours more of discretionary time on weekend days compared to weekdays. During the non-school time on weekdays and during their waking hours on weekends, children participate in a variety of activities. Exact classifications of

the non-mandatory activity purposes vary from study to study in earlier research, but they can be loosely classified as: 1) Non-structured (or free play) recreation and social activities, 2) Organized or structured activities, 3) Studying/homework, 4) Paid work, 5) Receiving childcare, 6) Personal business or shopping, and 7) Meals.

2.2.2.1 Non-Structured Recreation and Social Activities

Non-structured recreational activities include unorganized hobbies and sports, outings, playing, television viewing, and music. Almost all children spend some amount of time participating in non-structured recreational activities each day and spend more time in those activities on both weekdays and weekend days compared to any other non-school activity (Copperman and Bhat, 2007b). Copperman and Bhat (2007b) found that children who recreate, spend, on average, 3 ½ hours per day on the weekday and 6 ½ hours on the weekend in non-structured recreational activities.

With regard to specific types of non-structured recreational activities, television viewing has the highest participation rates and duration of participation. Ninety percent of children watch television at least once a day for on an average of 2 ½ hours per day, with higher durations on weekend days (Hofferth and Sandberg, 2001; Bianchi and Robinson, 1997; Shann, 2001; Copperman and Bhat, 2007b; Barnes *et al.*, 2007; Zill *et al*., 1995; Rideout *et al.*, 2005). Approximately 15-22% of children participate in hobbies each day for about an hour per day (Hofferth and Sandberg, 2001; Copperman and Bhat, 2007b; Zill *et al*., 1995). As for physical activity participation, approximately 14% of children participate in non-structured physical activity on weekdays and 22% of children participate in non-structured physical activity on weekend days (Sener *et al*., 2008). Children who participate in recreational physical activity participate for ½ hour to 2 hours per day (Hofferth and Sandberg, 2001; Sener *et al*., 2008; Larson and Verma, 1999). In addition, participation rates and duration levels in physically active recreation are higher for boys than for girls (Gibbons *et al.*, 1997; Shann, 2001; Larson and Verma, 1999; Kohl and Hobbs, 1998; Sallis *et al*., 2000; Barnes *et al*., 2007).

Social activities include conversations, being intimate, parties, and visiting. Copperman and Bhat (2007b) found that 37.5% of children participate in social activities for over an hour on weekdays and over 60% of children participate in social activities on the weekends for over 2 hours per day. However, it should be noted that Copperman and Bhat (2007b) include religious

[1] This statistic is calculated using the 2002 CDS-II survey of the PSID. See Copperman and Bhat (2007b) for

activities as a social activity and, therefore, durations and participation rates in pure visiting activities are likely to be lower, especially on weekend days.

2.2.2.2 Organized Activities

Organized activities involve a regular participation schedule, are led by an adult activity leader or coach, emphasize skill-building, require sustained attention, and include performance feedback (Mahoney and Stattin, 2000; Sener *et al*., 2008). These activities include extracurricular pursuits, lessons, enrichment activities, youth groups, meetings, clubs, and organized games and meets. Participation rates per day range from 11-12% for young children to 22-23% for adolescents (Hofferth *et al*., 1991; Copperman and Bhat, 2007b). Children who participate in organized activities spend 1 ¾ hours per day on weekdays and 2 ¼ hours on weekends (Copperman and Bhat, 2007b; Barnes *et al*., 2007).

While not considered within the statistics above, religious activities are another form of organized activity. Approximately ¼ of elementary and middle school children and over 1/3 of high school children attend religious activities at least once a week (Hofferth and Sandberg, 2001; Huebner and Mancini, 2003; Zill *et al.*, 1995). Hofferth and Sandberg (2001) found that children participate in religious activities for approximately 1 ½ hours per week. Most likely, a high percentage of these religious activities occur on the weekend, due to the predominance of religious services and religious school taking place on Sunday. In addition, two studies reveal that black children participate, and spend more time, in church-related activities compared to other racial groups (Hofferth and Sandberg, 2001; Huebner and Mancini, 2003).

Some studies have examined participation in organized/structured physical activity. Zill *et al*. (1995) report that approximately 13% of high school students take sports lessons at least once per week, while Sener *et al.* (2008) found that 9% of children participate in an out-of-home structured physical activity on weekday and 6% of children participate in an out-of-home structured physical activity on weekends. Children who participate in structured physical activities participate, on average, for 1 ¾ hours on weekdays and for 2 1/4 hours on weekends.

2.2.2.3 Studying/Reading

Several studies have examined participation levels in studying, homework, and reading. These studies have found that between 40-62% of children study on a daily basis on weekdays

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survey and sample information.

(Hofferth and Sandberg, 2001; Bianchi and Robinson, 1997; Copperman and Bhat, 2007b). Several studies separated reading from studying, and reveal that 20% of adolescents, 34% of children aged 9-12, and 43% of children aged 6-8 read on a daily basis (Hofferth and Sandberg, 2001; Zill *et al*., 1995). Significantly less children study on the weekends. For instance, Copperman and Bhat (2007b) found that only 16.5% of children study on the weekends.

Time spent in studying also differs by age and gender. High school and middle school children spend over 1 ¼ hours studying on weekdays, while elementary school children spend only 30-50 minutes per day studying (Copperman and Bhat, 2007b; Barnes *et al.*, 2007; Larson and Verma, 1999; Hofferth and Sandberg, 2001). With regards to gender, girls spend more time studying than boys (Fuligni and Stevenson, 1995; Medrich *et al.*, 1982; Timmer *et al.*, 1985; Harrell *et al*., 1997; Barnes *et al.*, 2007). While fewer children study on the weekend, children who do study on a weekend day spend a longer period of time studying than they do on a weekday (Copperman and Bhat, 2007b).

2.2.2.4 Work

Only high school students (*i.e.* children aged 15 and older) work at a paid job (O'Brian and Gilbert, 2003; McDonald, 2005). Copperman and Bhat (2007b) found that 12% of high school students work, on average, for 4 1/3 hours per day on weekdays, and 6 hours per day on weekends. Zill *et al.* (1995) determined that 27% of 10^{th} graders and 60% of 12^{th} graders work for at least 7 hours per week. In addition, Barnes *et al.* (2007) observe that adolescents work, on average, for 8 hours per week, while Larson and Verma (1999) report work duration hours at levels of 10-20 hours per week. The differences in daily compared to weekly participation and duration rates is most likely due to adolescents working two to three days a week for several hours, rather than working every day for shorter periods of time.

2.2.2.5 Receiving Childcare

Receiving childcare is an activity that is specific to elementary school children (Hofferth and Sandberg, 2001; McDonald, 2005; Hofferth and Jankuniene, 2001; Copperman and Bhat, 2007b). In particular, about 13% of elementary school children attend daycare or receive childcare on weekdays and less than 4% of elementary children attend daycare on weekend days (Hofferth and Sandberg, 2001; Copperman and Bhat, 2007b). Time spent in childcare average 2 hours on weekdays and 1 hour on weekends (Copperman and Bhat, 2007b).

2.2.2.6 Personal Business

Very few studies have examined children's participation levels in personal business activities. Copperman and Bhat (2007b) found that 23% of children on weekdays and 41% of children on weekends participate in some form of personal business. During the week, children spend about 50 minutes per day in personal business activities, while on weekends children spend about 1 ½ hours.

2.2.2.7 Meals

All children spend some amount of time eating either as the primary activity or in combination with other activities. Children spend about an hour per day eating, with slightly higher durations on weekends (Hofferth and Sandberg, 2001; Copperman and Bhat, 2007b). Approximately 3% of meals occur at a restaurant on weekdays and 5% of meals occur at restaurants on weekends, suggesting that 3-5% of meals can be classified as "eat-out" activities (Copperman and Bhat, 2007b). Rate of participation in eat-out activities varies by household income, with children from higher income households eating out more (McDonald, 2005).

2.3 Spatial Dimension

Few earlier studies have examined the location where children pursue activity episodes. Certain activities may take place at a well-defined single location. For example, the school activity will take place at the child's school and, as mentioned earlier, personal care and sleeping tend to take place at home (Copperman and Bhat, 2007b). However, other activities, such as sports, socializing with friends, and participating in clubs may take place at a variety of locations. For instance, children may stay after school at school to participate in an activity or they may go elsewhere to undertake the same activity. In particular, Weston (2005) found that, besides school, the most popular places young adolescents visit are malls, entertainment centers, homes of friends and family, stores, and restaurants. Two additional studies have examined children's activity locations, and these are discussed in turn in the following two paragraphs.

Hofferth and Jankuniene (2001) categorized the types of activities children aged 5- to 13-years-of-age pursue directly after school at home, at school, and elsewhere. Approximately 73% of children go home directly after-school, 8% remain at school, and 19% go somewhere else. They found that children at home are most likely to watch television (74% of children) and study

(50% of children). Only 15% of children who are at home after school play sports. On the other hand, only 1% of children watch television if they stay at school or are at another out-of-home location. Of the children who are at school after school, 24% play sports, 11% do art activities, and 11% participate in youth organizations. Only 8% of children study. At non-school and non-home locations, about 50% of children play sports, 25% shop, 14% socialize and hang-out, and 15% participate in some form of educational activity.

Copperman and Bhat (2007b) divided weekday and weekend activities into in-home and out-of-home activities. They then further reported the most popular out-of-home locations for each activity. The results showed that work and organized activity episodes are most likely to be pursued out-of-home on both weekdays and weekend days, with over 90% of these episodes pursued out-of-home. In contrast, episodes corresponding to meals, household chores, studying, and recreation are primarily pursued in-home, particularly on weekdays. On weekend days, the absence of school provides more flexibility to port these activities out-of-home. The predominantly in-home nature of recreation activities is also consistent with television being the primary kinds of recreational activity that is pursued (see Section 2.1.2.1). These results are similar to the findings of Hofferth and Jankuniene (2001) discussed above. As for specific out-of-home locations, someone else's home is a very common location for participation in all types of out-of-home episodes, except for organized activities and personal business episodes. This is particularly the case for recreation and social episodes on both weekdays and weekend days, and for receiving child care episodes on weekend days. Another very frequent location for participation in all types of out-of-home episodes (except personal business episodes) on weekdays is school. On the other hand, on weekends, a rather large fraction of organized activity and social/religious out-of-home episodes are pursued at church.

2.4 Activity Sequencing Dimension

Two transportation studies discuss the sequencing of out-home activity participation for weekday after-school activities. Specifically, McDonald (2005) and Clifton (2003) indicate that three-fourths of all children go directly home after school. This rate is higher for middle school children compared to other age groups. McDonald (2005) also found that 42% of children go directly home after-school and stay at home the rest of the evening, while Clifton (2003) reported that 31.2% of teenagers go directly home after-school and do not participate in any other out-of-home activities. Overall, between 36-40% of children go directly home from school and then go

back out to participate in out-of-home activities. Further, according to McDonald, 15% of school children make stops on the way home from school and then remain at home, while 8% of school children make stops on the way home from school and then go back out to participate in other activities.

2.5 Travel Dimension

This section discusses children's travel characteristics in three sections: Mode choice (Section 2.4.1), trip duration/distance (Section 2.4.2), and activity and location chaining (Section 2.4.3).

2.5.1 Mode Choice

There are three studies that have descriptively examined mode choice using the 2001 U.S. National Household Travel Survey (NHTS) (see McDonald, 2005; Cain, 2006; and Weston, 2005). Each of the studies examined modal split as a percentage of all trips, but for different age groups of children. McDonald (2005) examined all children under the age of eighteen, while Cain (2006) focused on non-driving school-aged children, and Weston (2005) concentrated on children aged 13-15. The results of these studies show that car trips make up the highest percentage of children's travel, ranging from 65.7-75% of all trips. Walking is the second most frequent choice of mode, constituting between 12.0-16.5% of all trips. The third highest mode utilized is school bus, followed by biking and transit. In addition, two studies in Canada found that car trips makes up the highest percentage of all children's trips, followed by walking (see O'Brien and Gilbert, 2003; Stefan and Hunt, 2006). In both the U.S. and Canada, it was found that children make approximately 80% of weekend trips by car (Weston, 2005; Stefan and Hunt; 2006) which is a higher percentage than for weekday trips.

One main reason for the lower percentage of weekday trips made by auto is the presence of the school trip on weekdays. While auto is still a highly chosen mode for school trips, comprising 54% of school trips, school bus trips also make up a high proportion of school trips. McDonald (2005) found that 30% of school trips are made by school bus. Approximately, 11-15% of school trips are made by walking. In both the United States and Canada, school bus trips make up an even higher share of school trips for middle school students compared to elementary and high school students (Weston, 2005; O'Brien and Gilbert, 2003). In addition, middle school students travel the most by walking and biking (McDonald, 2005; Stefan and Hunt, 2006).

Similar to children's overall trip-making across all different purposes, biking and transit make up the lowest percentage of trips to school (McDonald, 2005).

Clifton (2003) studied mode choice of teenagers to the first activity directly after school, using the 1995 U.S. National Personal Transportation Survey (NPTS). Comparable to the results of the other studies examining trips to and from school, Clifton found a high proportion of auto and school bus trips. There was also a large difference between the modes chosen by young teenagers (age 13) and older teenagers (age 17 and 18). More young teenagers travel by school bus (47%) to after-school activities (including home) than they travel by car (33%). On the other hand, by age 17, 76% of teenagers travel by car compared to only 10% who travel by bus. The percentage of students who walk to their first activity after school is also lower for younger teenagers. Much of this change in travel patterns can be attributed to having a driver's license and having friends who have driver's licenses. More than half of teenagers with licenses drive themselves to their first activity after school (Clifton, 2003).

McDonald (2005) and Weston (2005) also examined mode choice to non-school activities. Over 90% of meal and shopping trips are made by auto. For meals, this may reflect the lack of restaurants within walking distance of a child's residence. For shopping, the need to carry purchased items home from a store encourages traveling by car. A much higher proportion of trips taken to socialize with friends are by walking. Children, overall, make 20% of social trips by walking, while young teenagers make close to 30% of social trips by walking. Sports trips also have a high proportion of non-motorized mode usage with close to 40% of sports trips made by either walking or biking (McDonald, 2005; Weston, 2005).

2.5.2 Trip Duration and Distance

In terms of travel time and distance, McDonald (2005) found that most trips made by children take under 20 minutes and are less than 5 miles away. Sallis et al. (2004), however, reported that most children's trips are to destinations more than 5 miles away. Specifically, they observe that only 40% of all children's trips are less than 5 miles, 9% of all trips are less than 1 mile, and 5% of all trips are less than ½ a mile away. Clifton (2003) also discovered that motorized transport trips made by teenagers to after-school activities are quite long. On average, teenagers travel 5.1 miles by car, 7.2 miles by school bus, and 11.2 miles by public transport to reach post-school activities. Mackett (2001) found that, in Britain, children travel longer distances to non-school activities compared to school activities, while Copperman and Bhat (2007a) observed that

children spend, on average, a total of 1.5 hours traveling by motorized transport to reach weekend activities.

2.5.3 Activity and Location Chaining

Copperman and Bhat (2007b) examined the propensity of children to chain out-of-home episodes by activity purpose and by activity location. In the overall, 41% of all out-of-home tours involving children's episodes are activity purpose-chained (i.e., involve activity episodes of different purposes, though the episodes may not necessarily take place at separate locations). The percentage of tours that are activity purpose-chained during the weekend days is marginally higher than that on weekdays. Among all purposes, school episodes are the only ones that are more likely to be undertaken in isolation than being chained with episodes of other activity purposes. For weekday work episodes, the propensity to chain with episodes of other activity purposes is about the same as the propensity to not chain, while weekend work episodes are more likely to be undertaken in isolation.

With regard to location chaining, there is much more spatial diversity (scattering) in the location of participation of activity episodes over the weekend days. Specifically, only 26% of weekday tours are activity location-chained, compared to 66% of weekend tours (a tour is characterized as being activity location-chained if it involves episode participations at multiple locations, though the episodes may not necessarily be of different activity purposes). This result suggests that individuals are more willing to invest time in travel, perhaps to their desired locations for participation in each type of activity, over the weekends. On the other hand, there is a tendency to pursue activities at a single location in tours on weekdays.

2.6 With-Whom Dimension

As expected, non-driving age children depend to a large extent on their parents to drive them to activities. Weston (2005) found that children aged 13-15 are driven by their parents on 61% of all trips. McDonald (2005) noted that in two-parent households, parents escort their children on 47% of all their children's trips. Not surprisingly, mother's take-up more of the escorting responsibilities compared to fathers (McDonald, 2005; Sener and Bhat, 2007; Yarlagadda and Srinivasan, 2007). McDonald (2005) revealed that there is less of a difference in escorting responsibility between the mother and father if both parents work full time, both parents are more highly educated, and if the children are older.

Some studies have examined children's accompaniment arrangements by non-household members, as well as household members. For example, Clifton (2003) found that 33% of teenagers are accompanied by household members directly after school, while 37% of teenagers are accompanied by non-household members. Weston (2005) observed that older siblings accompany children aged 13-15 on over 4% of trips, while other friends' parents escort children on 8% of trips. It has also been found that household members accompany children more on trips taken on the weekend and over the summer (Weston, 2005; Stefan and Hunt, 2006). Sener and Bhat (2007) examined accompaniment arrangements in weekend discretionary activities and indicated that a high percentage of children undertake out-of-home discretionary activities with no parents (65%) and with parents and others (51%) on weekend days. The study also reveals that children spend a large amount of time (3 hours) without parents on the weekend.

Many children also travel independently to activities. Clifton (2003) found that 38% of teenagers travel alone on their trip directly after school. As expected, the proportion of trips made alone increases with age (McDonald, 2005; Clifton, 2003; Stefan and Hunt, 2006; Mackett *et al*., 2002). Mackett *et al*. (2002) determined that only 10% of children aged 5-10 travel alone to school, while 46% of children over the age of 10 travel alone to school. In addition, Clifton (2003) revealed that 62% of 18 year-olds travel alone to their activity directly after-school compared to only 34% of 13 year-olds.

Children spend a significant amount of time alone. Larson and Verma (1999) reported that young adolescents spend 17-25% of their time alone, while older adolescents spend approximately 25% of their time alone. The study also determined that 14-33% of a child's time is spent with family members. Crosnoe and Trinitapoli (2008) found that most shared family time is spent watching television. They reveal a difference in out-of-home family time between high and low income households. Higher income households are more likely to pair shared family time with family time outside of the home, while lower income households are more likely to, either only share television watching, or to couple television watching with other home-based activities.

2.7 Summary

The above assessment on the dimensions of children's activity-travel patterns reveals several interesting findings. Children participate and spend time in a variety of activities during the week and on weekends. Specifically, besides personal care, sleep, and school, children spend a

considerable amount of time in non-mandatory pursuits such as recreation, organized activities, and studying. With regard to the location of these activities, in addition to home, the most common location of activity participation includes the school location and someone else's home. Not surprisingly, children mostly travel by car to reach out-of-home activities. However, for the school activity, walking and school bus also represent a significant share of the travel mode chosen. Children also participate in many activities with parents, friends, and other household and non-household members and rely on these same people to transport them to activities.

CHAPTER 3:
FACTORS AFFECTING CHILDREN'S ACTIVITY-TRAVEL PATTERNS

3.1 Introduction

There are a number of different factors that shape and influence the many dimensions of a child's activity-travel pattern. These factors may be grouped into four categories: the demographics of the child and the child's social contacts (including household and non-household members), the attitudes of the child and his/her social contacts, the activity-travel patterns of the child's social contacts, and the child's environment. Figure 1 illustrates a conceptual framework of the effect of each category of factors on a child's activity-travel pattern. The child's and the child's social contacts' demographics (see box at top left of Figure 1) have a direct influence on the child's activity-travel patterns. For example, a child's age directly influences the types of activities a child will participate in. The child's and social contacts' demographics also influence the attitudes, disposition, beliefs, culture, and personality of the child and his/her social contacts (see the top arrow in Figure 1). For example, the gender of an individual may determine the extent to which an individual perceives the safety and security of a particular mode of transportation. In turn, the attitudes of the child and his/her social contacts influence the activity-travel patterns of the child and his/her social contacts. For instance, if a child's mother does not perceive the local bus as a safe mode of transportation for her child, she may not allow the child to travel to an activity alone, or with a friend, on the bus. A child's social contacts' activity-travel patterns (box at the bottom right of Figure 1) both influence, and are influenced by, the child's activity-travel patterns. For example, non-driving siblings are dependent on their parents to escort them to activities. They must also share their parents' time availability. If a parent is driving one child to basketball practice, that parent may not be available to drive the other child to a friend's house. Environmental conditions, composed of the social, natural, land-use, and transportation environment, also affect both a child's activity-travel patterns as well as the activity-travel patterns of social contacts. For example, a child who lives more than a mile away from school does not have the option to walk to school. All of these factors contribute to the formation of a child's overall daily activity-travel pattern and are discussed in more detail in the next four sections.

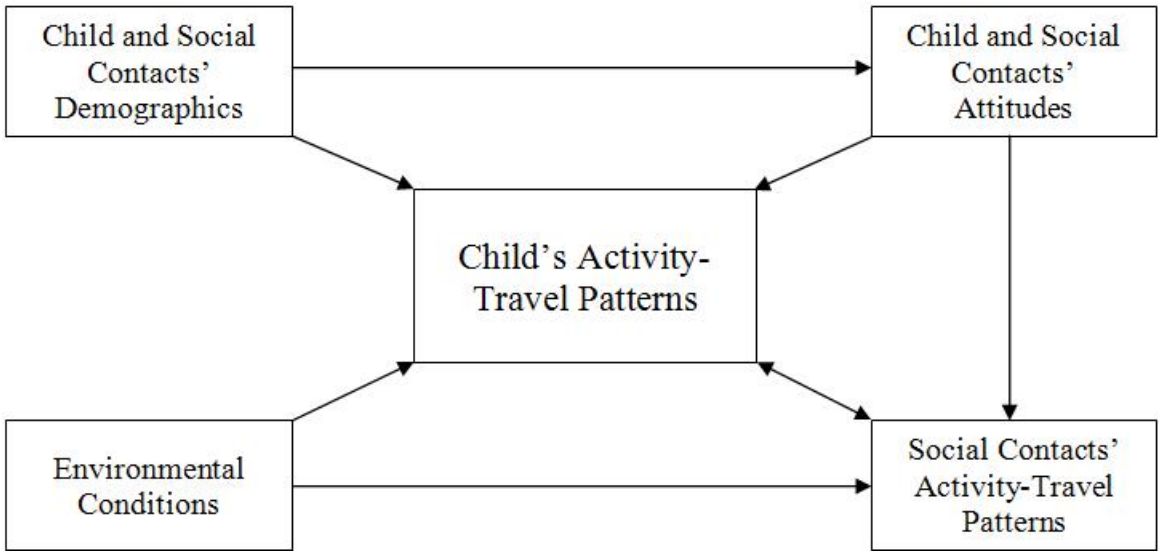

Figure 1. Factors Affecting a Child's Activity-Travel Patterns

3.2 Demographic Characteristics

It is well documented that an individual's time-use and overall activity-travel pattern are influenced by the demographic characteristics of the individual and the household in which s/he resides (see Section 3.2.1 and Section 3.2.3). For example, individuals residing in high income households make more trips than lower income households (Hu and Reuscher, 2004). However, a child's activity-travel pattern is also affected by his/her parent's and other household members' individual demographics (Section 3.2.2), as well as his/her friends' and friends' household's demographics (Section 3.2.4). Figure 2 illustrates the types of demographic factors that have an impact on a child's activity-travel pattern.

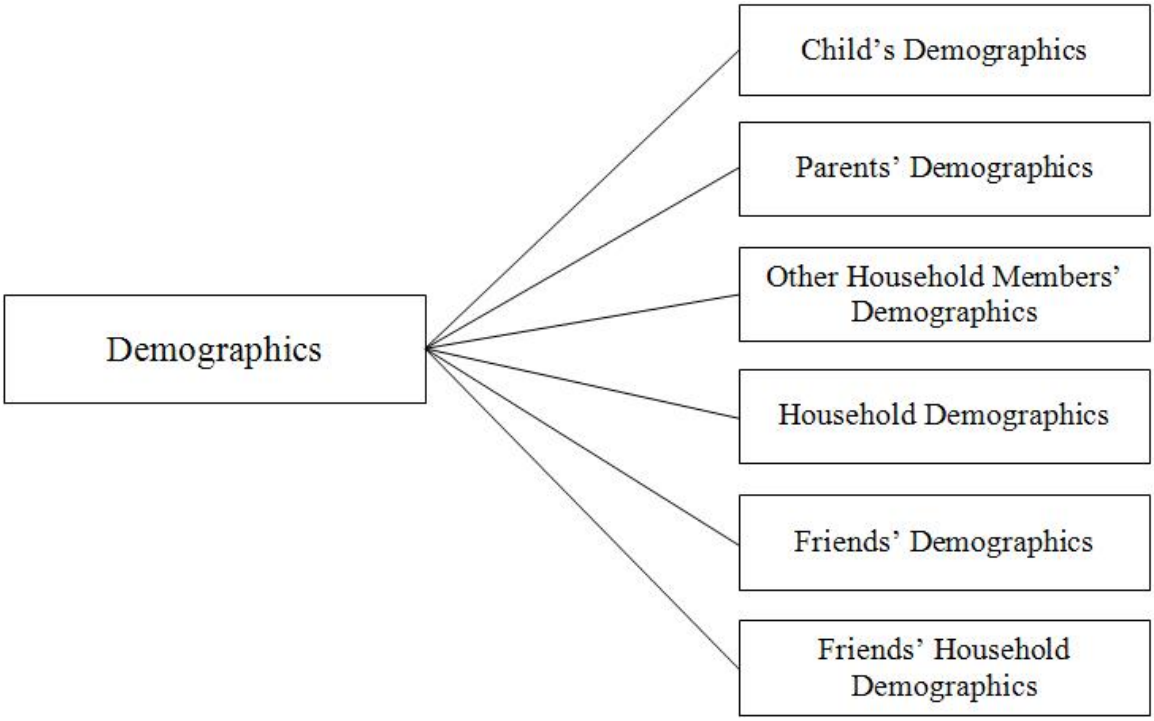

Figure 2. Types of Demographic Factors Affecting a Child's Activity-Travel Pattern

3.2.1 Child's Demographics

The three most well-known child demographic variables affecting a child's activity-travel pattern are age/grade level, gender, and ethnicity, each of which are discussed in detail in the next three sections. There are other demographics that have an impact on a child's activity-travel patterns, such as owning a driver's license and disability status, but we do not discuss the impacts of these demographics in detail.

3.2.1.1 Age/Grade Level

As children progress from young children to the adolescent stage in their lives, their activity and travel patterns change rather substantially. In general, as children get older their geographic boundaries increase and they travel farther and spend more time traveling on a daily basis (Vliet, 1983; Stefan and Hunt, 2006). They also acquire more freedom and are able to travel more independently by themselves and with friends and stay out later at night (McDonald, 2005; Sener and Bhat, 2007; Stefan and Hunt, 2006; Mackett *et al*., 2002). However, with the increased independence comes more responsibility and, therefore, as children get older they spend more time doing homework and chores (Larson and Verma, 1999), as we discuss further below.

Elementary school children are characterized by more escorting by parents to school, less independent travel, and very little transit use (Stefan and Hunt, 2006; McDonald, 2005; O'Brian and Gilbert, 2003). Young elementary school children are the only age group who participate in day care (Hofferth and Sandberg, 2001; McDonald, 2005; Hofferth and Jankuniene, 2001). Younger children also spend more time sleeping and eating (Stefan and Hunt, 2006; Hofferth and Sandberg, 2001).

Middle school children make the least number of trips and are the most likely to go straight home after school compared to other age groups (McDonald, 2005; Clifton, 2003) Middle school students also travel the most by walking and biking, compared to both younger and older children (McDonald, 2005; Stefan and Hunt, 2006). Specifically, they are the most likely to walk to a friend's house directly after school. Most authors contribute these characteristics to the increased freedom granted to stay alone at home and travel alone or with friends.

High school students travel and spend the most time both alone and with non-family members (McDonald, 2005; Sener and Bhat, 2007; Yarlagadda and Srinivasan, 2007; Clifton, 2003; Crosnoe and Trinitapoli, 2008). Correspondingly, they spend the most time outside the home (Stefan and Hunt, 2006). They are the least likely to take the school bus to school and the most likely to take transit for out-of-home activity participation, compared to the other age groups (McDonald, 2005, Clifton, 2003; O'Brian and Gilbert, 2003; Stefan and Hunt, 2006). Many high school students also spend time working outside of the home, either full or part time (McDonald, 2005; Clifton, 2003; Stefan and Hunt, 2006; O'Brian and Gilbert, 2003; Larson and Verma, 1999; Zill *et al.*, 1995).

Older high school students also differ in their activity-travel patterns compared to younger high school students. Once adolescents have a driver's license they drive themselves on approximately 50% of all trips (McDonald, 2005). They walk and bike less for recreation and as a means of transportation (McDonald, 2005; Clifton, 2003; Stefan and Hunt, 2006; Copperman and Bhat, 2007a). Older high school students also participate in different types of after-school activities compared to their younger high school counterparts. Overall, they participate in less extracurricular activities (Eccles and Gootman, 2002; Darling, 2005) and participate more in work, serve passenger, social, and shopping pursuits (Clifton, 2003; Stefan and Hunt, 2006; McDonald, 2005). When they do partake in after-school activities, they participate in more

volunteer groups, clubs, leadership groups, and performing groups compared to younger adolescents (Darling, 2005).

3.2.1.2 Gender

Boys and girls have different travel patterns. Boys, in general, and especially when they are younger, have more freedom or mobility and are less closely supervised than girls (Fuligni and Stevenson, 1995; Medrich *et al.*, 1985; Timmer *et al.*, 1995; McDonald *et al.*, 2004; Shann, 2001). They travel farther away from home than girls and walk or bike alone or with a friend to school at higher rates than girls (Hillman *et al.*, 1990; Yarlagadda and Srinivasan, 2007; Vliet, 1983). Younger boys also travel more than girls, which may be due to the increased independence allowed to them (McDonald, 2005). However, once girls reach driving age they travel more than boys, but are much more likely to be a passenger in a car (McDonald, 2005; Mackett, 2001). High school boys travel less than girls, but when they do travel they are more likely to be the drivers (McDonald, 2005).

Boys also differ from girls in the types of activities they are involved in. It is well established that boys play more sports and pursue more physical activity than girls (Gibbons *et al.*, 1997; Shann, 2001; Larson and Verma, 1999; Kohl and Hobbs, 1998; Sallis *et al.*, 2000; Barnes *et al.*, 2007). Boys participate more than girls in both active recreational pursuits, such as playing basketball and soccer, as well as in active travel, such as walking and biking (Evenson *et al.*, 2003; Weston, 2005; Copperman and Bhat, 2007a; Sener and Bhat, 2007). Girls, however, spend more time on homework and chores (Fuligni and Stevenson, 1995; Medrich *et al.*, 1985; Timmer *et al.*, 1995; Harrell *et al.*, 1997; Barnes *et al.*, 2007). High school girls also attend church and go shopping more than boys (Huebner and Mancini, 2003; McDonald, 2005; Sener and Bhat, 2007). Interestingly, the time spent with mothers and fathers also depends on the gender of the child. Girls do more activities out-of-home with their mothers, while boys do more activities with their fathers (Sener and Bhat, 2007; Yarlagadda and Srinivasan, 2007).

3.2.1.3 Race and Ethnicity

There are many studies that have examined the influence of a child's ethnicity on one or more dimensions of the child's activity-travel patterns. However, many of the results are conflicting and mixed, especially with regard to activity participation. This suggests that ethnicity may be serving simply as a proxy for the true underlying reasons (such as the social environment) for

observed differences in children's activity-travel patterns (see Section 3.4.1). Despite these limitations, it is still important to discuss the results of many of these studies in an attempt to begin understanding how different population groups differ in their activity-travel patterns.

White children are less likely to walk than children of other ethnicities. McDonald (2005) found that white children walk on only 9% of trips, compared to 17% of trips for non-white children. In addition, she found that white children walk less to school compared to black children, with 10% of white children walking to school and 22% of black children walking to school. Kerr *et al.* (2007) also observed that only 12% of white children reported walking over a 2 day period compared to 18% of non-white children. In addition, Evanson *et al.*, (2003) found that non-white middle and high school students are more likely to walk to school on a daily basis. However, McDonald (2008) controlled for several individual and neighborhood variables when examining active transport to school and found no difference in active transportation between racial groups, suggesting, as alluded to above, that observed differences in behavior are due to overall differences in socio-economic and neighborhood conditions rather than culture.

Some studies also observed that white children use transit less and auto more compared to non-white children (see Yarlagadda and Srinivasan, 2007; McDonald, 2005; Copperman and Bhat, 2007a). White children also make the most number of trips per day, while black children make the least number of trips per day (McDonald, 2005). A study by Copperman and Bhat (2007a) also discovered that Asians make a high number of auto trips compared to other ethnicities and are the least likely to walk.

McDonald (2005) attributes some of the differences in overall number of trips to the fact that non-white children make fewer trips for sports and exercise, social, and dining out activities. Sener and Bhat (2007) also found that black children, specifically, make the least number of eat-out trips. While black children may eat out less, another study observed that they spend more time eating, compared to other ethnicities except for Hispanics (Hofferth and Sandberg, 2001). Two studies also report that black children participate, and spend more time, in church-related activities (Hofferth and Sandberg, 2001; Huebner and Mancini, 2003).

A few earlier studies have focused on how leisure activities differ by ethnicity. Pesavento and Kelly (1991) found that black children participate in less leisure activities, while Floyd, *et al.* (1994) report that they actually participate equally in leisure activities if you control for socio-economic characteristics. A third study observed that black and white children participate in different types of leisure activities (Phillip, 1998). These differences may also be

gender related. For example, Harrell *et al.* (1997) found that black boys reported participating in more physically active activities than white boys, while white girls reported participating in more physically active activities than black girls.

Darling (2005) observed that white children participate in more extracurricular activities, while Hispanics are least likely to participate in extracurricular activities. In contrast, Barnes *et al.* (2007) did not find a difference in extracurricular activity time-use between white and black adolescents. However, they did find that black adolescents spend more time watching television, less time in paid work, more time in housework and sibling care, more time relaxing, and more time with their peers. Hofferth and Sandberg (2001) report that Hispanics do not read as much, but do more housework, compared to other ethnicities. The same study found that Asians read more, do less housework, and watch more television, while black children read less, do less housework, and watch more television.

There are also differences in parental participation in travel and activities by a child's ethnicity. Specifically, results from a study by Yarlagadda and Srinivasan (2007) reveal that white and Asian children are more likely to be driven to school by their mother, and white children are more likely to be driven from school by their father, compared to other ethnicities. Also, Sener and Bhat (2007) found that black children are more likely to participate in activities without either parent, while white children are more likely to eat out without either parent. They also found that black children are less likely to participate in activities with their father.

3.2.2 Parents' and Other Household Members' Individual Demographics

A parent's individual demographics also have an impact on a child's activity-travel pattern. The educational attainment of a parent may influence a child's choice of non-school activities. For example, one research study found that children with highly educated parents study more, watch less television, and do more housework (see Hofferth and Sandberg, 2001). In addition, if a parent does not have a driver's license, the child's activity-travel pattern will be affected, since that parent is unable to drive the child to out-of-home activities. Other household members' demographics may also have an impact on the child's activity-travel patterns. A child with an older sibling who has a driver's license may be driven around by that sibling. On the other hand, if the child has a younger sibling the child may be responsible for walking the sibling to a friend's house. Parental education and employment are the most studied parent and household members' individual demographics and are discussed in detail in the next two sections.

3.2.2.1 Parental Education

Higher parental education is associated with more time spent, and higher participation levels, in certain types of activities, and less time spent, and lower participation rates, in other activities. As indicated above, Hofferth and Sandberg (2001) found that children with highly educated parents study more, watch less television, and do more housework. In addition, Huebner and Mancini (2003) found that high school students participate in more volunteer activities if they have well-educated parents. Sener and Bhat (2007) reveal that maternal education is associated with less shopping and paternal education is associated with more social activities. Powell *et al.* (2007) determine that children with parents who have less than a high school education are less likely to participate in physical activity, whereas students with college-educated parents had significantly higher participation rates in physical activity.

3.2.2.2 Parental Employment

Different types of parental employment arrangements affect children's activity levels and accompaniment arrangements. Hofferth and Sandberg (2001) found that children from dual-earner households watch less television, spend less time at home, and spend less time sleeping. They also found that children with working mothers sleep less, while children in two parent households, with only an employed father, read more and spend more time in religious activities. Interestingly, Powell *et al.* (2007) found that students with mothers who work part- or full-time, versus not working, participate in physical activity more frequently.

Yarlagadda and Srinivasan (2007) focused on examining children's escorting arrangement to and from school. Specifically, they observed that children in dual-earner households are escorted from school more by their father compared to non-dual earner families. They also found that mothers who work on the school day are less likely to drive children home from school, but are more likely to drive the children to school rather than walk the children to school. Interestingly, children whose mother's work part-time, compared to non-working or full-time employed mothers, are more likely to escort their children to school. Also, children whose mothers are employed are less likely to be driven home from school by their mother and more likely to either walk or be driven home by a non-parent. The study also examined the flexibility of a parent's work schedule in determining escorting responsibilities and discovered that the

more flexible the father's work schedule the more likely the father is to drive his children to school.

3.2.3 Household Demographics

A child's household demographics constitutes another category of variables affecting a child's activity-travel pattern as discussed in the subsequent sections.

3.2.3.1 Household Income

Children's activity-travel patterns differ based on household income. Specifically, children of lower income-level households walk more than higher income households (see Kerr *et al.*, 2007; McMillan, 2007). However, overall, children in high-income households make more trips and travel further to reach activities (Vliet, 1983; McDonald, 2005). Several studies also reported findings that reinforce the idea that higher income households make more trips to participate in activities away from home and school. One study found that children in the lowest income group (less than $25,000) are less likely to participate in out-of-home recreation (Sener and Bhat, 2007). A second study observed that children in higher income groups participate in more sports and exercise and eat-out trips (McDonald, 2005). Finally, a third study found that children in lower income groups are more likely to be enrolled in sports settings at school compared to at other locations (Hofferth and Jankuniene, 2001).

3.2.3.2 Number of Household Vehicles

Not surprisingly, children's travel patterns differ based on the number of household vehicles. With regard to school trips, studies have found that children living in households with no vehicles are more likely to walk, take school bus or transit, and are less likely to go to school via a car (Yarlagadda and Srinivasan, 2007; Bradshaw and Atkins, 1996; Mackett *et al.*, 2002). Interestingly, children in zero vehicle households use a car more for non-school travel than school travel (Mackett *et al.*, 2002). This may be due to the availability of non-household members to drive children to non-school activities. Also, children living in a household without a vehicle spend more time traveling, but make 42% less trips (McDonald, 2005). This is most likely due to children in households with less vehicles walking more and using motorized transport less (Copperman and Bhat, 2007a; Kerr *et al.*, 2007).

3.2.3.3 Household Composition

Several studies have considered household size and structure when examining children's activity-travel patterns. Children in smaller households walk more (Kerr *et al.*, 2007; Copperman and Bhat, 2007a). With regards to school travel, one study found that children with no other school going children in the household are more likely to be picked up from school by their mother (Yarlagadda and Srinivasan, 2007). The same study also reported that children in larger households are more likely to take the school bus, and a different study found they are more likely to walk or bike to school (Yarlagadda and Srinivasan, 2007; McMillan, 2007). According to the study by Hofferth and Sandberg (2001), children in larger households are also more likely to play sports, but visit with others less.

There are also differences in children's activity-travel patterns between children living in single-parent versus two-parent households. Children in single-parent households spend less time in leisure activities, and young children in single-parent households spend more time watching television and less time sleeping and playing (Douthitt, 1991; Fuligni and Stevenson, 1995; Timmer *et al.*, 1995; Medrich *et al.*, 1985). But at least one study (Sener and Bhat, 2007) has found that children in single-parent families participate in more physically active pursuits than children in non-single parent families. The literature also suggests that high school children in two-parent households do more volunteer work and attend church more frequently (Huebner and Mancini, 2003). Children in two-parent households also participate in higher levels of physically active activities (Powell *et al.*, 2007)

3.2.4 Child's Friends' Individual and Household Demographics

The child's friends' personal and household demographics may also affect a child's activity-travel pattern. For example, if a child has older friends then s/he may get involved in activities that are usually associated with older children. Similarly, if a child's friend's family does not have a vehicle the child and the child's family may frequently escort the friend to activities that both children are involved in. However, no studies to date, that we are aware of, directly measures the impact of these factors.

3.3 Attitudes

In this research effort, attitude refers to the disposition, beliefs, culture, personality, and previous experiences that contribute to how an individual perceives the world. Similar to demographic

characteristics, a child's activity-travel patterns are affected by not only the child's attitudes (Section 3.3.1), but also his/her parent's (Section 3.3.2), other household members' (Section 3.3.2), his/her friends' (Section 3.3.3), and his/her friends' parents' attitudes (Section 3.3.3). Figure 3 illustrates the types of attitudes that affect a child's activity-travel patterns.

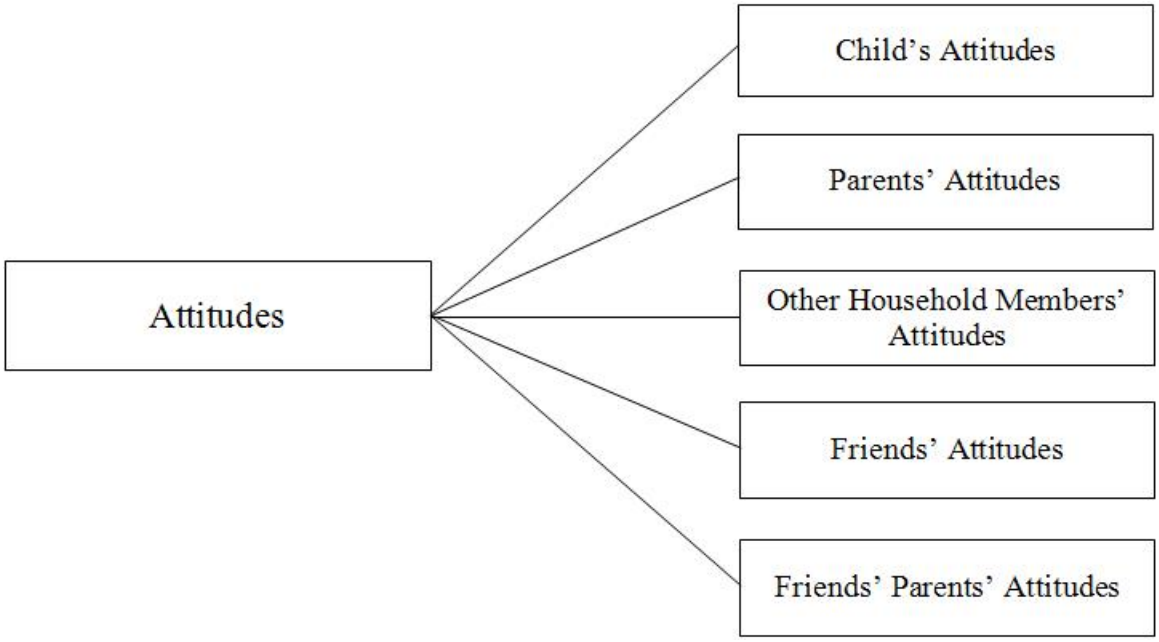

Figure 3. Types of Attitudes Affecting a Child's Activity-Travel Pattern

3.3.1 Child's Attitudes

With regard to children's attitudes, two studies found that one reason for the increasing car use by children and the chauffeuring of children by parents is because children want to be driven by car (Fotel and Thomsen, 2004; Bradshaw and Jones, 2000). This may be partly due to the high social status associated with cars (Bradshaw and Jones, 2000) and the belief that cars are more comfortable and convenient (Stafford *et al.*, 1999). Children also have attitudes towards walking and public transit that have an impact on their mode choice. A child's perception of the safety and security of walking alone or taking public transit influences whether the child chooses to use the mode (Stafford *et al.*, 1999; Weston, 2005).

Two studies had contrasting results with regard to the effect of self-esteem on children's activity engagement. Raymore *et al.* (1994) found that children with low self-esteem participate in less leisure activities, while Huebner and Mancini (2003) found that self-esteem does not have an impact on participation levels in non-school activities. The latter study also reported that

more time spent in unstructured outdoor activities was related to poorer academic grades, poorer work habits, and poorer emotional adjustment. A number of studies have observed a relationship between greater academic commitment and achievement and higher participation levels in extracurricular activities (Darling, 2005; Posner and Vandell, 1994; Huebner and Mancini, 2003; Jordan and Nettles, 1999; Cooper *et al.*, 1999). However, it is unclear whether it is the greater commitment to academic achievement that causes children to participate in more extracurricular activities or whether the participation in extracurricular activities contributes to greater academic achievement.

3.3.2 Parents' and Other Household Members' Attitudes

Many parents perceive that the car is a more secure and safe mode of transportation compared to transit, school bus, or non-motorized modes. Parents' concern over neighborhood and road safety contributes to their desire to escort their children and the desire to have children travel by car (McMillan, 2007; Fotel and Thomsen, 2004; Bradshaw and Jones, 2000). Specifically, McMillan (2007) found that if traffic speeds are greater than 30 mph on route to school, parents are more likely to believe that it is unsafe for their children to walk to school. Parents also believe that chauffeuring their children by car is easier and more convenient (Fotel and Thomsen, 2004).

Parental attitudes toward certain activities affect children's level of participation in the activity. For example, Huebner and Mancini (2003) found that children participate more in extracurricular activities if there is parental endorsement of the activity. If parents perceive that an organized activity will take away from helping out at home, parents may discourage their children from participating (Elder and Conger, 2000; Furstenberg *et al*., 1999). In addition, if parents fear the types of children and adults involved in the activity, they may keep their children from participating in the activity (Jarrett, 1997). It has also been found that if parents' are less involved in sports and exercise they are less likely to encourage their children to use local playgrounds (Miles, 2008).

Children are not just influenced by the attitudes of their parents, but also by other household members. If an older sibling is very enthusiastic about his/her participation in an activity, the younger child may also want to participate in the activity. If a live-in grandparent is very religious, s/he may encourage the child to attend a weekly religious service with him/her.

3.3.3 Friends' and Friends' Parents' Attitudes

Children are also influenced by their friend's attitudes toward travel modes and non-school activities. Huebner and Mancini (2003) reveal that children participate more in extracurricular activities and religious activities if their friends endorse the activity. Weston's (2005) results suggest that many high school students stop riding their bikes to school because they do not see other students riding their bike, and therefore do not think it is a socially acceptable activity. Since children are highly influenced by their parents, children will also be influenced by their friend's parents. For example, if a friend's parent does not deem a park as safe, s/he may discourage both the friend and the child from playing at the park alone together.

3.4 Activity-Travel Patterns of a Child's Social Contacts

One of the most complex aspects of simulating an individual's activity-travel patterns is incorporating the other household and non-household member's activity patterns (Bhat and Pendyala, 2005). However, it is necessary to understand how the activity-travel patterns of individuals who interact with the child affect the child's activity-travel pattern. Figure 4 illustrates the relationship between the activity-travel patterns of a child and his/her social contacts, including parents (Section 3.4.1), other household members (Section 3.4.1), friends (Section 3.4.2), and friends' household members (Section 3.4.2).

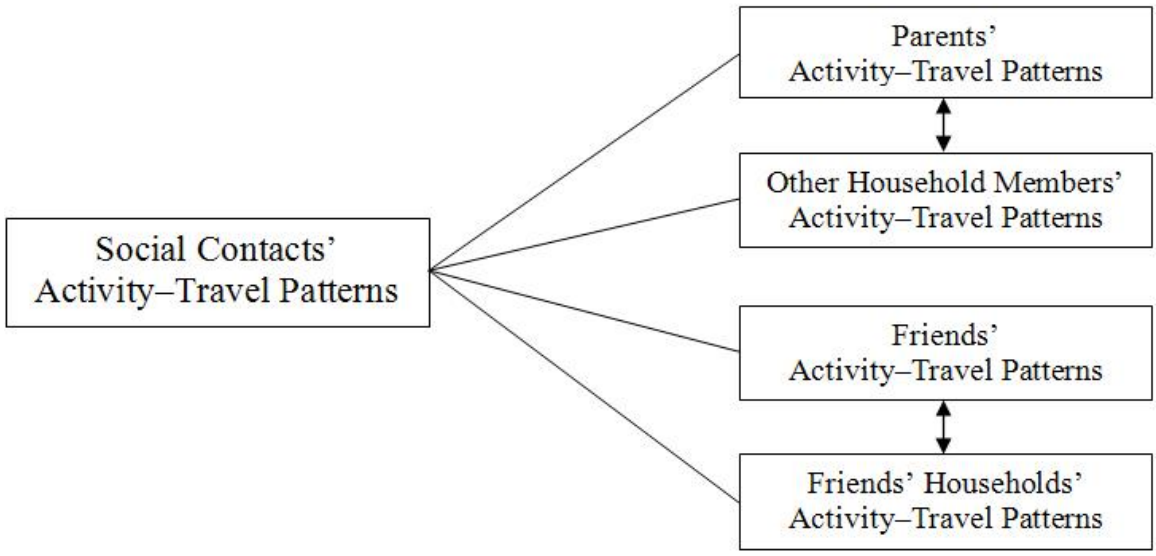

Figure 4. Activity-Travel Patterns of Child's Social Contacts

3.4.1 Parents' and Other Household Members' Activity-Travel Patterns

The most influential social contact within a child's life is his/her parents or adult guardians (Abundant Assets Alliance, 2002). Parental figures are responsible for the child and make many long-term and short-term decisions for and with the child. In some cases it is an activity of a parent, for example going to the grocery store, rather than the child's activity, that determines a child's activity-travel pattern. This is especially true in the case of younger children. In addition, children's escorting arrangement to school is affected by a parent's work participation and schedule (Yarlagadda and Srinivasan, 2007). Additionally, long-term decisions regarding extracurricular activity participation are discussed with parents and may be scheduled around a parent's commitments. Rosenbloom (1987, 1989) recognizes that parents' schedules, especially their work schedules, makes them more or less available to transport children. This in turn affects the amount and types of trips children make and the types of out-of-home activities they are able to participate in. Shann (2001) also recognized that the limited availability of parents to pick children up from after-school activities prevent many inner-city middle school students from staying after-school. However, in many cases it is the child's activities that dictate the parent's activity-travel patterns, especially for the mother. For example, non-workers in household with children make more serve-passenger trips than any other group, leading to more complex trip chaining, and more private vehicle use (see, Misra and Bhat, 2000; Hensher and Reyes, 2000; Strathman and Dueker, 1995).

The activity-travel patterns of other members of a child's household may also have an impact on the child's activity-travel pattern. For example, an older sibling of driving age may be responsible for driving the child home from school. On the other hand, a parent may drop a sibling off at one activity on the way to dropping off the child at his/her own activity. Extended family members, such as grandparents or aunts, may also live with the family and share the escorting responsibilities for the child.

3.4.2 Friends' and Friends' Household Members' Activity-Travel Patterns

Children are also influenced by what their friends are doing. With regard to long-term decision-making, a child may choose to participate in an extracurricular activity because his/her friend is participating in the activity. A child's daily activity-travel pattern may also depend on a friend's and a friend's household's activity-travel patterns. For example, a child may choose to play with a friend after-school if the friend is available to play. The location of the play-date, whether at

the child's house or the friend's house, may depend on the activity-travel patterns of both the child's household and the friend's household. Additionally, car pooling arrangements may be made between a child's parents and a friend's parents, if a child and his/her friend live close by and are attending the same activity (see Reisner, 2003).

3.5 Environmental Conditions

The environment is defined as the conditions, resources, and influences that characterize an individual's surroundings. There are many different types of environmental conditions that have an impact on a child's activity-travel patterns (see Figure 5). These environmental conditions may be grouped into four areas: social (Section 3.5.1), natural (Section 3.5.2), land-use (Section 3.5.3), and transportation (Section 3.5.4).

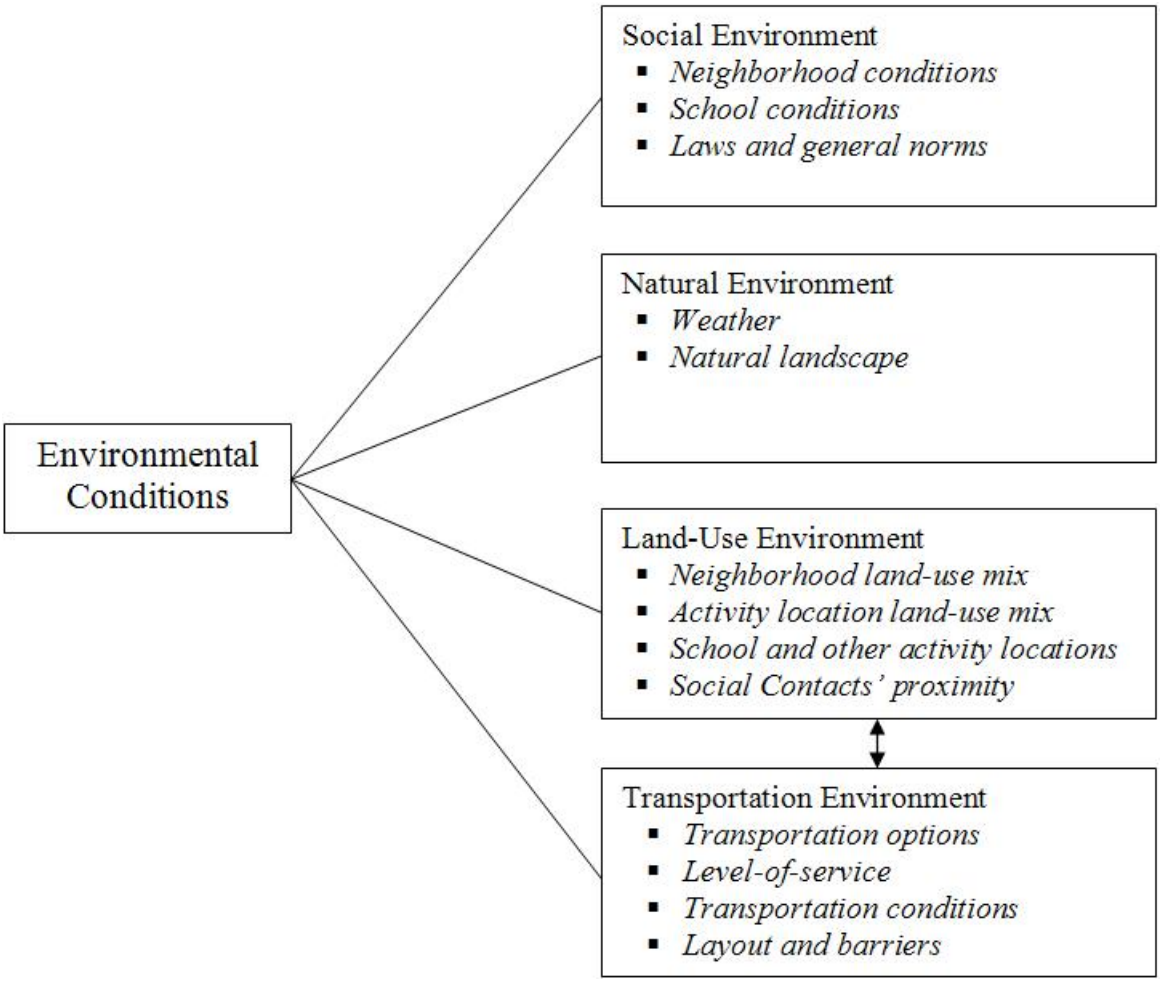

Figure 5. Environmental Factors Affecting a Child's Activity-Travel Patterns

3.5.1 Social Environment

In this research effort, the social environment refers to the community and culture that influences an individual, and in which the individual is immersed. There are three aspects of the social environment that have an influence on a child's activity-travel patterns: neighborhood conditions (Section 3.4.1.1), school conditions (Section 3.4.1.1), and laws and general norms (Section 3.4.1.2).

3.5.1.1 Neighborhood and School Conditions

The influence of neighborhood conditions on a child's activity-travel patterns can be best expressed using the social ecology theory. Social ecology is defined as the family, school, neighborhood, and community environment in which a child lives in (Earls and Carlton, 2003). Earls and Carlton (2003) indicate that if a child lives in a very financially poor community then the whole facet of social ecology suffers. The quality of housing, schools, recreation areas, businesses, and transportation is diminished and the safety and security of the neighborhood is threatened. In turn, all of these conditions may have an impact on the choice of activities and travel options available to the child.

Research on the effects of neighborhood composition and conditions on children has mainly focused on crime, drop-out rates, teenage pregnancy, and employment. Although some of these areas do not relate directly to children's activity-travel patterns, they are indirectly related, and are therefore worth mentioning. These studies have found that adolescents living in inner-city poor neighborhoods are more likely to be involved in crime, more likely to be teenage parents, and less likely to hold jobs (Ricketts *et al.*, 1988; Coulton *et al.*, 1995; Ellen and Turner, 1997; Crane, 1991). Additionally, research has shown that dropping out of high school is likely to occur among teenagers living in neighborhoods where few workers have decent paying jobs (Crane, 1991). Ellen and Turner (1997) found that teenagers living in an area where few adults have decent paying jobs are less likely to find jobs themselves. They attribute this to teenagers not knowing adults who can alert them of possible openings and who can vouch for their reliability and character. Case and Katz (1991) found that teenagers who live in an area where a high proportion of their peers use drugs and commit crimes are more likely to engage in similar behavior.

A few studies have examined how aspects of the social environment, including neighborhood income, culture, and conditions, affect rates of physical activity. McDonald (2005) found that children living in high poverty neighborhoods with more immigrants are more likely to walk to school, while Powell *et al.* (2007) indicate that children who live in neighborhoods with higher per capita income are associated with a greater probability of both frequent physical activity and vigorous exercise. McMillan's (2007) study reveals that children who walk to school through areas where more windows face the street are more likely to walk or bike to school. Miles (2008) found that parents who live in neighborhoods with low to moderate physical disorder (*i.e.,* litter, graffiti, and lack of green-space) compared to high physical disorder were more likely to encourage their children from using the local playground. More research is needed to better understand the effect of neighborhood conditions and socio-demographics on children's activity-travel patterns.

School conditions will also have an impact on a child's activity-travel patterns. Availability of school-sponsored after-school programs will affect whether a child has the option to attend an extracurricular activity at school, and the rigorousness of the school program will affect the amount of time a child spends on homework. The overall school quality may contribute to the amount of academic support and encouragement a child receives, in turn affecting a child's decision to participate in out-of-school academic and enrichment programs, or the amount of time a child chooses to spend on his/her studies.

3.5.1.2 Laws and General Norms

Every society has laws and general norms that affect behavior. For example, if a city has a 10pm curfew for children, then after 10pm most children will not participate in activities alone with their peers in a public area, such as a park or mall. Also, different cultures vary in the typical activities that children are involved with. For example, children in East Asia spend more time doing homework than American children (Larson and Verma, 1999). Also, Netherlands has a very high bicycling rate, and similar to adults, children in the Netherlands bicycle to activities more than American children (Ministry of Transport, Public Works and Water Management, 2007).

In addition, the laws and norms associated with a specific day of the week will affect a child's activity-travel pattern for that day. For example, it is a societal norm within the Christian religion to participate in church on Sunday, while it is a law within the United States to attend

school during the week. Therefore, it is these general norms and laws that contribute to weekday activity-travel patterns differing from weekend activity-travel patterns.

3.5.2 Natural Environment

There are two components of the natural environment that affect a child's activity-travel patterns: weather and natural landscape. The weather, including temperature and precipitation, will affect a child's activity-travel pattern. For example, in periods of cold weather it is unlikely that a child will swim outdoors. In addition, if it is raining a child may not choose to walk to an activity that s/he usually walks to. The natural landscape in which a child lives will also affect the activities a child participates in. For example, in a cold mountainous environment, a child may ski on a daily basis, while in a warm climate along a coast, a child may take surfing lessons.

There are only a handful of studies that have found an association between the natural environment and children's activity-travel patterns. Copperman and Bhat (2007a) found an increase in the use of motorized vehicles for travel on a rainy day. Sener and Bhat (2007) found that children participate in more active recreation during the spring and summer, while Copperman and Bhat (2007a) report an increase in physically active travel during the summer. However, it is hard to discern whether an increase in recreation and physically active pursuits during the summer is due to warm weather, or due to the increased time available to spend on non-school activities.

3.5.3 Land-Use Environment

The land-use environment is defined as the presence and number of different types of man-made alterations to the natural environment that exist in a particular area, excluding transportation related alterations. With respect to the affect on children's activity-travel patterns, the land-use environment is represented by four dimensions: neighborhood and activity location land-use mix (Section 3.5.3.1), residential accessibility (Section 3.5.3.2), and the residential and activity locations of a child's social contacts (Section 3.5.3.3).

3.5.3.1 Neighborhood and Activity Location Land-Use Mix

Land-use mix refers to the percentage of different types of land-uses in a particular area. For example, rural areas have very different land-uses than very urban areas, and areas with a high employment density (such as a downtown central business district) have a very different land-use

mix than a suburban residential area. A child who lives in a rural area, where houses are spaced far apart and with few retail businesses in the area, may never walk from home to participate in a shopping, school, or social activity. On the other hand, a child who lives in an urban area may frequently walk or take public transportation to reach his/her activities. The land-use mix at the activity location will also influence a child's activity-travel patterns. If a child's school is located in an urban area where s/he can walk to access stores and restaurants, s/he may be more likely to hang out at these places after school.

A number of studies have examined how children's activity and travel behavior differs between children who live in an urban area and children who live in suburban and rural areas. Children who live in an urban area walk more than suburban and rural children (Weston, 2005; McDonald, 2004; Copperman and Bhat, 2007a) and take transit more (O'Brian and Gilbert, 2003; Weston, 2005; McDonald, 2004). Children living in a high population density and with good land-use mix are also more likely to walk to school (Yarlagadda and Srinivasan, 2007; Isebrand *et al.*, 2006; McMillan, 2007; Kerr *et al.*, 2007).

In contrast, those who live in a suburban or rural area travel by car more and are more likely to take the school bus to and from school (Isebrand *et al.*, 2006; O'Brian and Gilbert, 2003; Vliet, 1983; Weston, 2005; McDonald, 2004). McMeeking and Purkayastha (1995) found that children who live in a suburban area are less likely to have friends in walking and biking distance, compared to urban children. They are also more reliant on parents to chauffer them to activities. The study also revealed that children in suburban areas take part in more structured activities compared to urban children.

3.5.3.2 Residential Accessibility

The location of school and other desired activity locations in relation to a child's residence will greatly affect a child's activity-travel pattern. Many studies have confirmed that distance to school is a main determinant of whether or not a child will walk to school. The farther a child lives from school, the less likely a child will walk to school (Yarlagadda and Srinivasan, 2007; diGiuseppi *et al.*, 1998; Dellinger, 2002; Sjolie and Thuen, 2002). Specifically, McDonald (2005) found that only 3% of students walk who live over 1 mile away from school. In contrast, 79% of students walk who live within ¼ mile of school, 69% of children walk who live within ½ mile of school, and 54% walk if living within one mile of school. Overall, less than one-quarter of children live within 1 mile of school, and therefore, three-fourths of children essentially do not

have the option to walk to school (Sallis *et al.*, 2004; McDonald, 2005). Taking into account street characteristics, Falb *et al.* (2007) found an even lower percentage of children who could potentially walk to school. They calculated that 6% of elementary school students, 11% of middle school students, and 6% of high school students are able to walk to school in Georgia.

A policy that is becoming more common in U.S. school systems is the concept of school choice, system-wide schools, and magnet schools. Essentially, parents are given the option of sending their children to a school other than their neighborhood school. Wilson *et al.* (2007) sought to examine the implications of school choice on walking to school and report that city-wide schools had six times fewer children walking to and from school compared to neighborhood schools. Unfortunately, if school choice is adopted by more school systems, the number of children walking and bicycling to school could decrease even further.

Yarlagadda and Srinivasan (2007) also found some interesting results with regard to school location. They discovered that walking distance was a larger barrier to walking to school compared to walking home from school and, therefore, children are more likely to walk further distances home from school than they are to reach school. In addition, they found that school location in reference to a mother's work location influences whether a child will be driven to school by his or her mother. Specifically, the greater excess travel time to get to school on the way to work, the less likely a mother will drive a child to school.

The location of other activities will also affect the mode a child takes to reach activities and whether a child participates in a specific type of activity. If the activity is located at school, then a child will not have to be escorted to the activity by a parent or other driving adult, and may have the option to take the after-hours school bus home from school. If a store is located close to a child's house, then a child may choose to walk to and shop at the store. If the store is not in walking distance, the child may not leave home. Four studies in the literature focused on the impact of the number and type of different land-uses and facilities within a neighborhood on levels of physical activity. The studies found that (1) children who live in an area with more restaurant and food stores are more likely to walk as a means of transportation (Copperman and Bhat, 2007a); (2) children with greater access to recreational facilities are, also, more likely to walk (Kerr *et al*., 2007); (3) more commercial physical activity facilities within ¾ miles of home is associated with higher levels of vigorous physical activity in female adolescents (Pate *et al.*, 2008); and (4) having an access to a safe park is associated with higher levels of regular physical activity in adolescents in urban areas, but not rural areas (Babey *et al*., 2008).

3.5.3.3 Residential and Activity Locations of a Child's Social Contacts

The residential and activity locations of a child's social contacts also affect a child's activity-travel patterns. Axhausen (2003) highlights the importance of analyzing the spatial location of individual's social networks when analyzing an individual's activity-travel patterns, specifically with regard to leisure travel. In the case of children, whether a child is allowed to visit with a friend after school, and the amount of planning required, may be determined by the residential location of the child's friend. If a child's friend lives next door, a child may choose to play with the friend at the last minute and very little resistance may come from the parent, since escorting the child is not required. The location of a parent's work in relation to a child's school influences whether a child is dropped off at school by the parent. For example, as mentioned earlier, if school is very close, or on the way to a mother's work, then the mother is more likely to drop the child off at school (Yarlagadda and Srinivasan, 2007).

3.5.4 Transportation Environment

The activity-travel pattern of a child is affected by the transportation environment. The transportation environment includes the transportation modes available, level-of-service on the available modes, the condition of the modes, and the layout of the transportation system.

The selected mode of transportation used to get to different activities is limited by the availability of a particular mode. For example, if a child attends school in a school system that does not provide school bus service then the child does not have the option to travel to school by school bus. On the other hand, if a child lives in a very transit-oriented metropolitan area, such as New York City, the child may take the subway to an activity after school.

The level-of-service by each transportation mode will also have an impact on a child's activity-travel patterns. A study of British school children found that high monetary cost is a major deterrent of a child's desire to ride public transport (Stafford *et al.*, 1999). If a child is traveling during the peak travel period, the child's travel time will be higher than if the child travels during the non-peak period. Reliability of the transportation mode to get an individual to an activity on time may also influence the decision to use the mode. For example, Schwanen and Ettema (2006) point to the strong desire of parents to not be late when picking up their children from day care.

The conditions of the transportation mode may encourage or discourage a child from using the mode. In general, children find private vehicles, compared to other modes, to be more comfortable and secure (Stafford *et al.*, 1999). Some children in Britain have a negative view toward the cleanliness of the local buses, which deters them from using the bus system (Stafford *et al.*, 1999). The lack of good pedestrian lighting in a neighborhood may discourage children from walking at night, or discourage parents from allowing their children to walk alone at night.

The transportation system, including highways, transit lines, bicycle lanes, and sidewalks, may be laid out in such a way that either promotes or discourages a child from traveling by a particular mode or traveling to a particular activity location. For example, a grocery store may be less than a quarter mile away from a child's residence, but if there is a major highway separating the residence from the store, then the child will never access the grocery store by walking. The presence of cul-de-sacs near a child's residence may have both a positive and negative effect on children's participation in physical activity. For example, cul-de-sacs allow children to play sports in the street, since cul-de-sacs tend to have low traffic volumes and speeds. However, suburban areas with cul-de-sacs tend to have very circuitous streets that do not allow easy access by walking to reach stores or businesses, even if the Euclidian distance is quite short.

Only a few studies have attempted to find a relationship between the transportation environment and an aspect of a child's activity-travel patterns. The results are sparse and mixed. Copperman and Bhat (2007a) examined the effect of transportation environment characteristics on children's participation rates and levels in active recreation and report that larger average block size and greater bikeway density around the child's home is associated with higher levels of participation in active recreation. McMillan (2007), Bournet *et al.* (2005), and Staunton *et al.* (2003) focused on the transportation environment's influence on mode choice to school. They found that sidewalk and street crossing improvements near a school are associated with more children walking to school. On the other hand, McMillan (2007) observed that the presence of a complete sidewalk system along the journey route to school showed no relationship to a child's mode choice to school.

3.6 Summary

A number of different factors influence a child's activity-travel pattern. These factors may be grouped into four categories: the demographics of the child and the child's social contacts, the

attitudes of the child and his/her social contacts, the activity-travel patterns of the child's social contacts, and the child's environment. Previous research has focused on examining the effects of many of these factors, with emphasis on the impact of the demographic factors associated with the child, parent, and household. However, despite the extensive research on children's activity-travel patterns, considerable investigation is still needed to better understand the extent to which other household members' and non-household members' demographics, attitudes, and activity-travel patterns influence children's activity and travel behavior. There are also several different types of environmental factors that affect children's activity-travel behavior, all of which warrant further study.

CHAPTER 4:
EMPIRICAL ANALYSIS OF CHILDREN'S AFTER SCHOOL OUT-OF-HOME ACTIVITY-LOCATION ENGAGEMENT PATTERNS AND TIME ALLOCATION

4.1 Representation of Children's Post-School Activity-Travel Patterns

At a fundamental level, the complete characterization of a child's post-school activity-travel pattern entails the full spatial, temporal, activity purpose, and travel mode attributes of each activity episode undertaken after school, as well as the sequencing of all activity episodes (in-home as well as out-of-home). Due to the large number of attributes across activity episodes and the large number of possible choice alternatives for each attribute, the joint modeling of all attributes of all episodes is infeasible. Consequently, a representation framework that is feasible to implement from a practical standpoint is required.

We propose a three-tiered representation framework for children's post-school activity-travel patterns. At the first level, we propose the examination of the overall progression of a child's pattern in terms of three activity-travel dimensions: (1) the broad characterization of the activity episode location immediately following the end of classes at school (*i.e.*, whether the child goes home, stays at school, or goes to a non-home location at the end of classes), (2) the broad characterization of the episode locations immediately following any stay at school episode (*i.e.*, whether the child goes home or goes to another location after staying at school), and (3) the post-home arrival activity-travel pattern (whether a child stays at home after arriving home or pursues one or more non-home activities after returning home). Figure 6 shows the seven possible patterns based on these three dimensions. The patterns are numbered at the bottom and correspond to the following:

1. Return directly home from school and stay at home,
2. Return directly home from school and go back out,
3. Stay at school after school, then return home and stay home,
4. Stay at school after school, then return home and go back out,
5. Stay at school after school, then go elsewhere,
6. Go elsewhere after school, then return home and stay home, and
7. Go elsewhere after school, then return home and go back out.

For Patterns 2, 4, and 7, note that the "go back out" activity instances include all episodes until the final return home at the end of the day. Thus, Pattern 2 may represent a child who goes back out to do personal business after returning home directly from school, then returns home from the personal business episode, and then goes back out again to recreate. The personal business episode, the home return, and the recreation episode all are contained in the "go back out" activity instance of Pattern 2. For Pattern 5, one could extend the pattern to a return home followed by a "go elsewhere" activity instance, but such an extended pattern rarely occurs. So, we confine the analysis to a "stay at school" activity instance followed by one or more episodes pursued at one or more non-home locations (within the "go elsewhere" box) and a return home/stay home episode.

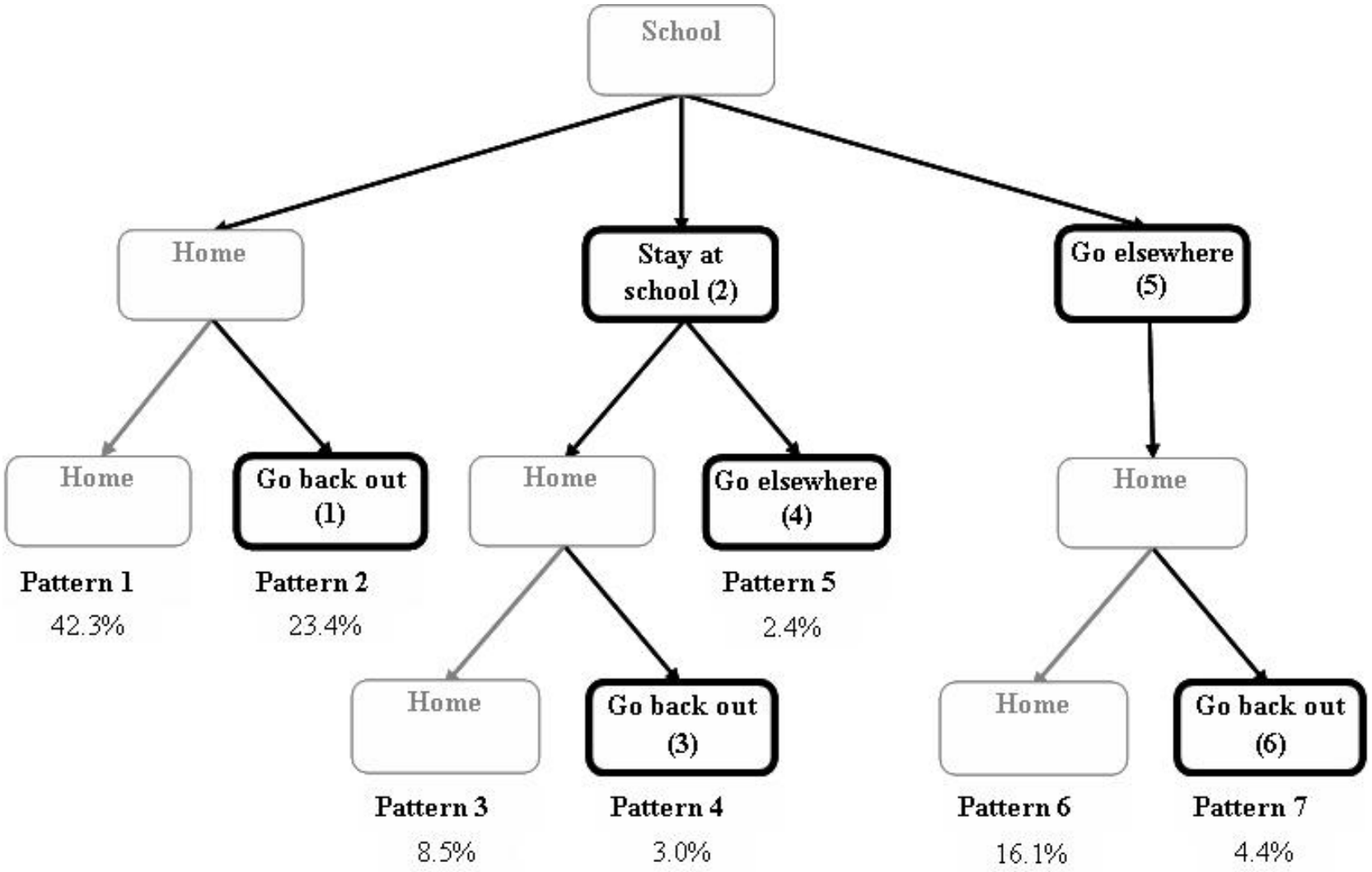

Figure 6. Children's Post-School Patterns and Percentage of Children Choosing each Pattern

At the second level of the representation framework, the emphasis is on analyzing the attributes of each out-of-home activity episode within the "stay at school", "go back out", and "go elsewhere" activity instances of the child's chosen pattern of Figure 6 (these instances are identified by the dark boxes in Figure 6, and have been numbered within the dark boxes). The attributes of the out-of-home activity episode participations include activity purpose, duration, and location type, where the location type attribute is applicable only for the episodes in the "go back out" and "go elsewhere" activity instances. It should also be noted that, while any activity purpose taxonomy may be used for episodes at this level, the one adopted in the empirical analysis of the current paper includes seven activity purposes – organized activities, personal business, recreation, social, childcare, meals, and other. These activity purposes were determined based on the classification scheme adopted in the survey that formed the basis for the empirical analysis, as well as on ensuring that a reasonable number of children actually chose each activity purpose in the sample. Similar considerations led to the use of four location types for activity episode participations in the "go back out" and "go elsewhere" activity instances – school, someone else's home, restaurant, and other location types.[2] Note that a child may participate in multiple out-of-home episodes of different purposes at each of the activity instances (dark boxes of Figure 6), and this is accommodated at this second representation level (we will refer to this second level as the *activity episode purpose-location type* level in the rest of this paper).

The third and final representation level entails the sequencing of the out-of-home episodes within each of the "stay at school", "go elsewhere" and "go back out" activity instances, along with the precise spatial location, time-of-day, and travel mode attributes of each episode (for brevity, we will refer to this third level as the *episode sequencing* level). This level also determines if there are any in-home episodes interspersed between out-of-home activity episodes of each activity instance. At the end of this three-level representation, one essentially has characterized the complete post-school activity-travel pattern of a child.[3]

[2] It is possible to have "school" as an activity location alternative for each of the "go back out" and "go elsewhere" instances. For example, consider the "go elsewhere" instance (box number 5) of Pattern 6 in Figure 6. If a child leaves school to participate in a recreation activity at someone else's home, next returns back to school for a recreational event, and finally goes home and stays there, the child would fall in Pattern 6 and the "go elsewhere" instance would include two episodes - "recreation at someone else's home" and "recreation at school".

[3] If one desires, it is also possible to detail the in-home activity episode attributes in a manner similar to level 2 for the out-of-home episodes. Then, all the in-home and out-of-home episodes can be sequenced in level 3. In this paper, we do not consider the in-home episodes of children.

4.2 Current Study in the Context of Earlier Studies

The focus of the current study is on the first two levels – the *pattern* level and the *activity episode purpose-location type* level – of the three-tiered representation just discussed. In doing so, we build upon several earlier studies that have examined one or more dimensions of children's activity participation within these two levels. We provide a brief overview of these studies below.

In the context of the *pattern* level of our proposed representation framework, Clifton (2003) and McDonald (2005) descriptively examined the percentage of students who returned directly home from school, made stops on the way home from school, and who went back out after returning home. But these studies did not estimate models to study the factors affecting a child's choice of post-school activity pattern. These studies also did not examine the activity location instance (whether at school or elsewhere) of the activities pursued immediately after school, nor did they consider all possible after school patterns.

Several studies have examined children's participation and duration of participation in activities by purpose during the after school period. These studies contribute to the *activity episode purpose-location type* level of our proposed framework, and can be grouped into three areas: (1) Studies that examine a specific type of after school activity such as leisure participation or structured activities (see, for example, Huebner and Mancini, 2003; Sener *et al*., 2008; and Harrell *et al*., 1997), (2) Descriptive time-use studies which examine children's overall daily participation rate and duration of participation in a variety of activities (see, for example, Hofferth and Sandberg, 2001; Copperman and Bhat, 2007b; Stefan and Hunt, 2006; and Larson and Verma, 1999), and (3) Studies that examine the factors affecting after-school daily or weekly activity participation within a select age or population group (see, for example, Zill *et al*., 1995; Posner and Vandell, 1999; and Shann, 2001). The studies identified above, while providing important insights, are focused on overall time-use in activities after school, rather than on the sequencing of activity episodes and duration/location type of individual episodes.

An important aspect of the current study is the emphasis on the location dimension of activity episode participation. In particular, we recognize school as an important location for after-school activities. There are three reasons to explicitly consider school as a possible location for children's post-school activities. First, school is a popular activity location for after school activities. A study by Copperman and Bhat (2007b) found that over 20% of children participate in activities at school during the post-school period. In addition, Hofferth and Jankuniene (2001)

found that 8% of children, aged 5 to 13, remain at school directly after school. Second, if a child remains at school after classes, he/she may not have the option to take the school bus home since the school bus normally departs immediately at the end of classes. Previous research on school mode choice does not recognize this issue as a factor in mode choice decisions (see Yarlagadda and Srinivasan, 2007 for a review of school mode choice studies). Third, the explicit consideration of the propensity of children to participate in activities at school provides an improved characterization of children's post-school activity-travel pattern.

Notwithstanding the importance of the location dimension for after-school activities in general, and the importance of considering school as a potential location in particular, there has been only one study by Hofferth and Jankuniene (2001) that has explicitly examined children's activity location directly after school. However, this earlier study is descriptive in nature and does not consider the location of activity episodes beyond that pursued immediately after school (*i.e.*, it does not consider the location of out-of-home episodes pursued after a child returns home from school or from the non-school location activity episode(s) pursued immediately after school).

The rest of this report is structured as follows. Section 4.3 describes the analysis framework and model formulation. Section 4.4 discusses the data source and sample formation, and presents the *pattern* level and *activity episode purpose-location type* level descriptive statistics. Section 4.5 presents the empirical analysis results. Finally, Section 4.6 summarizes the chapter and discusses important findings.

4.3 Analytic Framework

In this section, we present the alternatives and the model structures used for each of the pattern and activity episode purpose-location type models.

4.3.1 Pattern Model

As indicated earlier in Section 4.1, there are seven possible alternatives for a child's post-school activity-travel pattern (see Figure 6). We considered a simple multinomial logit model as well as different two-level nesting structures to analyze the choice among these seven alternatives. However, the nesting structures were not supported by the data, either because the log-sum parameter exceeded one or was not significantly less than one. Thus, the final model structure

for location class sequencing in the current paper corresponded to a simple multinomial logit (MNL) model.

4.3.2 Activity Episode Purpose-Location Type Model

This model examines the activity episode purpose-location type attributes, as well as the activity duration, for each out-of-home episode within the "stay at school", "go back out", and "go elsewhere" instances, conditional on the child's pattern. As indicated in Section 4.2, we identify seven activity purposes. Further, for episodes in the "stay at school" instance (box 2 in Figure 6), there is only one location type, which is "school". Thus, for the episodes in this box, the only available activity episode purpose-location type combinations are the seven activity purposes. For the out-of-home episodes in the "go back out" and "go elsewhere" boxes, there can be four location types – school, someone else's home, restaurant, and other. Technically, then, one could have 28 activity purpose-location type combinations for each of these two box types. However, many of these combinations seldom occur in the sample. For instance, consider "personal business" episodes within the non-stay at school instances (boxes 1, 3, 4, 5 and 6 of Figure 6). Almost all of these episodes occur at a location other than at someone else's home, school, or at a restaurant. Thus, we use a single "personal business" alternative without further partitioning this by location type.

After careful consideration of the number of episodes of each possible activity episode purpose-location type combination in the sample, we identified a total of twelve alternatives for the empirical analysis: (1) Organized activities at school, (2) Organized activities at a location other than school, (3) Personal Business, (4) Recreation at someone else's home, (5) Recreation at school, (6) Recreation at other locations, (7) Social at someone else's home, (8) Social at locations other than someone else's home, (9) Childcare, (10) Meals at restaurant, (11) Meals at a location other than a restaurant (over 70% of such episodes are at someone else's home), and (12) Other.

As children can engage in multiple activity episode purpose-location type combinations within each of the activity instances (boxes labeled 1 through 6) in Figure 6, and allocate time to each of the activity episode purpose-location types, a multiple discrete-continuous extreme value (MDCEV) model formulation is adopted (see Bhat, 2005 and Bhat, 2008). While separate MDCEV models can be estimated for each activity instance, we estimate a single universal MDCEV model for efficiency considerations. In doing so, however, we use variables that

identify the activity instance, since some activity episode purpose-location type combinations are more likely to occur in certain activity instances than others (for example, "organized activities at school" are more likely to occur in the "stay at school" activity instance than in other activity instances). Also, note that some alternatives may not be available for episodes in some activity instances, which we recognize by considering only the feasible alternatives for each activity instance (for example, "organized activities at location other than school" or "recreation at other locations" are not feasible alternatives for the "stay at school" box in Figure 6). We next briefly describe the basic MDCEV model structure.

Let t_k be the time invested in alternative k (k = 1, 2, …, K) at each activity instance, where k is an index for the activity episode purpose-location type combinations. Consider the following additive, non-linear, functional form to represent the utility accrued by an individual through time investment in various activity episode purpose-location type combinations at each activity instance (the index for the individual and the activity instance is suppressed in the following presentation)[4]:

$$U(\boldsymbol{t}) = \sum_{k=1}^{K} \frac{1}{\alpha_k} \exp(\beta' z_k + \varepsilon_k) \left\{ \left(t_k + 1\right)^{\alpha_k} - 1 \right\} \quad (1)$$

z_k is a vector of exogenous determinants (including a constant) specific to alternative k (there is no such vector for the first alternative because only differences in utilities matter, as shown later). The term $\exp(\beta' z_k + \varepsilon_k)$ represents the random marginal utility of one unit of time investment in alternative k at the point of zero time investment for the alternative. This can be observed by computing the partial derivative of the utility function $U(\boldsymbol{t})$ with respect to t_k and computing this marginal utility at $t_k = 0$ (*i.e.*, $\partial U(\boldsymbol{t}) / \partial t_k \big|_{t_k = 0}$). Thus, $\exp(\beta' z_k + \varepsilon_k)$ controls the discrete choice participation decision in alternative k. We will refer to this term as the baseline preference for alternative k. α_k is a satiation parameter whose role is to reduce the marginal utility with increasing consumption of alternative k. When α_k = 1 for all k, this represents the case of absence of satiation effects. Values of α_k closer to zero imply higher satiation (or lower time investment) for a given level of baseline preference.

[4] Several other additive, non-linear, utility forms, as proposed by Bhat (2008), were also considered. However, the one provided below was the best form in the empirical analysis of the current paper.

From the analyst's perspective, individuals are maximizing random utility $U(\boldsymbol{t})$ at each activity instance subject to the time budget constraint that $\sum_k t_k = T$, where T is the total time available for children to participate in various activity episode purpose-location types. The optimal time investments t_k^* (k = 1, 2, ..., K) can be found by forming the Lagrangian function (corresponding to the problem of maximizing random utility $U(\boldsymbol{t})$ under the time budget constraint T) and applying the Kuhn-Tucker (KT) conditions. After extensive, but straightforward, algebraic manipulations, the KT conditions collapse to (see Bhat, 2008):

$$\begin{aligned} &V_k + \varepsilon_k = V_1 + \varepsilon_1 \text{ if } t_k^* > 0 \ (k = 2, 3, \ldots, K) \\ &V_k + \varepsilon_k < V_1 + \varepsilon_1 \text{ if } t_k^* = 0 \ (k = 2, 3, \ldots, K), \text{ where} \\ &V_k = \beta' z_k + (\alpha_k - 1)\ln\left(t_k^* + 1\right) \ (k = 1, 2, 3, \ldots, K). \end{aligned} \tag{2}$$

Assuming that the error terms ε_k (k = 1, 2, …, K) are independent and identically distributed across alternatives with a type 1 extreme value distribution, the probability that the child allocates time to the first M of the K alternatives (for duration t_1^* in the first alternative, t_2^* in the second, … t_M^* in the M^{th} alternative) is (see Bhat, 2008):

$$P\left(t_1^*, t_2^*, t_3^*, ..., t_M^*, 0, 0, ..., 0\right) = \left[\prod_{i=1}^{M} c_i\right]\left[\sum_{i=1}^{M} \frac{1}{c_i}\right]\left[\frac{\prod_{i=1}^{M} \varsigma_i e^{V_i}}{\left(\sum_{k=1}^{K} \varsigma_k e^{V_k}\right)^M}\right](M-1)! \tag{3}$$

where $c_i = \left(\frac{1-\alpha_i}{t_i^* + 1}\right)$ and ς_k = 1 if alternative k is available for the activity instance under consideration.

4.4 Data Source and Sample

4.4.1 Data Source

The data source for this analysis is the 2002 Child Development Supplement (CDS-II) to the Panel Study of Income Dynamics (PSID). The PSID is a longitudinal study that collected demographic, employment and health information from a national sample of individuals and households. The CDS-II surveyed over 2,500 children through health and achievement test surveys, primary caregiver and child interviews, and a two-day time-use diary - one for a

weekday and the other for a weekend day. The time-use diary collected information on the type, number, duration, and location of activities for each 24-hour survey day beginning at midnight. Paper diaries were mailed to children, filled out on or around the activity day, and then retrieved and reviewed by an interviewer either by phone or in person. Older children and adolescents were expected to fill out their own diary, while primary caregivers aided younger children.

4.4.2 Sample Formation

The process of generating the sample for analysis involved several steps. First, only individuals aged five through seventeen who were enrolled in primary or secondary school and who attended school on the activity day were considered for the analysis. Also, only children who filled out at least a weekday diary and provided complete supplemental information were included. The final sample for analysis includes 2,065 children. Second, activity episode purposes were reclassified from the 365 original types into 8 activity purposes: (1) School, (2) Organized activities (*i.e.* lessons, meetings, and clubs), (3) Personal business (*i.e.* shopping, obtaining services, paying bills, writing e-mails or letters), (4) Recreation (*i.e.* unorganized hobbies and sports, outings, reading, playing, TV viewing, and music), (5) Social (including conversations, being intimate, parties, visiting, and religious services), (6) Childcare (*i.e.* daycare, being babysat) (7) Meals (including snacks), and (8) Other. Third, activity episode locations were collapsed into five location types: (1) Home, (2) School, (3) Someone else's home (including other parents' home), (4) Restaurant, and (5) Other. Fourth, out-of-home activity instances were identified by re-organizing the activity episodes based on location of performance (in-home or out-of-home), followed by the tracing of the sequence of out-of-home and in-home episodes. Fifth, the time investments across all activity episode purpose-location types in an activity instance were aggregated to obtain total activity instance time investments. Thus, for each individual, there is a complete profile of multiple activity episode purpose-location type participation at each activity instance point. Finally, individual and household demographic and socio-economic characteristics, as well as attitude and environment variables, were appended to the activity and time use data set to compile a comprehensive database suitable for modeling children's activity-location engagement patterns as a function of observed characteristics.

4.4.3 Pattern and Activity Episode Purpose-Location Type Statistics

Figure 6 provides statistics on the percentage of children in each pattern. As can be observed, 65.6% of all children go directly home after school (corresponding to Patterns 1 and 2), 13.9% stay at school immediately after school (corresponding to Patterns 3, 4, and 5), and 20.5% go elsewhere immediately after school (corresponding to Patterns 6 and 7). Hofferth and Jankuniene (2001), McDonald (2005), and Clifton (2003) also find similar results. Overall, over 30% of children do not go home directly after school, and a majority of children (57.7%) participate in at least one out-of-home activity after school. These findings reinforce the notion that children's activities are responsible for a significant number of household trips.

Table 1 presents the number and percentage of activity episode purpose-location type participations within each activity instance (the percentages are computed row-wise, so that for each activity episode purpose-location type combination, the percentages sum to 100 across all activity instance columns). By definition, the "Stay at school" activity instance (box 2 in Figure 6) does not include some activity episode purpose-location type combinations (see Columns 5 and 6 of Table 1).

Table 1. Number and Percentage of Activity Episode Purpose-Location Type at each Activity Instance

Activity episode purpose-location type	Total	Go back out (1)		Stay at school (2)		Go back out (3)		Go elsewhere (4)		Go elsewhere (5)		Go back out (6)	
		Num.	% of type	Num.	% of type	Num.	% of type	Num.	% of type	Num.	% of type	Num.	% of type
Org. activities at school	226	38	16.8	152	67.3	6	2.7	4	1.8	15	6.6	11	4.9
Org. activities at location other than school	169	95	56.2	--	--	16	9.5	8	4.7	30	17.8	20	11.8
Personal business	235	100	42.6	1	0.4	10	4.3	16	6.8	87	37.0	21	8.9
Rec. at someone else's home	245	91	37.1	--	--	3	1.2	8	3.3	131	53.5	12	4.9
Rec. at school	87	32	36.8	35	40.2	6	6.9	1	1.1	4	4.6	9	10.3
Rec. at other location	176	86	48.9	--	--	10	5.7	5	2.8	66	37.5	9	5.1
Social at someone else's home	115	56	48.7	--	--	6	5.2	6	5.2	35	30.4	12	10.4
Social at location other than someone else's home	111	44	39.6	28	25.2	6	5.4	7	6.3	17	15.3	9	8.1
Childcare	122	4	3.3	52	42.6	0	0.0	1	0.8	65	53.3	0	0.0
Meals at restaurant	100	53	53.0	--	--	8	8.0	6	6.0	24	24.0	9	9.0
Meals at location other than restaurant	139	29	20.9	9	6.5	1	0.7	10	7.2	87	62.6	3	2.2
Other	310	84	27.1	66	21.3	9	2.9	14	4.5	131	42.3	6	1.9
Total	2035	712	35.0	343	16.9	81	4.0	86	4.2	692	34.0	121	5.9

There are several interesting insights that may be drawn from Table 1. First, the majority of organized activities at school take place directly after school (*i.e.*, in activity instance "stay at school"), while the majority of organized activities at locations other than school are undertaken by children who first return directly home from school (*i.e.*, in box 1 of Figure 6). Second, personal business is most likely to be undertaken after returning home directly from school (in box 1 of Figure 6) and directly after school (in box 5 of Figure 6). It is quite possible that these statistics indicate children accompanying an adult on the adult's errands, rather than a child undertaking his/her own personal business needs. Third, among all activity episode purpose-location type alternatives, children participate most in "recreation at someone else's home" (see the second column of Table 1 labeled "Total"; the row labeled "Other" has a higher number than "Recreation at someone else's home", but is a combination of several activity episode purpose-location types). The majority of participations in "recreation at someone else's home" is undertaken immediately after school (in box 5 of Figure 6). The finding that many children travel to a friend's or relative's home immediately after school, instead of to their own home, emphasizes the importance of considering inter-household interactions in school and post-school mode and activity choice models. Finally, over 95% of "childcare" episodes occur immediately after school, either at school or at another location. This finding is logical, since it is during the afternoon period, when parents are still at work, that a child needs non-parent adult supervision.

Table 2 presents additional descriptive statistics on participation in the activity episode purpose-location types, including (1) the percentage of activity episode purpose-location type cases that are participated alone within an activity instance, (2) the percentage participated in combination with other episode types, (3) the total number of each episode type across all activity instances, and (4) the mean duration of participation in each activity episode purpose-location type alternative, conditional on participation in that alternative. The findings reveal that organized activities and childcare are the activities that are most likely to be undertaken in isolation (see Column 2 of Table 2). In combination with the findings from Table 1, the implication is that many children stay at school for the sole purpose of participating in organized activities or daycare, or make a single one stop tour immediately after school or from home to undertake these activities. On the other hand, social activities and meals at a location other than a restaurant are most likely to be undertaken in conjunction with other episode types. It is also noteworthy that "meals at restaurant" have a much higher solo participation rate and duration of participation compared to meals at other locations. This finding reinforces the importance of

examining episode location in addition to activity type. With regard to duration of participation, not surprisingly, organized activities, recreation, and receiving childcare have the longest duration of participation, while personal business and meals have the shortest duration of participation (see last column of Table 2).

Table 2. Descriptive Statistics of Activity Episode Purpose-Location Type Participation

Activity episode purpose-location type	Only activity episode purpose-location type in activity instance (%)	Act. episode purpose-location type + other act. episode purpose-location types in act. instance (%)	Total num.	Mean duration in activity instance (min.)
Organized activities at school	71.7	28.3	226	111.7
Organized activities at location other than school	60.9	39.1	169	98.8
Personal business	50.6	49.4	235	45.1
Recreation at someone else's home	37.1	62.9	245	105.7
Recreation at school	48.3	51.7	87	102.1
Recreation at other location	35.8	64.2	176	95.5
Social at someone else's home	1.7	98.3	115	82.3
Social at location other than someone else's home	4.5	95.5	111	69.4
Childcare	79.5	20.5	122	127.4
Meals at restaurant	35.0	65.0	100	61.3
Meals at location other than restaurant	10.1	89.9	139	32.0
Other	33.2	66.8	310	111.7

4.5 Empirical Analysis

4.5.1 Variable Specification

Discrete choice and MDCEV model specifications were developed and estimated for this study. Several types of variables were considered as determinants of children's activity-travel patterns. Also, different variable specifications and functional forms (*e.g.*, linear and non-linear income and age effects) were attempted to identify the model specification that provided the most

intuitively appealing behavioral interpretation and statistical indications. The final set of exogenous variables in the models may be classified into five groups:

1) Child demographics: grade (grade k-4, grade 5-8, and grade 9-12), ethnicity (White Non-Hispanic, Hispanic, Black Non-Hispanic, and other), disabled (whether child is physically or mentally disabled or not), and overweight status (whether child has BMI above 95% in the child's gender and age group or not).

2) Household demographics: household income (yearly income is less than $25,000, $25,000-$90,000, or above $90,000), number of household vehicles, household size, number of adults in household, single child household (whether child is only child in household or not), internet access (whether household has internet or not), single-family home (whether household resides in single-family house or not), primary caregiver (whether primary caregiver is mother, father, grandmother, or other individual), age of primary caregiver, presence of younger siblings, and presence of older siblings.

3) Child's attitude variables: high educational ambition (whether child's preferred education is to attend professional/graduate school or not), gifted program participation (whether child has ever attended a gifted program or not), special education participation (whether child has ever attended special education or not) and sociability (whether child socializes with friends at least once a week or less than once a week).

4) Environment/contextual variables: private school (whether child attends private school or not), neighborhood quality (whether primary caregiver believes neighborhood is a good place to raise a child or not), neighborhood safety (whether primary caregiver believes neighborhood is safe or not), city size (whether child resides in county containing city size over 1 million or not), metropolitan area county (whether child resides in county within a metropolitan area or not), and Friday (whether activity day is Friday or not).

5) Others' activity-travel patterns: primary caregiver works after school (whether primary caregiver works on activity day later than child finishes school or not), and other caregiver works after school (whether non-primary caregiver works on activity day later than child finishes school or not).

4.5.2 Empirical Results

4.5.2.1 Pattern Model

Model estimation results for the pattern MNL model are presented in Table 3 and the model estimation results for the activity episode purpose-location type participation and time-use MDCEV model are presented in Table 4. The reader should note that the missing variables in Table 3 and Table 4 constitute the base category. For instance, in Table 3, the base category for introducing the grade-level variables is grades k-4, while in Table 4 the base category is grades 5-12. Also, note that some estimates may be the same across different alternatives for a variable, which implies that the coefficient values are not statistically significantly different and have been combined. Finally, the variable effects in Tables 3 and 4 reflect the impacts on the utility of alternatives. If a variable effect does not appear in the row corresponding to an alternative (as reflected by a "--" entry), it implies that the alternative forms the base about which the variable effect on other alternatives is evaluated. For instance, in Table 3, the effect of the "Grade 5 to 8" variable appears only for sequences 6 and 7, with the effective coefficient for all the other alternatives being zero.

Table 3. Pattern MNL Model

	Constants	Child Demographics			
		Grade 5 to 8	Grade 9 to 12	Disabled	Overweight
Go home then:					
Stay at home (Pattern 1)	--	--	--	--	--
Go back out (Pattern 2)	-1.7177 (-11.66)	--	0.3686 (2.95)	-0.8343 (-2.29)	-0.2407 (-2.05)
Stay at school then:					
Return home and stay home (Pattern 3)	-2.7536 (-19.96)	--	0.9402 (6.67)	--	--
Return home and go back out (Pattern 4)	-5.0839 (-19.05)	--	0.9402 (6.67)	--	-0.2407 (-2.05)
Go elsewhere (Pattern 5)	-5.0969 (-21.63)	--	0.9402 (6.67)	--	-0.2407 (-2.05)
Go elsewhere then:					
Return home and stay home (Pattern 6)	-1.2788 (-6.47)	-0.6084 (-4.69)	--	--	--
Return home and go back out (Pattern 7)	-3.6021 (-9.74)	-0.6084 (-4.69)	--	--	-0.2407 (-2.05)

Table 3 (cont.) Pattern MNL Model

	Household Demographics				
	Income is $90,000+	**Num. of hh vehicles**	**Only one child lives in hh**	**Num. of adults in hh**	**Household has internet**
Go home then:					
Stay at home (Pattern 1)	--	-0.2235 (4.62)	-0.2846 (2.18)	--	0.3220 (-3.15)
Go back out (Pattern 2)	0.3132 (2.55)	--	-0.2846 (2.18)	--	--
Stay at school then:					
Return home and stay home (Pattern 3)	--	-0.2235 (4.62)	--	--	--
Return home and go back out (Pattern 4)	0.3132 (2.55)	--	--	--	--
Go elsewhere (Pattern 5)	0.3132 (2.55)	--	--	--	--
Go elsewhere then:					
Return home and stay home (Pattern 6)	--	--	--	-0.2856 (-3.43)	--
Return home and go back out (Pattern 7)	0.3132 (2.55)	--	--	-0.2856 (-3.43)	--

Table 3 (cont.) Pattern MNL Model

	Household Demographics		Other's Dem.	Child's Attitudes		
	Single-family dwelling unit	**Father is prim. caregiver**	**Has older sibling**	**High educ. ambition**	**Gifted program**	**Sociable**
Go home then:						
Stay at home (Pattern 1)	--	--	--	--	-0.3169 (2.85)	--
Go back out (Pattern 2)	--	--	--	--	-0.3169 (2.85)	0.5679 (5.14)
Stay at school then:						
Return home and stay home (Pattern 3)	--	--	--	0.4375 (3.20)	--	--
Return home and go back out (Pattern 4)	--	--	--	0.4375 (3.20)	--	0.5679 (5.14)
Go elsewhere (Pattern 5)	--	--	--	0.4375 (3.20)	--	0.5679 (5.14)
Go elsewhere then:						
Return home and stay home (Pattern 6)	--	0.6683 (2.94)	--	--	--	--
Return home and go back out (Pattern 7)	0.8860 (2.79)	--	0.4490 (2.04)	--	--	0.5679 (5.14)

Table 3 (cont.) Pattern MNL Model

	Environment/Contextual				
	Attends private school	**High quality neighborhood**	**Safe neighborhood**	**City size over 1 million**	**Activity day is Friday**
Go home then:					
Stay at home (Pattern 1)	--	--	--	--	--
Go back out (Pattern 2)	0.6111 (3.03)	-0.4251 (-2.53)	--	--	0.3381 (2.80)
Stay at school then:					
Return home and stay home (Pattern 3)	0.8662 (3.81)	--	--	--	--
Return home and go back out (Pattern 4)	0.8662 (3.81)	--	--	--	0.3381 (2.80)
Go elsewhere (Pattern 5)	0.8662 (3.81)	--	0.7892 (2.31)	--	0.3381 (2.80)
Go elsewhere then:					
Return home and stay home (Pattern 6)	--	--	--	--	--
Return home and go back out (Pattern 7)	--	--	--	-0.8951 (-3.61)	0.3381 (2.80)

Table 3 (cont.) Pattern MNL Model

	Other's Activity-Travel Patterns	
	Prim. caregiver works after sch.	**Other caregiver works after sch.**
Go home then:		
Stay at home (Pattern 1)	-0.6858 (7.10)	--
Go back out (Pattern 2)	-0.6858 (7.10)	--
Stay at school then:		
Return home and stay home (Pattern 3)	--	--
Return home and go back out (Pattern 4)	--	0.6441 (2.36)
Go elsewhere (Pattern 5)	--	--
Go elsewhere then:		
Return home and stay home (Pattern 6)	--	--
Return home and go back out (Pattern 7)	--	--

Child Demographics

The pattern model results in Table 3 indicate that children in grades 5-8 are less likely than children in grades k-4 and grades 9-12 to go elsewhere directly after-school (see the negative coefficient of -0.6084 for Sequences 6 and 7 in the column labeled "Grades 5 to 8"). Such children are more likely to either go back home or stay at school immediately after school. This result is similar to other studies that found that middle school children make the least number of post-school trips and are the most likely to go straight home from school compared to other age groups (McDonald, 2005; Clifton, 2003). On the other hand, adolescents in grades 9 to 12 are more likely than other children to go back out after returning directly home from school, and are more likely to stay at school after-school. This may reflect the higher availability of extracurricular activities at high school relative to middle and elementary school, as well as the greater freedom to remain after school at school to socialize or study with friends.

Not surprisingly, children who are mentally or physically disabled desist from undertaking out-of-home activities after returning directly home from school. Children who are overweight partake less than their non-overweight peers in out-of-home activities after returning home. In the face of increasing levels of obesity in children, this result warrants more attention and research.

Household Demographics

It is a very intuitive and interesting finding that children living in high income households and/or in households with several vehicles are more likely to go elsewhere directly after school and to participate in additional out-of-home activity episodes after returning home. This result reinforces the notion that children in households with higher income and higher number of vehicles make more daily trips (McDonald, 2005). In addition, this finding may shed additional light on why households with higher income and higher number of vehicles are more likely to drive their children from school (Yarlagadda and Srinivasan, 2007; Bradshaw and Atkins, 1996; Mackett *et al*., 2002). However, further research should be undertaken to disentangle the causation effects to understand whether children are being driven from school because they are undertaking out-of-home activities directly after school, or whether they make a stop on the way home from school because they are traveling by car.

With regard to household composition, if the child is an only child, then s/he is more likely than other children to stay at school after school or go elsewhere directly after school. The

latter result may be a reflection of having more opportunities to participate in out-of-home activities, since the child does not have to compete with other children for parental escorting. On the other hand, the results also indicate that children in households with several adults are less likely to go elsewhere directly after school.

Interestingly, if a child lives in a household with internet access, the child has a high propensity to go home directly after school and remain at home for the remainder of the day. This may be due to the use of the internet for homework and socializing, as a substitute for studying elsewhere or socializing in person. Another notable finding is that children who live in single-family dwelling units tend to go elsewhere after school and then pursue additional out-of-home activities. While this result should be further examined, this variable may be a proxy for neighborhood characteristics that are not directly examined in this study. The next variable effect in Table 3 indicates that if the father is the primary caregiver, then the child is more likely to go elsewhere after school and then stay home for the rest of the evening. Finally, in the group of household demographics, if a child has older siblings in the household, the child is more inclined to go elsewhere directly after school and go back out after returning home. This result may be either due to the older siblings taking on the escorting responsibilities for their younger sibling, or the younger sibling accompanying the older sibling on the older sibling's activities.

Child's Attitudes

Children who have high educational ambition tend to stay at school after school. Similarly, children who have ever been in a gifted program are more likely to stay at school after school or go elsewhere directly after school. Further research should be undertaken to determine whether these children choose to take part in more after school activities because they have high educational ambitions or whether the involvement in after school activities influence their educational ambitions. If the latter, it would suggest the development of policies and campaigns to encourage more after school activities. Children who socialize with friends at least once a week outside of school are positively predisposed toward going elsewhere after staying at school or after returning home. By nature, these children may have a strong desire to undertake out-of-home activities, so they can interact more with friends and peers.

Environment/Contextual Variables

Children who attend private school are likely to go back out after returning directly home from school or to stay at school after school. Private schools may provide more after-school programs and extracurricular activities at school, compared to public schools. The results also indicate that children who live in high quality neighborhoods tend to return home directly and then go back out. Children who live in safe neighborhoods are more likely to stay at school after school and then go elsewhere. In addition, if a child lives in county containing a city size over 1 million, s/he is less likely to go elsewhere after school and then return home and go back out. The above three results need further exploration. Finally, if it is a Friday, children have an inclination to go back out after returning home or go elsewhere after staying at school. This is to be expected, since children are likely to be allowed to participate in more activities out of home in the evening when not faced with the constraint of going back to school the next day.

Others' Activity-Travel Patterns

As expected, children whose primary caregivers are working after the end of school tend to stay at school after school or go elsewhere directly after school. If a child's non-primary caregiver works after school, then a child is more likely to stay at school after school and then return home and go back out.

4.5.2.2 Activity Episode Purpose-Location Type Model

Table 4 presents the results of the activity episode purpose-location type model, which are discussed by variable group below. The estimates presented in the table refer to the β vector in Equation (1).

Table 4. Activity Episode Purpose-Location Type MDCEV Model

	Child Demographics				Household Demographics	
	Grade k to 4	**Caucasian**	**Hispanic**	**African-American**	**Income is $90,000+**	**Household size**
Organized activities at school	--	--	--	--	--	--
Organized activities at location other than school	--	0.3814 (2.68)	--	--	--	--
Personal business	0.3703 (2.38)	0.4358 (2.92)	--	--	--	0.2087 (3.16)
Recreation at someone else's home	0.4151 (3.40)	--	--	--	--	--
Recreation at school	0.4151 (3.40)	0.5849 (2.47)	--	--	--	--
Recreation at other location	0.4151 (3.40)	0.3814 (2.68)	1.0154 (3.39)	--	--	--
Social at someone else's home	--	--	--	--	--	--
Social at location other than someone else's home	--	--	--	--	--	--
Childcare	2.3343 (8.99)	--	--	--	--	--
Meals at restaurant	--	--	--	-1.3555 (-4.12)	0.5503 (2.46)	--
Meals at location other than restaurant	0.8511 (4.44)	--	--	--	--	-0.2452 (-2.89)
Other	--	--	--	--	--	--

Table 4 (cont.) Activity Episode Purpose-Location Type MDCEV Model

	Household Demographics				Others' Demographics	
	Only child	**Household has internet**	**Single-family dwelling unit**	**Grandpar. is prim. caregiver**	**Age of prim. caregiver**	**Has younger sibling**
Organized activities at school	--	0.4974 (2.99)	--	--	--	--
Organized activities at location other than school	--	0.4974 (2.99)	0.4523 (2.63)	--	--	--
Personal business	0.5404 (2.46)	--	--	--	--	--
Recreation at someone else's home	--	--	--	--	-0.0388 (-3.69)	-0.3510 (-2.38)
Recreation at school	--	--	--	--	--	--
Recreation at other location	--	--	0.4523 (2.63)	1.0908 (2.75)	--	--
Social at someone else's home	--	--	--	--	--	--
Social at location other than someone else's home	--	--	--	--	--	--
Childcare	--	--	--	--	--	--
Meals at restaurant	--	--	--	--	--	--
Meals at location other than restaurant	--	--	--	--	--	--
Other	--	--	--	--	--	--

Table 4 (cont.) Activity Episode Purpose-Location Type MDCEV Model

	Others' Dem.	Child's Attitudes			
	Has older sibling	**High educ. ambition**	**Gifted program**	**Special education**	**Sociable**
Organized activities at school	--	--	--	--	0.3037 (2.00)
Organized activities at location other than school	0.4886 (3.82)	--	--	--	0.3037 (2.00)
Personal business	--	-0.3162 (-1.98)	--	0.7311 (2.91)	--
Recreation at someone else's home	--	-0.5567 (-4.04)	--	--	--
Recreation at school	--	--	--	--	--
Recreation at other location	0.4886 (3.82)	--	--	--	--
Social at someone else's home	--	-0.5567 (-4.04)	--	--	--
Social at location other than someone else's home	--	--	--	--	--
Childcare	--	--	-1.17 (-3.98)	--	--
Meals at restaurant	--	--	--	--	--
Meals at location other than restaurant	--	--	--	--	--
Other	--	--	--	--	--

Table 4 (cont.) Activity Episode Purpose-Location Type MDCEV Model

	Environment/Contextual			Others' Activity-Travel Patterns	
	Child attends private School	**Metropolitan area county**	**Activity day is Friday**	**Prim. caregiver works after sch.**	**Other caregiver works after sch.**
Organized activities at school	--	--	-0.9951 (-5.66)	--	0.3779 (2.95)
Organized activities at location other than school	0.8041 (3.27)	--	-0.9951 (-5.66)	--	0.3779 (2.95)
Personal business	--	--	--	--	--
Recreation at someone else's home	--	--	--	-0.7356 (-4.88)	--
Recreation at school	--	--	--	--	--
Recreation at other location	--	--	--	--	--
Social at someone else's home	--	--	--	--	--
Social at location other than someone else's home	--	--	--	--	--
Childcare	--	0.9745 (3.05)	--	1.1073 (4.55)	--
Meals at restaurant	--	0.5961 (3.21)	--	--	--
Meals at location other than restaurant	--	0.5961 (3.21)	--	--	--
Other	--	--	--	--	--

Table 4 (cont.) Activity Episode Purpose-Location Type MDCEV Model

	Activity Instance			
	Stay at school (2)	**Go back out (3)**	**Go elsewhere (5)**	**Go back out (6)**
Organized activities at school	2.4295 (11.34)	--	-1.1138 (-3.65)	1.0548 (2.85)
Organized activities at location other than school	--	--	-1.2581 (-5.74)	0.7373 (2.51)
Personal business	--	0.9103 (3.04)	--	0.9617 (3.43)
Recreation at someone else's home	--	--	--	--
Recreation at school	1.2830 (4.79)	--	-2.2594 (-4.27)	0.9124 (2.28)
Recreation at other location	--	--	--	--
Social at someone else's home	--	--	--	0.9459 (2.77)
Social at location other than someone else's home	0.5598 (2.14)	--	-1.2030 (-4.28)	--
Childcare	4.0500 (8.09)	--	2.3929 (5.05)	--
Meals at restaurant	--	--	-0.9432 (-3.82)	--
Meals at location other than restaurant	--	--	0.9596 (4.98)	--
Other	--	--	--	--

Table 4 (cont.) Activity Episode Purpose-Location Type MDCEV Model

	Baseline Preference Constants	Satiation Parameters
Organized activities at school	-1.8430 (-7.69)	1.0000 (--)
Organized activities at location other than school	-1.8216 (-6.98)	0.9681 (3.07)
Personal business	-1.4574 (-4.09)	0.8666 (8.89)
Recreation at someone else's home	1.4577 (3.28)	0.9142 (6.50)
Recreation at school	-1.8913 (-7.95)	0.9435 (3.34)
Recreation at other location	-1.5770 (-8.17)	0.9109 (6.10)
Social at someone else's home	-0.8837 (-7.20)	0.8756 (6.51)
Social at location other than someone else's home	-0.9782 (-6.89)	0.9071 (5.34)
Childcare	-6.0873 (-10.24)	0.9780 (2.32)
Meals at restaurant	-1.1416 (-5.03)	0.8619 (6.36)
Meals at location other than restaurant	-1.1658 (-2.92)	0.6978 (11.19)
Other	--	0.8576 (11.30)

Child Demographics

Children in kindergarten through fourth grades are more likely than other children to participate in personal business activities, recreation activities, childcare, and meals at locations other than restaurant. The first result is intuitive, since younger children are likely to accompany their parents on errands and, therefore, it is the parent's personal business activity in which a child is likely participating. The higher propensity of younger children to partake in recreational activities is perhaps because of more leisure time availability, since older children may participate in paid work and spend more time on homework and studying (Hofferth and Sandberg, 2001; O'Brian and Gilbert, 2003; McDonald, 2005). The result that younger children are much more likely to participate in childcare compared to older children supports the results found in other studies (see, Copperman and Bhat, 2007b, Hofferth and Sandberg, 2001; McDonald, 2005; Hofferth and Jankuniene, 2001).

The child demographic effects also reveal that ethnicity is a significant factor in episode type participation. Caucasian children are more likely to undertake personal business activities and recreation at school, while Hispanic children are more likely to pursue recreation at other locations and African-American children are less likely to eat out at restaurants (see Sener and Bhat, 2007 for similar results). Of course, it is important to disentangle whether it is truly race and culture that is contributing to differences in time-use in different kinds of activity episode purpose-location types, or whether it is a proxy reflection of differences in activity opportunities across different schools and neighborhoods.

Household Demographics

Not surprisingly, children living in high-income households have a greater tendency to eat out during the post-school period relative to children in low-income households (see, also, McDonald, 2005). The household size and "only child" variable effects indicate that single children with several adults in the household are predisposed toward undertaking personal business activities. Children living in households with internet access tend to undertake organized activities, if they participate in out-of-home activities at all. Perhaps this can be attributed to better awareness of organized activity opportunities through the internet. Children living in single-family dwelling units are more likely to undertake organized activities and recreation at non-school locations. Again, the single family dwelling unit variable may be a proxy for neighborhood characteristics that are not directly examined in this study. Interestingly,

children whose grandparent is the primary caregiver have a higher propensity to undertake recreation at locations other than school and someone else's home. Also, as the age of the primary caregiver increases, the less likely a child is to partake in, and spend time in, recreation at someone else's home. A similar result is obtained for children with younger siblings. On the other hand, if a child has an older sibling in the household, the child is more inclined to pursue organized activities at locations other than school and recreation activities at locations other than someone else's home and school. Children who have older siblings may be more involved in non-school activities because they accompany their siblings on the older sibling's activities.

Child's Attitudes

The child's attitude variables reveal that children who have high educational ambitions have a lower propensity to pursue personal business activities after school. These children may be choosing (or their parents may be allowing them) to spend their time on educational activities, such as studying, instead of on errands. Also, children who have ever been in a gifted program are less likely to attend childcare, while children who have been in special education are predisposed toward undertaking personal business activities. This latter result is quite intuitive, since these children may need extra care and so are more likely to accompany their parents on errands instead of participating in other activities independently or staying home alone. Finally, children who socialize with their friends at least once a week are more likely to pursue organized activities, perhaps because organized activities offer the opportunity to meet new people and socialize.

Environment/Contextual Variables

The results show that children attending private school have a higher tendency relative to other children to undertake organized activities at locations other than school. Parents who send their children to private school may also have the desire to provide additional extracurricular activities for their children. Also, children who reside in a metropolitan area county are more likely to receive childcare and eat meals out-of-home. This finding may reflect the differences in availability of childcare services and restaurants between metropolitan and non-metropolitan areas. Finally, the day of week effect reveals lower levels of participation in organized activities on Friday.

Others' Activity-Travel Patterns

The effect of others' activity-travel patterns indicate, not surprisingly, that if a child's primary caregiver works during the after-school period, the child is less likely to recreate at someone else's home and more likely to attend daycare. Interestingly, if the non-primary caregiver works after school, then a child is more likely to participate in organized activities.

Activity Instance Variables

Activity instance variables were added as independent variables in the activity episode purpose-location type model to accommodate variations in episode type participation based on activity instance. The results indicate that children staying at school after school (box 2 of Figure 6) are positively predisposed to spend time in organized activities, recreation, social activities, and childcare. Children who stayed at school after school are most likely to pursue personal business activities during any additional out-of-home tours from home (box 3 of Figure 6). On the other hand, children who go elsewhere directly after school (box 5 of Figure 6) are most likely to receive childcare or eat meals at a location other than a restaurant, and are less likely to undertake organized activities, recreation at school, social at a location other than someone else's home, and meals at a restaurant. The finding that children are most likely to attend childcare at school or directly after school at another location corroborates the results of the descriptive statistics of Table 2. Finally, children who complete additional tours after coming home from participating in non-school out-of-home activities directly after school (box 6 of Figure 6) tend to pursue organized activities, personal business, recreation at school, and social at someone else's home. Overall, these results underscore the different propensities to participate in diverse activity episode purpose-location type combinations at various points in the post-school period.

Baseline Preference Constants

The baseline preference constants (see second to last column of Table 4) do not have any substantive interpretations. They capture generic tendencies to participate in each activity episode purpose-location type alternative as well as accommodate the range of the age and household size variables in the model.

Satiation Parameters

The final column of Table 4 presents the satiation parameter (α_k) estimates for the activity episode purpose-location type MDCEV model. The t-statistics for the α_k parameters have been computed with respect to a value of 1 (i.e., for the null hypothesis that $\alpha_k = 1$ for each k). These t-statistics indicate that the satiation parameters are significantly different from 1 for all activity episode purpose-location types except organized activities at school, thereby indicating satiation effects in the duration of episodes. Note that, as indicated earlier, values of α_k farther away from one and closer to zero imply higher satiation (or lower time investment) for a given level of baseline preference.

The satiation effect is equal to 1 for organized activities at school, indicating that once children begin participation in organized activities at school, they will continue to participate in only that activity and spend a substantial duration in the activity. This is consistent with the descriptive statistics in Table 2. At the other end, meals at locations other than a restaurant have the highest satiation effects. Again, this result mirrors the findings in Table 2, which indicate that meals at a location other than a restaurant have a high likelihood of being combined with other episodes and have the lowest average duration levels.

4.5.3 Likelihood Based Measures of Fit

The log-likelihood value at convergence of the pattern MNL model is -297.76. The likelihood value for the model with only the constants is -316.81. The likelihood ratio test for testing the presence of exogenous variable effects is 38.09, which is larger than the critical $\chi 2$ value with 24 degrees of freedom at a .05 level of significance.

The log-likelihood value at convergence of the final activity episode purpose-location type MDCEV model is -8143.09. Further, the likelihood value for the model with only the MDCEV baseline preference constants and the satiation parameters is -8673.54. The likelihood ratio test for testing the presence of exogenous variable effects is 1060.90, which is substantially larger than the critical $\chi 2$ value with 50 degrees of freedom at any reasonable level of significance.

4.6 Summary and Important Findings

In this chapter, data from the 2002 Child Development Supplement (CDS) of the Panel Study of Income Dynamics (PSID) is used to undertake a comprehensive assessment of the post-school out-of-home activity-location engagement patterns of children aged 5 to 17. Specifically, this research effort utilizes an MNL model to analyze children's post-school patterns and employs the MDCEV model to study the propensity of children to participate in, and allocate time to, multiple activity episode purpose-location types during the after school period.

There are several important findings from the study. First, over 55% of children pursue at least one out-of-home activity after school. This result confirms the importance of examining children's post-school activity-travel patterns, since in many cases it is the location and timing of children's activities that are dictating the activity-travel patterns of other household members. Second, organized activities and childcare are most likely to take place at school directly after school. Third, in addition to demographic characteristics, attitudinal, environmental, and others' activity-travel pattern variables have an impact on children's after school activity engagement patterns. These results confirm the importance of going beyond simple analysis of age, gender, and household income level when examining travel behavior, and support the collection of detailed geospatial information and the inclusion of questions on perceptions and attitudes in travel surveys. Finally, participation and time-allocation to episodes of different activity purposes are affected by different factors, depending on the location of participation. Therefore, studying the location type of activity participation will contribute to more accurate location modeling within activity-based travel demand modeling systems and should be further explored in future studies.

Overall, the study represents the first formulation and application of a comprehensive econometric framework to consider children's post-school location patterns and participation, and levels of participation, in joint activity and location combinations. Future research should explore inter-household and intra-household interactions by incorporating the dimension of with-whom children are performing activities, as well as the joint trip making characteristics of household and non-household members.

CHAPTER 5:
CONCLUSION

5.1 Summary

Children are an often overlooked and understudied population group, whose travel needs are responsible for a significant number of trips made by a household. In addition, children's travel and activity participation have direct implication for adults' activity-travel patterns. A better understanding of children's activity-travel patterns and the linkages between parents and children's activity-travel needs is necessary for the accurate prediction and forecasting of activity-based travel demand modeling systems. In contrast, existing activity-based research and modeling systems have almost exclusively focused their attention on the activity-travel patterns of adults. Therefore, the goal of this research effort is to contribute to the area of activity-based travel demand analysis by comprehensively examining children's activity-travel patterns.

This report begins by assessing the state-of-the-research on children's activity-travel patterns. The first part of the assessment provides a comprehensive review of previous research on children's activity engagement and travel by focusing on the dimensions characterizing children's activity-travel patterns. The second part of the assessment discusses the different factors that shape and influence the many dimensions of children's activity-travel patterns. In addition, data from the 2002 Child Development Supplement (CDS) of the Panel Study of Income Dynamics (PSID) is used to undertake a comprehensive assessment of the post-school out-of-home activity-location engagement patterns of school-aged children. Specifically, this research effort utilizes a multinomial logit model to analyze children's post-school location patterns, and employs a multiple discrete-continuous extreme value (MDCEV) model to study the propensity of children to participate in, and allocate time to, multiple activity episode purpose-location types during the after-school period.

5.2 Research Findings and Implications

It is evident from the comprehensive review of the research undertaken on children's activity-travel patterns (Chapter 2 and 3) that children should be studied and treated as a distinct group in the context of activity-based modeling. Further, the finding of Chapter 4, that over 55% of children pursue at least one out-of-home activity after school, confirms the importance of

examining children's activity-travel patterns, since in many cases it is the location and timing of children's activities that dictate the activity-travel patterns of other household members. However, despite the extensive research on children's activity-travel patterns, considerable investigation is still needed to better understand children's activity-travel behavior, much of which may require refinements to existing metropolitan area travel surveys. The rest of this section discusses the major findings of the report and their implications for activity-based travel demand modeling and travel survey improvements. The section also suggests directions for future research based on the findings.

The first finding from this report is that children have activity-travel characteristics that are unique and different than adults. For instance, they participate in higher levels of structured/organized activities and participate in unique activity purposes such as daycare and studying. They also depend on adults to escort them to/from out-of-home activities. These distinctive dimensions of children's activity-travel patterns should be considered and directly modeled within activity-based travel demand modeling systems. In addition, metropolitan area travel surveys should include activity classifications that are more representative of children's activities. If a travel survey includes organized activities within the recreational category, then salient characteristics that differentiate structured activities from other recreational activities is lost. Future research should be conducted to further determine appropriate activity type alternatives that share salient attributes, especially with regard to non-structured activities.

The second finding from this report is that, while not unique to children, activities take place both within and outside the home and at various activity locations. What is unique to children is the role school plays as a significant location for out-of-home activity participation for both school and non-school activities. In addition, participation and time-allocation to episodes of different activity purposes are affected by different factors, depending on the location of participation. With the advent of advanced spatially disaggregate GIS systems, it is becoming more feasible to perform location modeling at the parcel level. Therefore, assessing the location of activity participation within a certain location type setting (for example, school, someone else's home, own home, *etc.*) will contribute to more accurate geographic location modeling within activity-based travel demand modeling systems. To facilitate the study of location, travel surveys should collect detailed geospatial information.

The third finding from this report is that, in addition to demographic characteristics, attitudinal and environmental attributes, and other individuals' activity-travel pattern variables,

impact children's activity engagement patterns. These results confirm the importance of going beyond simple analyses of age, gender, and household income level when examining travel behavior, and support the collection of detailed geospatial information and the inclusion of questions on perceptions and attitudes in travel surveys. While there has been some research in this area within the transportation field, a significant amount is still unknown about the role attitudes and perceptions play in daily activity-travel patterns, and thus this area warrants further study.

Finally, a child's activity-travel pattern is impacted by not only household members, but also friends and other non-household members. Children mostly participate with other individuals (rather than alone) in out-of-home activity episodes, and a significant proportion of these joint participations are with individuals who are not family members. In addition, a significant number of out-of-home activities take place at someone else's home. These results highlight the need to examine children's inter-household interactions, as well as children's intra-household interactions, within a joint framework. Travel surveys should make a greater effort to incorporate questions on with whom individuals travel and participate in activities with, as well information on the social networks, and location of social networks, that comprise an individual's daily social contacts.

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