

EXPLORATORY ANALYSIS OF CHILDREN'S TRAVEL PATTERNS
USING TIME-USE AND TRIP-BASED SURVEYS

By

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To my father, who is forever in my heart. His intelligence, strong will, and convictions
shaped who I am today
To my mother, whose love, encouragement, and support helped make this
achievement possible

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Policy makers in the fields of transportation engineering and urban planning are becoming increasingly interested in understanding the activity-travel patterns of children so as to accurately assess the impacts of land-use and transportation policy actions on the transportation system (congestion) and on improving children's health (especially the problem of childhood obesity). In this context, the objective of this study is to conduct a detailed exploratory analysis of children's activity-travel patterns using two national-level surveys; the National Household Travel Survey (NHTS) and the Child Development Supplement of the Panel Study of Income Dynamics (PSID-CDS). The former (NHTS) is a travel survey designed for primarily to provide the data for supporting travel-demand forecasting and the latter (PSID-CDS) is a time-use survey designed primarily to provide data on children's time use and health to support public-health policy making. Thus, this research attempts to construct and compare descriptors of children's travel patterns using two surveys designed for different purposes. The empirical focus is on non-driving children (age 0-14 years). The analyses are conducted for both weekday and weekend travel. Within weekday travel, the school-going children are distinguished from non school-going children (the latter category has received relatively little focus in the literature thus far).

The travel patterns are described in terms of the characteristics of each of the tours (mode, companion type, time of the day, duration, and number of stops) and the characteristics of each of the stops (duration, location, and activity type) undertaken. This approach is directly useful for activity-based modeling as the focus of such models is on predicting the number and nature of the tours and stops undertaken by travelers. Finally, statistical models are developed to describe the impacts of demographics, location- and temporal- characteristics on the travel-generation decisions of children. Insights from the exploratory analyses presented here will be valuable in the development of advanced modeling systems to forecast the activity-travel patterns of children.

CHAPTER 1 INTRODUCTION

In the recent past, policy makers in the fields of transportation engineering and urban planning have become increasingly interested in the understanding of the activity-travel patterns of children. This interest can be ascribed to two major factors: (1) the need to accurately forecast the impacts of various complex land-use and transportation policy actions on the transportation system and (2) the desire to help public-health professionals with the evaluation of policies aimed at improving children's health. Each of these issues is discussed further in the next two paragraphs. Subsequently, the objectives and the empirical focus of this research are outlined. This chapter ends with a description of the organization of the rest of this thesis.

Accurate assessment of the impacts of policy actions on the transportation system has been one of the primary motivations for the development of activity-based travel-demand models. These models describe the activity-travel decision-making behavior of individuals incorporating space, time, and inter-personal constraints. However, the incorporation of children's travel within this framework has been relatively limited to date. Yet, this is very important for several reasons such as developing means to alleviate localized congestion around schools, assessing the impacts of policy actions on parents' travel because of the space-time constraints imposed by the travel needs of children in the house, and evaluating the effectiveness of land-use actions such as school siting (Yarlagadda and Srinivasan, 2008).

One of the primary concerns about children's health is the issue of obesity. The proportion of obese children, defined as Body-Mass-Index (BMI) exceeding the 95th percentile for age and sex based norms, has tripled in the past three decades (Troiano & Flegal, 1998). Current estimates indicate that approximately 10% of 2-5 year-olds and 15% of 6-19 year-olds are overweight (Ogden, Carroll, Curtin, McDowell, Tabak & Flegal, 2006). One of the causes of

increased childhood obesity is the broad shift over the past three decades to more sedentary leisure activities (Popkin, 2001) and reduction in physical activities. Hence, transportation and public health professionals are interested in evaluating the impacts of measures aimed at increasing physical-activity participation to promote healthy lifestyles.

In the light of the above discussions, there has been a growing interest in the study of the activity-travel patterns of children. While the transportation researchers have focused primarily on the volume of travel undertaken and the modes used (especially in the context of school travel), public-health researchers have focused on understanding why children participate in sedentary (such as watching TV) versus physically-active (such as playing sports) activities. With the need to understand the effects of policy actions on both congestion patterns as well as children's health, it is necessary to undertake a comprehensive analysis of children activity-travel patterns. The objective of this study is to contribute towards this end. Specifically, detailed exploratory analysis of children's activity travel patterns are undertaken using two national-level surveys; the National Household Travel Survey (NHTS) and the Child Development Supplement of the Panel Study of Income Dynamics (PSID-CDS). It is important to highlight that the former (NHTS) is a travel survey designed for primarily to provide the data for supporting travel-demand forecasting and the latter (PSID-CDS) is a time-use survey designed primarily to provide data on children's time use and health to support public-health policy making. Thus, this research attempts to construct and compare descriptors of children's travel patterns using two surveys designed for different purposes.

The empirical focus is on non-driving children (age 0-14 years). The analyses are conducted for both weekday and weekend travel. Within weekday travel, the school-going children are distinguished from non school-going children. Finally, statistical models are

developed to describe the impacts of demographics, location- and temporal- characteristics on the travel-generation decisions of children. It is envisioned that the exploratory analyses presented here will provide insights into the development of advanced modeling systems to forecast the entire travel-pattern of children.

The rest of the thesis is organized as follows. Chapter 2 reviews previous research on the dimensions characterizing children's activity-travel patterns, factors affecting children's activity travel patterns and the objectives of the current research. Chapter 3 identifies the data source used in the exploratory and empirical studies, describes the sample formation procedure, and presents sample descriptive statistics. Chapter 4 undertakes an exploratory analysis of weekday travel patterns of school-going children. Chapter 5 undertakes an exploratory analysis of weekday travel patterns of non school-going children. Chapter 6 undertakes an exploratory analysis of children's travel pattern on a weekend day. Chapter 7 discusses the travel generation models – models for weekday travel generation: school-going children, models for weekday travel generation: non school-going children and models for weekend travel generation. Chapter 8 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 LITERATURE REVIEW

This chapter provides an overview of the literature in the area of children's activity travel analysis. The focus of this chapter is on out-of-home activity travel patterns and, hence, the in-home patterns (such as sleep duration, watching TV etc) are not discussed. Consistent with the analysis approach adopted in this research, the literature review is divided into discussions on weekday (Section 2.1) and weekend (Section 2.2) patterns. Section 2.3 outlines the contributions of this study.

2.1 Weekday Travel Patterns

The school-related travel patterns of children are discussed first (Section 2.1.1) followed by the discussion on the non school related travel patterns (Section 2.1.2)

2.1.1 School-related activity-travel patterns

Almost all school-aged children go to school and invest time in school activities during the weekday. School is a mandatory activity, and it has a fixed start time, end time and occurs on all the weekdays. Hence, school acts as a highly constrained activity around which all other weekday activities have to be scheduled. Hofferth and Sandberg (2001) observed that, on an average, children invest about 6.5 hours per day in school. It was observed that the children spend less time in school related activities over a weekend day (Bhat and Copperman, 2007).

The mode of travel to/from school is perhaps one of the relatively well-examined aspects of children's school-related travel patterns. Characteristics of adult/child like age, gender, and ethnicity, employment and work flexibility characteristics of the parents have strong impacts on the mode choice decisions (Srinivasan and Yarlalagadda, 2007). The impacts of some of these attributes on the choice of mode to school are different from that of from school (Srinivasan and Yarlalagadda, 2007). In both the United States and Canada, for middle school students, school bus

trips were found to constitute a higher share of school trips compared to elementary and high school students (O'Brien and Gilbert, 2003). Middle school students were found to travel mostly walking and biking (Stefan and Hunt, 2006). Children aged 13 and 14 years were found to use school bus as the primary mode of travel. The choice of walking to and from school was found to have a strong and negative effect on the distance between home and school, with stronger impact for walking to school (Srinivasan and Yarlalagadda, 2007).

2.1.2 Non school-related activity-travel patterns

On weekdays, children are found to undertake non school related (out of home) activities predominantly during the after-school period. There appears to be few major publications directly addressing this aspect of children's travel patterns.

The first of these is work by Clifton (2003). She observed that 71.0% teenagers returned home after school. Of the after-school trips away from home, 7.9% constituted social and recreation purpose trips, 4.3% School-related trips, 3.8% personal business trips, 3.6% serve passenger trips, 3.3% dining out trips and 3.0% of the trips for shopping purposes. She considered only the first trip made directly after school for the teenagers. And observed that 44% of these trips were the final trip of the day; 56% were followed by additional trips and 25% of these who made additional trips remained at home 35 minutes or less before departing again. The portion of trips made to serve passengers increases with age. Parents tend to link their trip to pick up their teen after school with a trip to pick up other children, a spouse, or other family member.

For the after-school trips, for 13-year old teenagers, 33.2% were made by private automobile; for 18-year old teenagers, it was about 72.4% (Clifton, 2003). Once the teenagers have the license, they would have the option to choose to drive over other modes. About 54.9% were found to drive to their after-school activity. It also corresponds with teenagers' increasing participation in out-of-home activities as they age and suggests that the ability to drive may

enable such participation (Clifton, 2003). Children aged 13 and 14 years were found to use school bus as the primary mode of travel; it accounted for about 47.3% and 41.6% of after-school trips respectively and less than 10% of the trips were made by 17- and 18-year-olds (Clifton, 2003).

Clifton (2003) also discovered that motorized transport trips made by teenagers to after-school activities are quite long. For after-school activities, teenagers travel about 5.1 miles by car, 7.2 miles by school bus, and 11.2 miles by public transport. For after school activities, persons traveling alone travel about 5.7 mile and 18.2 minutes when compared to 4.4 miles and 14.2 minutes for those traveling with others. Teenagers who return directly home after school travel about 4.9 miles and 17.0 minutes compared to 5.4 miles and 13.9 minutes who link other activities before they reach home (Clifton, 2003).

Clifton (2003) observed that only 37.6% of the overall trips were made alone by adolescents, the remaining 62.4% with accompaniment; the average number of persons on a trip was 3.7; 52.7% of those not traveling alone were accompanied by household members; 59.4% of the trips by non-household members. Clifton (2003) also found that 33% of teenagers are accompanied by household members directly after school, while 37% of teenagers are accompanied by non-household members. For the after school trips, 18-year-old teenagers made about 62.3 % of the trips alone and for 13-year-old teenagers, it was about 34.3%.

A second study on post school activity-travel patterns of children was undertaken by Cooperman. This study found that over 55% of children pursued at least one out-of-home activity after school. The children had activity-travel characteristics that are unique and different than adults. Children participated in higher levels of structured/organized activities; also participated in unique activity purposes such as daycare and studying. They also depended on

adults to escort them to/from out-of-home activities. Children's activities took place both within and outside the home and at various activity locations. In addition to demographic characteristics, attitudinal and environmental attributes, and other individuals' activity-travel pattern variables, impacted children's activity engagement patterns. Children's activity-travel pattern was impacted by not only household members, but also friends and other non-household members.

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.

The health of the child is also found to influence the activity participation patterns of children. Overweight children 6-12 years of age spent fewer hours per week in sports, particularly team sports (Curtin, S. & Hofferth, S.L., 2004). Overweight children spent more time than their normal weight counterparts in marginally active and sedentary activities such as shopping, studying, visiting, and time on the computer (Curtin, S. & Hofferth, S.L., 2004). No significant differences were found between overweight and normal-weight children in time spent playing or viewing television (Curtin, S. & Hofferth, S.L., 2004). Also, the normal weight children were more likely to participate in active leisure pursuits; involved in team sports in their leisure time than overweight children (Curtin, S. & Hofferth, S.L., 2004).

Children mostly participate with other individuals in out-of-home activity episodes, and a significant fraction of these joint activity participations occur with non-household members (Bhat and Copperman, 2007). Male children were more likely to participate with their fathers than female children for out-of-home discretionary activity participation (Bhat and Copperman, 2007). Interaction between inter-household and intra-household is being captured by the fact that

a high fraction of joint out-of-home episodes occurred with non-household members (with or without household members) (Copperman and Bhat, 2007).

2.2 Weekend Day Children Pattern

Copperman (2008), Sener and Bhat (2007), Copperman and Bhat (2007), and Sener et al (2007) examine the activity travel patterns of children on weekend days. All their analysis use data from the PSID-CDS. These studies provide several insights into the travel patterns of children on weekend days. Some of these findings are summarized here highlighting the differences between weekday and weekend behavior, wherever appropriate.

A high percentage of children undertake out-of-home discretionary activities with no parents (65%) and with parents and others (51%) on weekend days. Children also spend a large amount of time (about 3 hours) in the overall without parents on the weekend.

Tour episodes on a weekday are more likely to take place at single location where as those on a weekend day are spatially scattered in the location of participation which implies less time constraint and more episode chaining on a weekend day when compared with that of a weekday (Bhat and Copperman, 2007).

Sports practice or games is found to be the most common organized activity type participated in during the weekday and that of clubs and other meeting during weekend days; the mean duration among those who participate in the above said activities is longer over the weekends than the weekdays.

Shopping (personal business activities) represents the largest percentage of personal business activities on both the weekday and weekend days and it is found that its share on weekend days are much higher. The mean durations, however, are always higher on weekend days for all personal business activities.

Other than the purposes of school, studying, and receiving child care, children participate more in all other activity purposes over the weekend days than the weekdays. For recreation purpose, the average duration of participation among children who recreate is about 3.5 hours on weekdays and 6.5 hours on weekend days. The adolescents work, on average, for about 4.5 hours on a weekday and 6 hours on a weekend day. It is observed that as children get older, the participation rates and mean durations in organized activities, social activities, and personal business increase, while the participation rate and duration of time spent receiving child care decreases.

Home is the most common location for activity participation on both weekdays and weekend days, especially on weekdays. It is surprisingly found that very common location for activity participation during the after-school period on weekdays, and on weekend days, is someone else's home. During the mid-morning period (8 a.m.-noon) on weekend days, church is the most frequented location outside of home, with a mean activity duration of 2½ hours; and store/retail business (including shopping) in the early afternoon period (noon-4 p.m.) of weekend days; non-retail businesses, outdoor recreational areas, and restaurants are also popular activity locations during the same period on weekend days. (Copperman, 2008).

About 41% of all out-of-home tours involving children's episodes are chained, while 43% of all tours on weekend days are chained. There exists spatial scattering in the location of participation of the episodes over the weekend days when compared to that on weekdays. 26% of weekday tours involve episode participations at multiple locations, compared to 66% of weekend tours.

For other purposes namely household chores, organized activities, studying, recreation, social, personal business, personal care and receive child care, episodes of these types are much

more likely to be the first episode, and much less likely to be the last episode, on weekend days relative to weekdays. Across both weekdays and weekend days, and among the non-school episodes, personal care episodes are most likely to be the first episode relative to other non-school episodes, and episodes for work, recreation, social, and personal businesses are most likely to be the last episodes. (Copperman, 2008).

The overall levels and intensity of activity participation are also on the low side during the late evening period (8 p.m. to midnight), as in the early morning period. The dominant activities during this late evening period are leisure-type activities (meals, recreation, social, and personal care activities). The daytime weekend time periods (8 a.m. to noon, noon to 4 p.m., and 4 p.m. to 8 p.m.) constitute the most intense activity periods, and have very similar participation percentages in most activity purposes. The most common activity type of participation during these periods is recreational activity, with 67%-80% of children participating in recreation for about 2-2 ½ hours. (Copperman, 2008).

2.3 Objectives Of The Current Research

Previous research has looked at various aspects like the time-use (weekday and weekend), IH/OH passive/active leisure (discretionary vs non-discretionary activities), sex difference in children's school travel, who is escorting the child, how the presence of child affects parent's travel behavior and health perspective of physically active and sedentary activities, but no studies has considered the detailed sequential framework of daily activity travel patterns of children (school going and non-school going separately) with respect to temporal (time of the day, weekday, weekend) and spatial constraints (location type, activity purpose, companion type, mode choice) especially the finer aspects of pattern, tour and stop level attributes and their characteristics. By doing so, we would able to get a better understanding of children's activities

in a broader perspective and even the policy makers will be in a better position to accurately forecast efficient models. In our analysis, child centric approach is being considered.

This research contributes to the growing body of literature on children's travel patterns in the following ways:

1. An exploratory analysis of both weekday and weekend travel behavior is presented. Within the weekday context, school-going children are distinguished from non school-going children (a child is defined as school-going on any day if (s)he travels to school on that day). It is useful to emphasize that little is documented about the weekday travel patterns of non school-going children. Non school going children include both non-students as well as students who did not travel to school on a weekday perhaps because the school is not in session.
2. The travel patterns are described in terms of the characteristics of each of the tours (mode, companion type, time of the day, duration, and number of stops) and the characteristics of each of the stops (duration, location, and activity type) undertaken This approach is directly useful for activity-based modeling as the focus of such models is to predict the number and nature of the tours and stops undertaken by travelers.
3. The analysis is conducted using two national level surveys of children's time-use and travel patterns: the NHTS and the PSID-CDS. The former is a travel survey designed for primarily to provide the data for supporting travel-demand forecasting and the latter (PSID-CDS) is a time-use survey designed primarily to provide data on children's time use and health to support public-health policy making. Thus, this research attempts to construct and compare descriptors of children's travel patterns using two different types of surveys designed for different purposes.
4. In addition to the aggregate exploratory analyses, disaggregate models are also developed to describe the travel-generation of children using socio-economics, location- and temporal- characteristics as explanatory factors. These models are the first steps in the development of comprehensive activity-travel forecasting models for children.

This research, however, focuses only the out-of-home activity-travel patterns of children.

The consideration of the in-home activities is identified as an important extent to this study.

Finally, a "child-centric" approach is adopted in this research. That is, the focus is only on the travel behavior of the children; the patterns of the other members of the household including the parents are not considered. The simultaneous modeling and analysis of all household members, including both adults and children, is an important and emergent area of research.

CHAPTER 3 DATA

This chapter describes the data used in the analysis. As already mentioned, Data used in this analysis come from two sources: (1) The National Household Travel Survey (NHTS) conducted in 2001-2002 and (2) The Panel Source of Income Dynamics (PSID) – Child Development Supplement (CDS-I and CDS-II). PSID CDS-I was conducted in 1997 and CDS-II in 2002. Both surveys collected data from a national sample. These data sources are described in Section 3.1. Section 3.2 details the sample formation procedure. Some aggregate sample characteristics are presented in Section 3.3.

3.1 Data Source

Data used in this analysis come from two sources: (1) The National Household Travel Survey (NHTS) conducted in 2001-2002 and (2) The Panel Source of Income Dynamics (PSID) – Child Development Supplement (CDS-I and CDS-II). PSID CDS-I was conducted in 1997 and CDS-II in 2002.

The National Household Travel Survey (NHTS) is a national survey of daily and long-distance travel. The survey includes demographic characteristics of households, people, vehicles, and detailed information on daily and longer-distance travel for all purposes by all modes. NHTS survey data are collected from a sample of U.S. households and expanded to provide national estimates of trips and miles by travel mode, trip purpose, and a host of household attributes. The NHTS interviews were conducted from April 2001 through May 2002. There are approximately a total of 66,000 households in the 2001-2002 NHTS dataset. About 26,000 households are in the national sample, while the remaining 40,000 households are from nine add-on areas. The NHTS collected travel data from a national sample of the civilian, non-institutionalized population of the United States. People living in college dormitories, nursing homes, other medical institutions,

prisons, and military bases were excluded from the sample. The 2001-2002 NHTS was conducted using Computer-Assisted Telephone Interviewing (CATI) technology. Each household in the sample was assigned a specific 24-hour “Travel Day” and kept diaries to record all travel by all household members for the assigned day. Additional details on the NHTS and the resulting data can be obtained from:

http://www.bts.gov/programs/national_household_travel_survey/

The second source of data for the present analysis is the obtained from 1997 and 2002 Child Development Supplement (CDS) to the Panel Study of Income Dynamics (PSID). The CDS-PSID is a longitudinal study that collected data on family composition changes, housing and food expenditures, marriage and fertility histories, employment, income, neighborhood, education, physiological, health, consumption, wealth, time-use, cognitive and behavioral development from a nationally representative sample of US individuals and the families in which they reside. The CDS-I conducted interviews during March-mid-June and September-December, 1997 with 2,380 families providing information on 3,563 children (aged 0-12 years) followed by the CDS-II which conducted interviews during the year 2002 with almost about the same number of families providing information on 2907 children (aged 5-18 years). Additional details on the PSID and the resulting data can be obtained from: <http://psidonline.isr.umich.edu/>

In addition to the fundamental difference in the objectives for collecting the data, it is useful to highlight that the NHTS employed a trip-based survey instrument whereas the PSID-CDS used a time-use instrument. Specifically, in the NHTS, data on the start time, end time, duration of travel, dwell time, distance, mode, and purpose are collected for each trip. The PSID used a time-use oriented survey instrument. Data on the start time, end time, duration of travel, dwell time, location, activity type, and companion type (who was present and participating with

the child and also, who was present but not participating with the child) are collected for each activity episode for a 24-hour period of the survey day. The NHTS collected data for only one day (a 24-hour period from 4 AM of one day to 4 AM of another day). The PSID-CDS collected data for two days: one weekday and one weekend day (each day was a 24 hour period from midnight to midnight)

3.2 Sample Formation

The empirical scope of this research is restricted to children in the age group of 0-14 years and the corresponding subset was extracted from each of the surveys. Next, only those children who began and ended their day at home were included in the analysis. The intent of this research is to describe the travel patterns of children by characterizing the commute travel, tours, and stops undertaken by them. Thus, the major step in the sample formation involved the extraction of such information from the two surveys. Prior to such a discussion, it is useful to define three key terms: “commute”, “tours”, and “stops”.

A “stop” is defined as a non-school activity-episode taking place at an out-of-home location. Stops are characterized by the activity type (such as shopping, recreation, and meals), location (such as friends’ house, mall, and day care center), time of day, travel duration, activity duration.

A “tour” is a circuit or journey that begins and ends at home. Tours are characterized by the following attributes: start time, duration, mode, companion type, and the number of stops. Each tour generally has at least one stop although no-stop tours (such as taking walk) are also possible.

The “commute” is defined as the travel between home and school. It comprises of the Home-to-School (H-S) journey and the School-to-Home (S-H) journey. Each of these journeys

can be characterized by the mode, accompanying person, start time, duration, and the number of stops. The commute journeys may or may not have stops.

As already described, the PSID-CDS is a time use survey. Each record in this file describes an activity episode undertaken for a particular purpose. It is possible that successive records could represent activities undertaken at the same location, but for different purposes. Hence, as a first step in the data assembly, successive activity episodes undertaken at the same location were aggregated. The location can be the child's home, some out-of-home place such as day-care center or shopping malls, or a mode of transportation. Correspondingly, the aggregated activity episodes are classified into one of "in-home", "out-of-home", and "travel" episodes. For activity episodes undertaken at out-of-home location, more detailed location information is also available (School, Babysitting/home based daycare, Church, Outdoor recreational places, Stores/shopping centers/malls/beauty parlor, Restaurants/bars/fast-food, Indoor recreational places, and "others"). For travel episodes, details about the accompanying person are also available. Specifically, the presence/absence of each of the following categories of people is known: mother, father, sibling, friend, grand parent, relative, and non-relative.

The NHTS is a trip-based survey. Each record in this file is a trip. Each trip is characterized by a purpose [(i) Home, (ii) School, (iii) Daycare, (iv) Religious, (v) Shopping, (vi) Active recreation, (vii) Social-visits, (viii) Passive recreation, (ix) Pick-up or drop-off someone, (x) meals and (xi) others], mode [(i) Household vehicle, (ii) Non-household vehicle, (iii) Public transportation, (iv) School-bus, (v) Walk or bike, and (vi) Others], and the companions [(i) Alone, (ii) Only mother, (iii) Only father, (iv) Only sibling, (v) Mother and father, (vi) Mother and sibling, (vii) Father and sibling, (viii) Mother, father and sibling, (ix) Non-household members, (x) Household and Non-household members].

The NHTS and PSID-CDS data were then segmented into weekday and weekend records. The weekday records were further segmented based on whether or not the child went to school during the day. For each of the three categories, episode-level data were suitably aggregated to determine the characteristics of each of the stops, tours, and commute as appropriate.

3.3 Sample Characteristics

The final estimation sample comprises of children below 14 years of age with 11,216 children from the NHTS and 9,460 children from the PSID. Table 3-1 presents the detailed age distribution of PSID and NHTS samples. From Figure 3-2, it is evident that the gender is uniformly distributed across both the datasets. The samples appear to be reasonably similar in terms age and gender distribution. NHTS has a larger share of non-Whites (around 75% versus 49%) compared to the PSID; whereas the PSID has a larger share of black non-Hispanic (38% versus 7%) compared to NHTS [*Note:* From the census 2000 data for children under 18 years, children belonging to White (70.9%), Black (13.3%) and Other race (15.8%). *Source:* <http://www.census.gov/prod/2004pubs/censr-14.pdf> (Table3)]. PSID has considerably more single parent households than the NHTS (36% versus 9.0%) [*Note:* From the census 2000 data for children under 18 years, children in single parent households (25.4%) and children in nuclear family households (74.7%). *Source:* <http://www.census.gov/prod/2004pubs/censr-14.pdf> (Table3)]. Relative to the NHTS, PSID has a larger share of the children from the multiple-children families (19-37% v/s 81-64% (PSID-NHTS) Figure 3-5). As already indicated, the PSID-CDS collected two days of data (one weekday and one weekend day) from each child. However, the NHTS collected only one day data. Correspondingly, the share of weekend-day records is significantly higher in the PSID-CDS (Figure 3-6)NHTS collected the data almost uniformly through all the seasons of the year, whereas the PSID has very less data (about 5%) collected during the summer. (*Note:* Winter (December, January, February), Spring (March,

April, May), Summer (June, July, August) and Fall (September, October, November)). The present study, later in chapter 7, discusses in detail, the sample characteristics for school going children on a weekday, non-school children on a weekday and children on weekend day, who decide to travel.

Table 3-1. Age distribution for weekday school going children (WD-SGC), weekday non-school going children (WD-NSGC), weekend day children (WE) and overall sum for PSID and NHTS samples

Age (yr)	Overall		WD-SGC		WD-NSGC		WE	
	PSID	NHTS	PSID	NHTS	PSID	NHTS	PSID	NHTS
	Percent							
0	3.68	5.78	0.48	0.28	11.70	12.00	3.64	5.36
1	4.75	5.30	0.93	0.64	14.06	10.82	4.76	4.58
2	5.10	7.15	1.29	0.80	14.66	13.81	5.04	7.41
3	4.34	6.24	1.72	1.81	11.10	11.26	4.26	5.89
4	5.12	6.25	3.19	3.76	9.70	8.86	5.16	6.35
5	7.58	6.52	7.94	6.91	6.59	5.99	7.61	6.67
6	8.41	6.53	10.59	8.24	3.26	4.13	8.36	7.31
7	9.10	6.85	11.04	9.48	4.37	4.16	9.09	6.63
8	8.09	6.99	9.69	9.57	3.77	3.99	8.19	7.31
9	8.94	6.36	11.19	8.54	3.33	3.84	8.96	6.60
10	9.05	6.91	10.86	9.62	4.29	4.36	9.13	6.39
11	8.29	7.04	10.02	10.08	4.00	3.99	8.30	6.74
12	8.59	8.08	10.35	11.09	4.07	4.93	8.65	7.95
13	4.99	7.04	5.87	9.98	3.03	3.96	4.93	6.92
14	3.97	6.97	4.81	9.20	2.07	3.91	3.93	7.91
Total(%)	100	100	100	100	100	100	100	100
Total	9460	11216	3323	4357	1351	4040	4786	2819

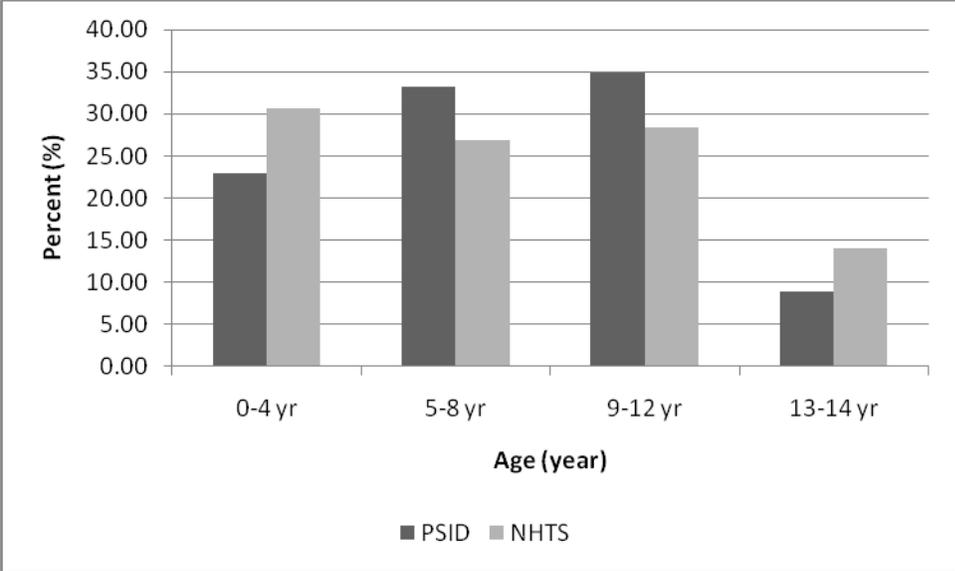


Figure 3-1. Age distribution

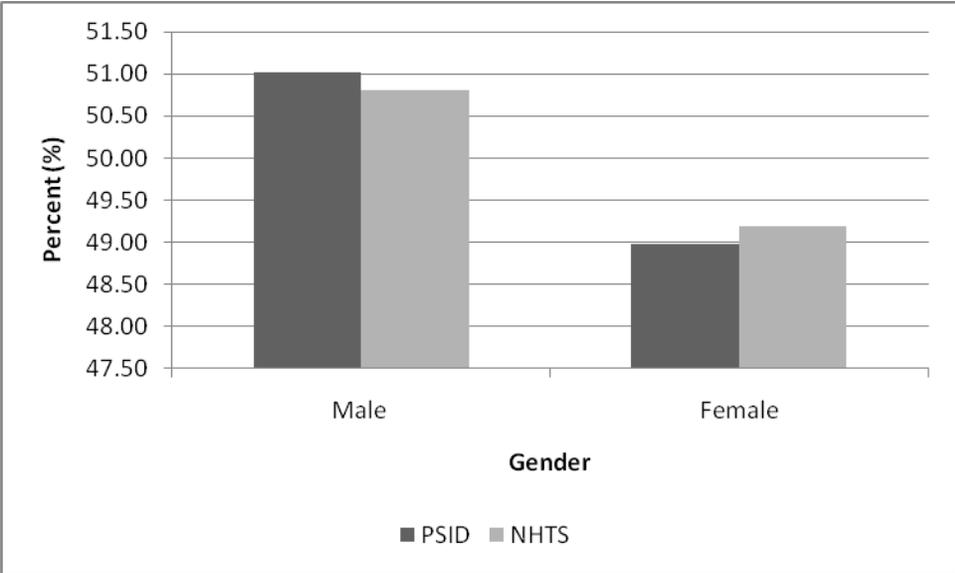


Figure 3-2. Gender distribution

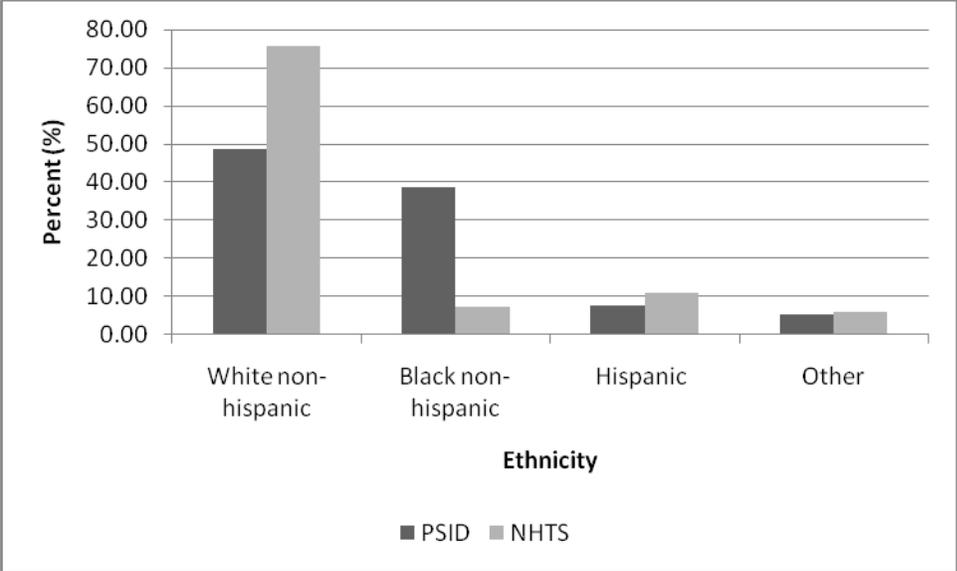


Figure 3-3. Ethnicity distribution

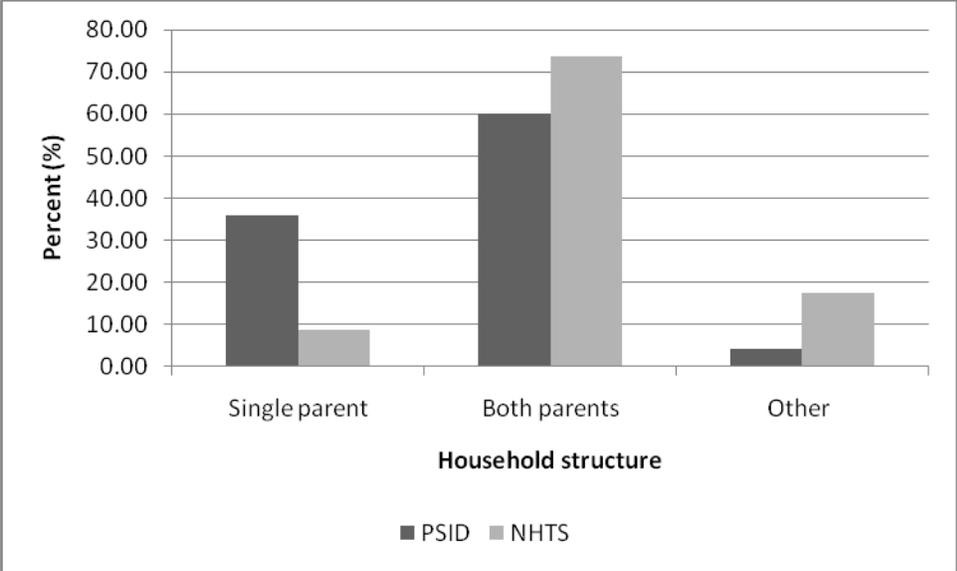


Figure 3-4. Household structure distribution

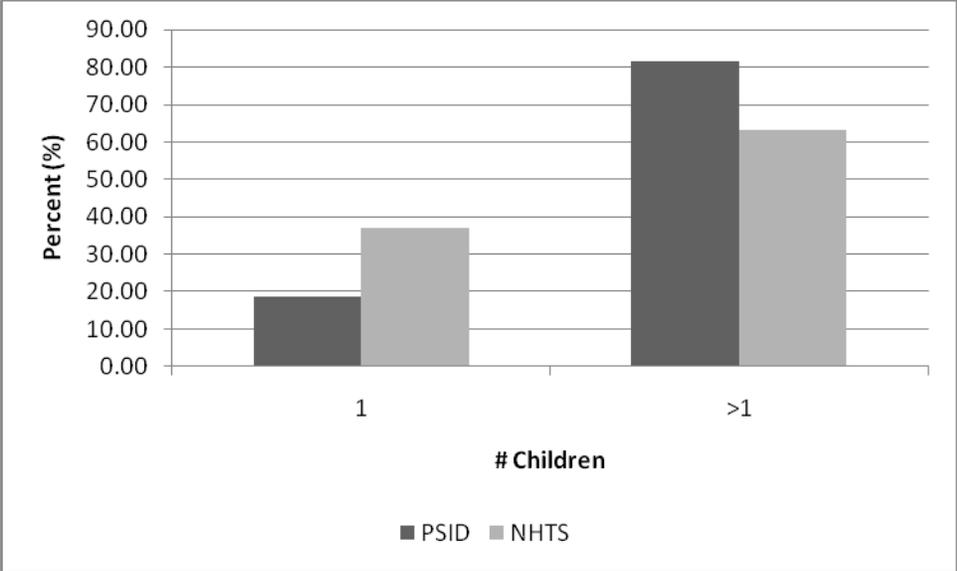


Figure 3-5. Household children distribution

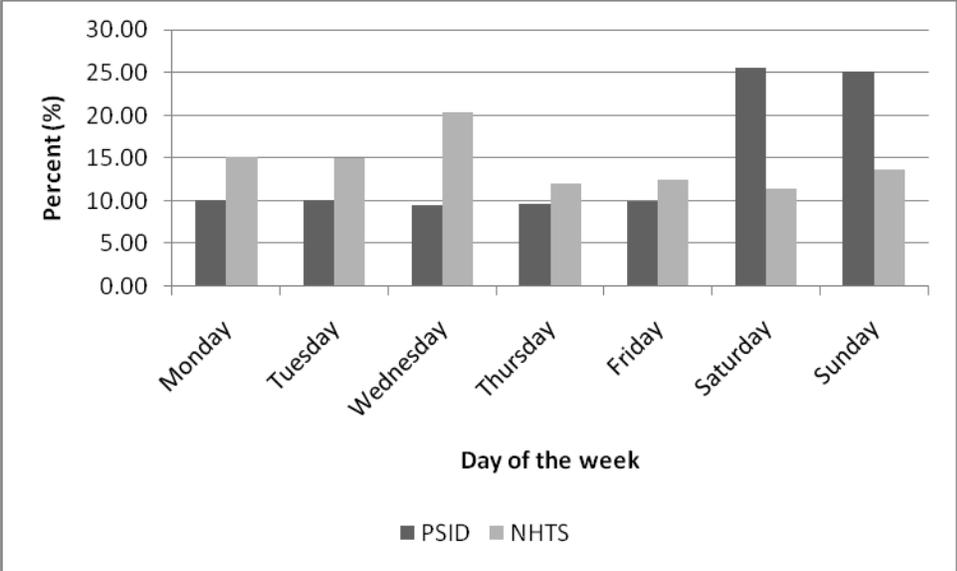


Figure 3-6. Day of the week distribution

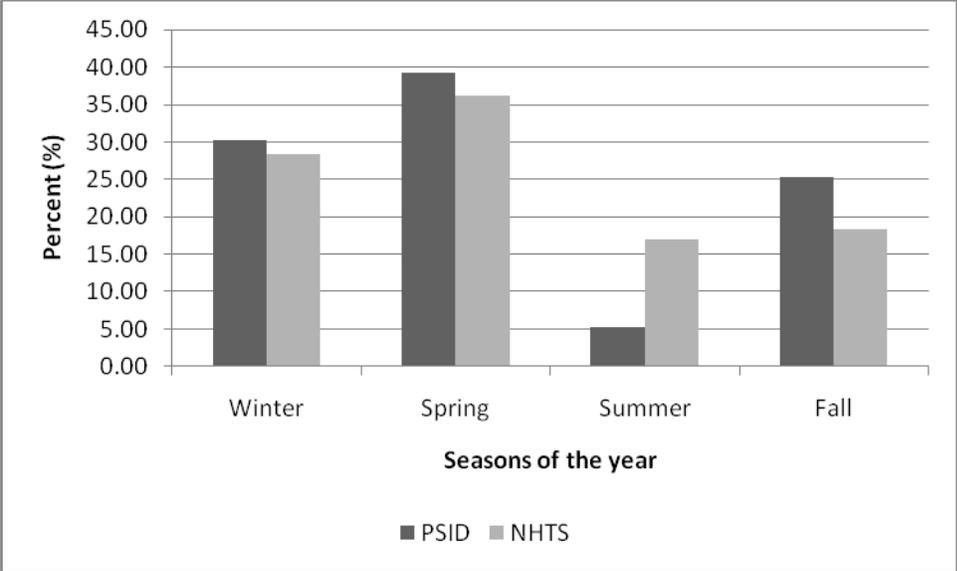


Figure 3-7. Seasons of the year distribution

CHAPTER 4 EXPLORATORY ANALYSIS OF WEEKDAY TRAVEL PATTERNS: SCHOOL-GOING CHILDREN

This chapter presents an exploratory analysis of school-going children's travel patterns on weekdays. Section 4.1 focuses on the commutes to and from school and Section 4.2 describes the travel undertaken during the post home-arrival period.

4.1 Exploratory Analysis Of The School Commute Patterns

This section of the chapter describes the commute patterns of children. The overall commute comprises of the home-to-school (H-S) and the school-to-home (S-H) journeys. The commute pattern is described in terms of the mode of travel, the start times, the children's companions for these travel activities, and the number of stops made during each of the H-S and S-H journeys. Each stop can further be characterized in terms of the activity type, location, and duration.

Table 4-1 presents the number of stops in home-to-school (H-S) and school-to-home (S-H) journey. Most of the school-going children travel directly from home to school without any intermediate stops (84.64% in PSID and 90.96% in NHTS) and few children are found to make stops during the H-S journey. But on the way back home from school (S-H journey), the children are more likely to make stops for various purposes. Although zero and one stop accounts for a major share, the percentage share of two or more stops is found to be significant as well.

Figures 4-1 and 4-2 present the distribution of the time-of-day of the start of the H-S and S-H journeys. The first figure presents the graph based on the PSID-CDS data whereas the second figure presents the graph based on the NHTS data. Both graphs show strong peaking characteristics indicating the constrained nature of the school travel.

Table 4-1. Number of stops in home-to-school (H-S) and school-to-home (S-H) journey

Dataset	H-S		S-H	
	PSID	NHTS	PSID	NHTS
#Stops	Percent			
0	84.65	90.96	74.04	77.76
1	14.32	8.1	18.87	15.1
2	0.81	0.8	5.04	3.9
3	0.18	0.11	1.36	1.88
>=4	0.03	0.02	0.69	1.35
Total	100(3323)	100(4357)	100(3313)	100(4357)

For the H-S journey, the average start times are about 7:14 am (PSID) and 7:44 am (NHTS) and the average end times are 7:47 am (PSID) and 8:11 am (NHTS). The mean durations of travel are 28.28 (PSID) and 20.37 (NHTS) minutes. It is observed that the mean distance traveled is about 4.26 miles for H-S journey for NHTS sample; the corresponding data is not being captured in PSID.

Similarly, for the S-H journey, the average start times are about 3:20 pm (PSID) and 2:59 pm (NHTS) and the average end times are 4:08 pm (PSID) and 3:43 pm (NHTS). The mean durations of travel are 47.74 (PSID) and 44.18 (NHTS) minutes. It is observed that the mean distance traveled is about 6.24 miles for S-H journey for NHTS sample; the corresponding data is not being captured in PSID.

It can be observed that the mean duration of travel for PSID (28.28 minute) is greater than that for NHTS (20.37 minute) and the children also tend to leave early during H-S journey in PSID compared to NHTS. For H-S journey, the median value for the duration of travel is 20 minute (PSID) and 14.34 minute (NHTS) and the standard deviation value is 87.77 minute (PSID) and 29.20 minute (NHTS). The 10th and 90th percentile for the duration of travel are 5 minute and 55 minute in PSID; 4.21 minute and 39.86 minute in NHTS. Similarly, for S-H journey, the median value for the duration of travel is 23.5 minute (PSID) and 19.50 minute

(NHTS) and the standard deviation value is 39.47 minute (PSID) and 74.30 minute (NHTS). The 10th and 90th percentile for the duration of travel are 10 minute and 63.7 minute in PSID; 4.95 minute and 120.18 minute in NHTS.

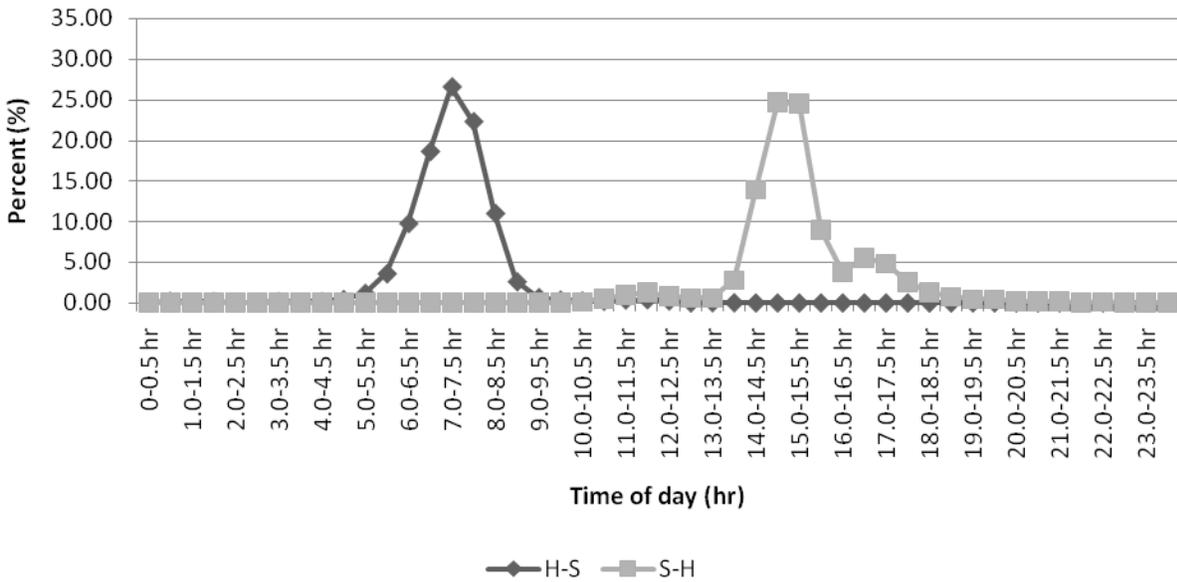


Figure 4-1. Start time of home-to-school (H-S) and school-to-home (S-H) journey for PSID dataset

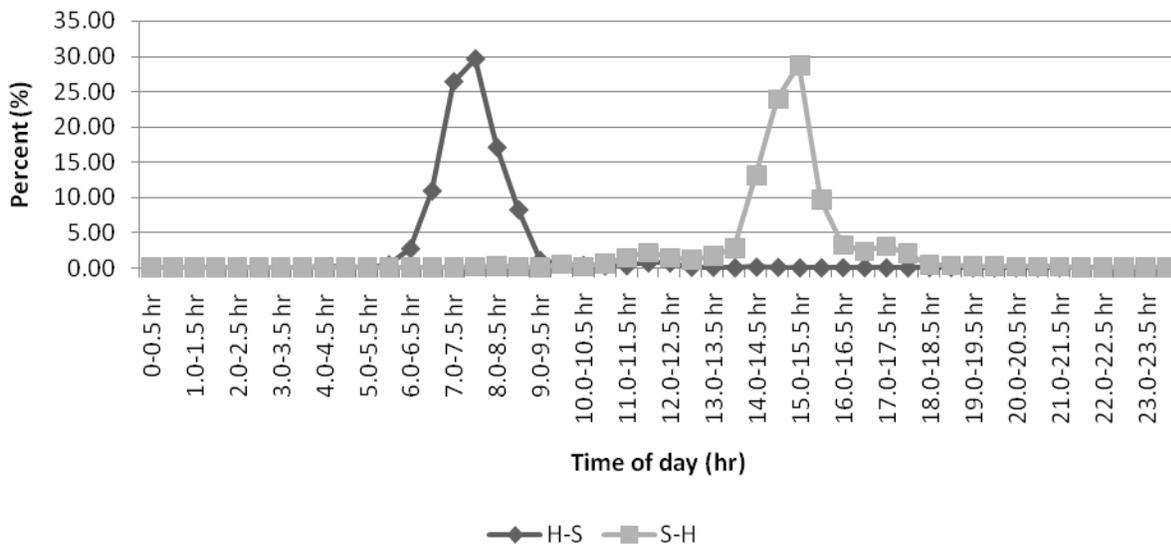


Figure 4-2. Start time of home-to-school (H-S) and school-to-home (S-H) journey for NHTS dataset

Table 4-2 presents descriptive statistics (cross tabulation) on the mode of travel to and from school based on the NHTS (PSID does not provide information on the mode of travel). The

children are very likely to choose the same mode of travel for both the H-S and for S-H journeys. The automobile is the most dominant mode of travel. While this automobile is a household vehicle in most case, some children do travel in non-household vehicles.

Table 4-2. Cross tabulation of mode chosen for travel for the entire tour for home-to-school (H-S representing rows) and school-to-home (S-H representing columns) journey for NHTS dataset

Mode type	Household Vehicle	Non-Household Vehicle	School Bus	Walk or Bike	Other	Total(%)	Total
Household Vehicle	82.2	45.93	16.01	23.3	40.24	46.2	2013
Non-Household Vehicle	3.57	36.67	1.09	2.87	4.34	4.77	208
School Bus	9.81	8.89	78.52	1.08	20	32.66	1423
Walk or Bike	2.72	3.7	2.74	69.53	6.02	11.66	508
Other	1.69	4.81	1.64	3.23	29.4	4.71	205
Total(%)	100	100	100	100	100	100	
Total	1652	270	1462	558	415	4357	4357

Table 4-3 presents the companion type for the entire tour for home-to-school (H-S) and school-to-home (S-H) journey. The mothers take up the responsibility of chauffeuring their children for the H-S and S-H journeys. Non household members as well as a miscellaneous combination of persons are also found to be likely travel companions of children. These results highlight the need for a rigorous analysis of intra- and inter-household interactions in shaping the travel patterns of children

Table 4-4 presents the activity type at each stop for home-to-school (H-S) and school-to-home (S-H) journey based on the NHTS sample. The activity type is mostly concentrated in the daycare and pick-up or drop-off someone which can be accounted for dropping-off or picking-up the sibling(s) or child's friend(s) at the daycare during H-S journey. Even during the S-H journey, pick-up or drop-off someone constitutes a major share; the activity types are dispersed

Table 4-3. Companion type for the entire tour for home-to-school (H-S) and school-to-home (S-H) journey

Dataset	H-S		S-H	
	PSID	NHTS	PSID	NHTS
Accompanying arrangement for Entire Tour		Percent		
Alone	6.98	19.88	5.71	22.45
Only Mother	13.48	13.95	10.95	11.18
Only Father	3.88	5.62	2.64	3.24
Only Sibling	10.26	16.69	8.6	14.62
Mother & Father	-	0.44	-	0.37
Mother & Sibling	13.03	17.58	8.91	14.23
Father & Sibling	2.92	3.88	1.38	2.57
Mother, Father & Sibling	1.02	0.39	0.97	0.78
Non-Household Members	33	7.9	36.57	10.86
Household & Non-Household Members	-	8.38	-	9.27
Miscellaneous	15.43	5.3	24.26	10.44
Total	100(3324)	100(4357)	100(3313)	100(4357)

for the S-H journey with shopping being the major activity. It is observed that a lot a trip chaining occurs during the S-H journey.

Table 4-4. Activity type at each stop for home-to-school (H-S) and school-to-home (S-H) journey

Dataset	NHTS		
	H-S	S-H	
Tour(i)-Stop(i)	Stop1	Stop1	Stop2
Activity		Percent	
Daycare	20.81	17.23	1.61
Religious	2.03	3.51	2.89
Shopping	5.33	14.96	31.51
Active Recreation	1.27	7.53	7.4
Social visits	2.79	8.67	4.5
Passive Recreation	0.76	4.85	4.18
Pickup or Drop-off someone	48.48	17.03	23.47
Meals	2.79	5.26	13.5
Others	15.74	20.95	10.93
Total	100(394)	100(969)	100(311)

Table 4-5 presents location type at each stop in home-to-school (H-S) and school-to-home (S-H) journey based on the PSID-CDS sample. The location type is mostly concentrated in the

daycare and indoor and outdoor recreational places which can be accounted for dropping-off or picking-up the sibling(s) or child’s friend(s) at the daycare and recreational places during both H-S and S-H journey; while the activity types are dispersed for the S-H journey with shopping being the major activity. It is observed that a lot a trip chaining occurs during the S-H journey. About 14.56% of the school going children make a single stop during H-S journey; 25.87% make a single stop and 7.07% make two stops during their S-H journey.

Table 4-5. Location type at each stop in home-to-school (H-S) and school-to-home (S-H) journey

Dataset	PSID		
	H-S	S-H	
Tour(i)-Stop(i)	Stop1	Stop1	Stop2
Location	Percent		
School	-	3.6	5.53
Babysitting/home based daycare	21.07	34.53	23.4
Church	1.65	0.93	2.55
Outdoor recreational places	19.42	9.3	14.89
Stores, shopping centers, malls and their parking lots, beauty parlor	1.03	12.33	19.15
Restaurants, bars, fast-food places, and their parking lots	1.86	3.37	14.04
Indoor recreational places	42.15	27.33	12.34
Others	12.81	8.6	8.09
Total	100(484)	100(860)	100(235)

Table 4-6 presents the stop duration in minute for stop1 and stop2 for home-to-school (H-S) and school-to-home (S-H) journey. For H-S journey, the mean dwell time at stop1 are 172.97 (PSID) and 41.24 minute (NHTS). For, S-H journey, the mean dwell time at stop1 are 77.44 (PSID) and 77.85 minute (NHTS); the mean dwell time at stop2 are 64.53 minute (PSID) and 41.14 minute (NHTS). Children spend more time in stop1 than in stop2.

Table 4-6. Stop duration in minute for stop1 and stop2 for home-to-school (H-S) and school-to-home (S-H) journey

Dataset	Stop Duration (min)	H-S	S-H	
		Stop1	Stop1	Stop2
PSID	Mean	172.97	77.44	64.53
	Median	45.36	60.78	49.14
	Std. Deviation	219.91	66.03	58.96
	10th percentile	0.25	13.43	10.09
	90th percentile	553.42	153.00	129.60
NHTS	Mean	41.24	77.85	41.14
	Median	5.10	44.80	18.14
	Std. Deviation	119.00	98.91	51.35
	10th percentile	0.30	1.56	1.07
	90th percentile	115.15	181.82	115.53

4.2 Exploratory Analysis Of The Post Home-Arrival Period

In addition to the travel to and from school, children are also found to travel in the post home-arrival period, i.e., after returning home from school. This section of the chapter describes the travel undertaken during that period.

Table 4-7 presents the number of tours made in the post home-arrival (PH) period. It is observed that about 41.49% and 39.18% of the school going children make post home arrival tours in PSID and NHTS samples. It can be observed that among the children who tend to make post home arrival tours, it is more likely that they make one tour when compared to two or more tours.

Table 4-7. Number of tours in post-home (PH) arrival journey

Dataset	PSID	NHTS
#Tours	Percent	
0	58.71	60.82
1	35.84	33.21
>=2	5.45	5.97
Total	100(3323)	100(4357)

Tables 4-8 and 4-9 present cross tabulations of the number of tours against the number of stops in the post home-arrival period. The first table is from the PSID dataset and the second is from the NHTS. The results indicate that most of the children who undertake only one tour also make only one stop (74-77 %) indicating a low incidence of trip-chaining. It is useful to note that, in the NHTS sample, tours by definition have at least one stop. On the other hand, tours from the PSID can have zero stops (for example a child taking a walk or a bike ride would be a home-based tour with no stops).

Table 4-10 presents the number of stops in tour in the post home-arrival period. Most of the school going children tend to make one intermediate stop in both tour1 and tour2 in both the

Table 4-8. Cross tabulation of number of tours against number of stops in post home-arrival period for PSID dataset

#Tours	#Stops					Total
	0	1	2	3	>=4	
1	3.11	77.67	15.03	3.19	1.01	100
2	2.76	8.84	61.88	18.78	7.73	100
Total	42	941	291	72	26	1372(100)

Table 4-9. Cross tabulation of number of tours against number of stops in post home-arrival period for NHTS dataset

#Tours	#Stops				Total
	1	2	3	>=4	
1	74.78	17.07	5.46	2.7	100
>=2	0	54.62	30	15.38	100
Total	1082	389	157	79	1707(100)

PSID and NHTS datasets ie., about 71.36% and 62.43% in PSID and 72.23% and 60.77% in NHTS for tour1 and tour2 respectively. The significant percentages of two and more stops in each tour indicate trip chaining.

Table 4-10. Number of stops in each tour in the post home-arrival period

Dataset Tour(i)	PSID		NHTS	
	Tour 1	Tour 2	Tour 1	Tour 2
#Stops	Percent			
0	3.06	2.76	-	-
1	71.36	62.43	72.23	60.77
2	18.15	28.18	18.92	27.69
3	4.96	4.97	6.03	8.08
4	2.48	1.66	2.82	3.47
Total	100(1372)	100(181)	100(1707)	100(260)

Table 4-11 presents the mode chosen for travel for the entire tour in the post home-arrival period. Children are most likely to travel in a household vehicle. Walk-Bike is the second most likely mode. As one would expect, school bus is not used for post-home arrival tours. In about 8-9% of the cases, children use multiple modes during the tour.

Table 4-11. Mode chosen for travel for the entire tour in the post home-arrival period

Dataset Tour(i)	NHTS	
	Tour 1	Tour 2
Mode type for Entire Tour	Percent	
Household Vehicle	65.55	65.77
Non-Household Vehicle	4.1	2.69
School Bus	-	-
Walk or Bike	20.8	23.46
Other	9.55	8.07
Total	100(1707)	100(260)

Table 4-12 presents the companion type for the entire tour in the post home-arrival period. A varied combinations of persons (miscellaneous) are significantly involved in post home travel companion arrangement (37.70% and 42.37% for PSID and about 23.84% and 20.38% for NHTS). It is followed by companion type of mother only, mother and sibling and traveling alone. In can be inferred that mothers are more likely to be involved in chauffeuring their children for post-home-arrival activities than fathers. About 12.8% and 15.23% of the children make tour2 in PSID and NHTS datasets respectively.

Table 4-12. Companion type for the entire tour in the post home-arrival period

Dataset Tour(i)	PSID		NHTS	
	Tour 1	Tour 2	Tour 1	Tour 2
Accompanying arrangement for Entire Tour		Percent		
Alone	16.89	15.82	10.72	9.23
Only Mother	13.25	10.73	13.53	12.31
Only Father	3.28	2.26	5.39	5.77
Only Sibling	4.29	3.95	4.34	5.77
Mother & Father	-	-	1.82	3.46
Mother & Sibling	11.79	4.52	18.45	14.62
Father & Sibling	1.38	2.26	4.22	8.85
Mother, Father & Sibling	6.99	11.3	6.62	7.69
Non-Household Members	4.44	6.78	4.75	4.23
Household & Non-Household Members	-	-	6.33	7.69
Miscellaneous	37.7	42.37	23.84	20.38
Total	100(1374)	100(177)	100(1707)	100(260)

Figures 4-3 and 4-4 present the distribution of the time-of-day of the start of the tour1 and tour2 journeys. The first figure presents the graph based on the PSID-CDS data whereas the second figure presents the graph based on the NHTS data.

For tour1 in the PH arrival period, the average start times for travel are about 5:34 pm (PSID) and 4:55 pm (NHTS); the average end times are 7:32 pm (PSID) and 6:56 pm (NHTS). The mean durations of travel are 118.52 minute (PSID) and 121.29 minute (NHTS). Mean distance traveled is about 11.72 miles for tour1.

Similarly, for tour2 in the PH arrival journey, the average start times for travel are about 6:26 pm (PSID) and 6:10 pm (NHTS); the average end times are 8:24 pm (PSID) and 7:36 pm (NHTS). The mean durations of travel are 95.25 minute (PSID) and 85.81 minute (NHTS). Mean distance traveled is about 11.58 miles for tour2.

For PSID, the start-times are uniformly scattered for tour1 and tour2, whereas in NHTS, there exists peaking at around 5:00 pm and 6:30 pm for tour1 and tour2 respectively. For tour1, the median value for the duration of travel is 37 minute (PSID) and 100.53 minute (NHTS) and

the standard deviation value is 96.90 minute (PSID) and 108.77 minute (NHTS). The 10th and 90th percentile for the duration of travel are 9 minute and 240 minute in PSID; 29.25 minute and 220.52 minute in NHTS. Similarly, for tour2, the median value for the duration of travel is 40 minute (PSID) and 77 minute (NHTS) and the standard deviation value is 57.46 minute (PSID) and 88.54 minute (NHTS). The 10th and 90th percentile for the duration of travel are 10 minute and 148 minute in PSID; 18.71 minute and 177.33 minute in NHTS.

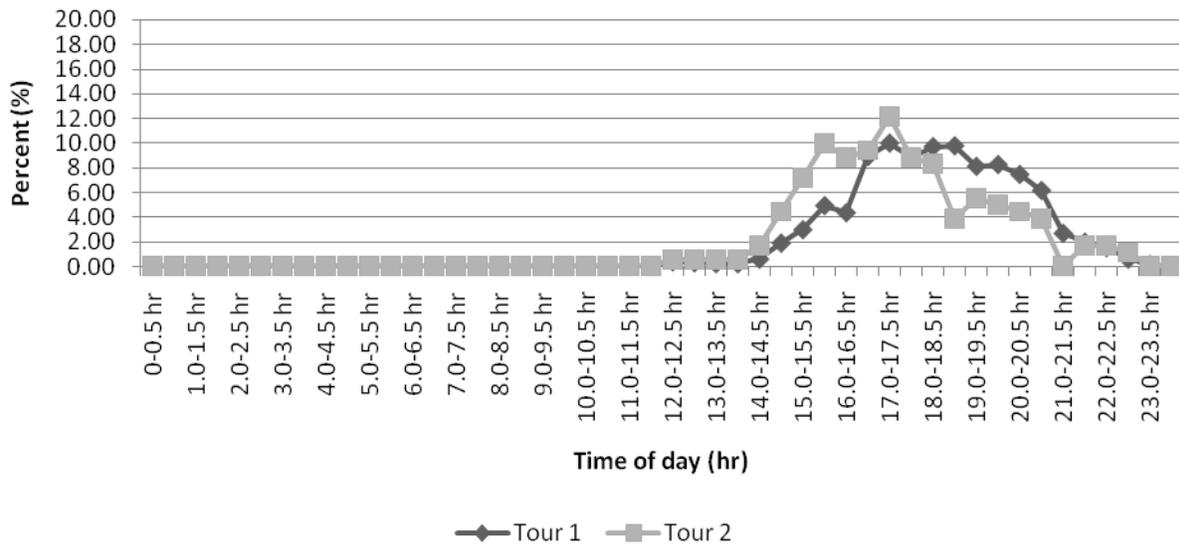


Figure 4-3. Start time of tour1 and tour2 for the post-home (PH) journey for PSID dataset

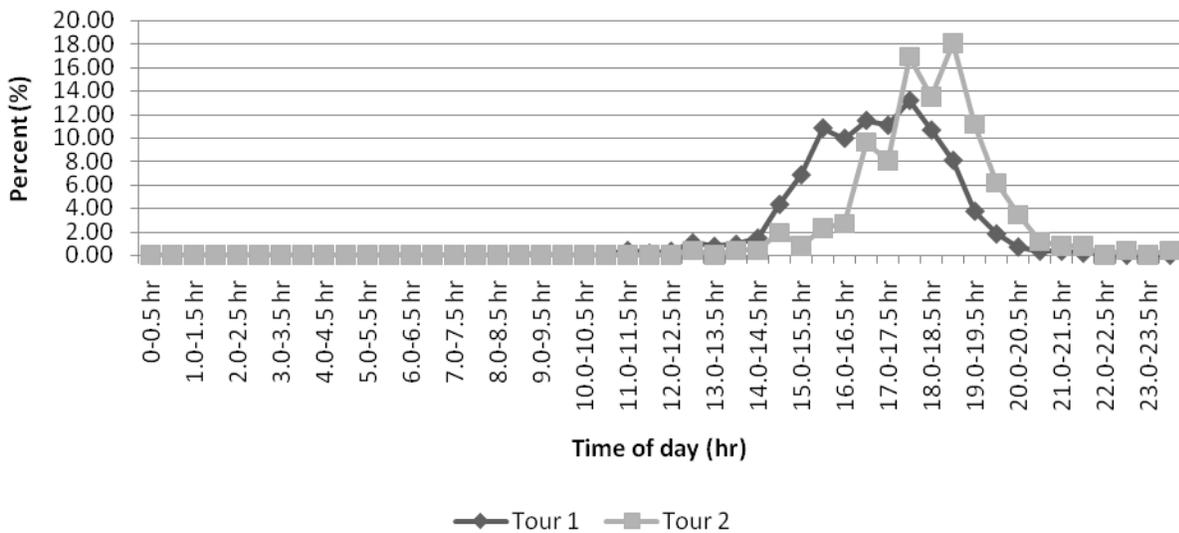


Figure 4-4. Start time of tour1 and tour2 for the post-home (PH) journey for NHTS dataset

Table 4-13 presents the activity type at each stop in each tour in the post home-arrival period. Activity type is mostly concentrated in the active recreation and passive recreation for first stop in each tour i.e., about 23.55% and 24.62% for active recreation and about 11.66% and 13.85% for passive recreation for stop1 in both tour1 and tour2 respectively. It is followed by shopping activity in each stop of tour1 which accounts for about 12.95% and 26.16% for stop1 and stop2 respectively in tour1 from which one can infer that shopping is undertaken as an independent activity with much relaxed time and space constraints. Pick-up or drop-off someone also constitutes a significant portion which can be accounted for dropping-off or picking-up the sibling(s) or child's friend(s) at the various locations; the activity types are dispersed for the post home journey. Among the children who make post home journey, about 27.76% of the children undertake various activities at stop2 in tour1; similarly, for tour2, the values are 15.23% (at stop1) and 5.97% (at stop2).

Table 4-13. Activity type at each stop in each tour in the post home-arrival period

Dataset Tour(i)-Stop(i) Activity	NHTS			
	Tour1-Stop1	Tour1-Stop2	Tour2-Stop1	Tour2-Stop2
	Percent			
Daycare	0.88	0.63	0.77	-
Religious	8.44	2.95	6.92	3.92
Shopping	12.95	26.16	9.23	12.75
Active Recreation	23.55	7.17	24.62	5.88
Social visits	12.24	9.92	13.85	8.82
Passive Recreation	11.66	7.38	13.85	9.8
Pick-up or Drop-off someone	11.07	16.03	13.46	20.59
Meals	8.85	20.25	10.77	22.55
Others	10.37	9.49	6.54	15.69
Total	100(1707)	100(474)	100(260)	100(102)

Table 4-14 presents the location type at each stop in each tour in the post home-arrival period. The location type is mostly concentrated in the daycare and indoor and outdoor recreational places which can be accounted for dropping-off or picking-up the sibling(s) or

child’s friend(s) at the daycare and children engaging themselves at recreational places for leisure time activities during post home journey; while the activity types are dispersed for the post home-arrival period with shopping being the major activity. It is inferred that a lot a trip chaining occurs during the post home journey. Among the children who make post home journey, about 24.68% of them make stops at various locations in stop2 in tour1; similarly, in tour2, the values are 14.46% (at stop1) and 2.0% (at stop2).

Table 4-14. Location type at each stop in each tour in the post home-arrival period

Dataset Tour(i)-Stop(i) Location	PSID			
	Tour1-Stop1	Tour1-Stop2	Tour2-Stop1	Tour2-Stop2
	Percent			
School	8.81	7.07	5.75	4.17
Babysitting/home based daycare	20.28	20.2	20.11	8.33
Church	7.48	3.7	8.62	4.17
Outdoor recreational places	22.11	15.49	14.37	16.67
Stores, shopping centers, malls and their parking lots, beauty parlor	10.14	20.54	8.62	20.83
Restaurants, bars, fast-food places, and their parking lots	4.99	15.49	4.02	37.5
Indoor recreational places	14.05	9.09	12.07	8.33
Others	12.14	8.42	26.44	-
Total	100(1203)	100(297)	100(174)	100(24)

Table 4-15 presents the stop duration in minutes for each stop in each tour in the post home-arrival period. The mean dwell time being 78.20 minute (PSID) and 71.09 minute (NHTS) for stop1 in tour1; 59.89 minute (PSID) and 49.46 minute (NHTS) for stop2 in tour1. Similarly, 61.87 minute (PSID) and 85.33 minute (NHTS) for stop1 in tour2; 44.08 minute (PSID) and 83.12 minute (NHTS) for stop2 in tour2. Children spend more time at stop1 than at stop2 in each tour.

Table 4-15. Stop duration in minute for each stop in each tour in the post home-arrival period

Dataset	Stop Duration (min)	Tour(i)-Stop(i)			
		Tour1-Stop1	Tour1-Stop2	Tour2-Stop1	Tour2-Stop2
PSID	Mean	78.2	59.89	61.87	44.08
	Median	60.88	44.26	50	31
	Std. Deviation	58.46	52.78	46.2	38.8
	10th percentile	16.82	12.33	14.98	5.9
	90th percentile	149.39	123.11	131.2	100.5
NHTS	Mean	71.09	49.46	85.33	83.12
	Median	59.72	30.30	49.67	58.00
	Std. Deviation	75.64	57.52	159.06	105.27
	10th percentile	1.65	2.29	1.57	5.56
	90th percentile	154.91	119.64	152.50	166.00

CHAPTER 5
EXPLORATORY ANALYSIS OF NON-SCHOOL GOING CHILDREN’S (NSGC) TRAVEL
PATTERN ON A WEEKDAY

This chapter presents the exploratory analysis of non-school going children’s travel pattern on a weekday. This section describes in detail, the pattern, tour and stop level attributes for non-school going children’s travel pattern.

Table 5-1 presents the number of tours. It is observed that about 23.89% of the non-school going children do not travel on a weekday in PSID and the corresponding value being 18.36% in NHTS. It can be observed that more children in NHTS tend to travel than those in PSID; the fraction of one or more tours being almost the same.

Table 5-1. Number of tours

Dataset	PSID	NHTS
#Tours	Percent	
0	23.89	18.36
1	46.36	45.82
2	22.13	23.54
3	6.26	7.77
>=4	1.36	4.52
Total	100(1351)	100(4040)

Tables 5-2 and 5-3 present cross tabulations of the number of tours against the number of stops. Of all the children who make only one tour 54-60% made only one stop. This indicates that trip chaining (multiple stops in the same tour) is occurring in more than 40% of children making only one tour. On examining children who make two tours, we find that 38-42 % make exactly two stops and hence have no trip chaining. Thus, the results suggest a greater extent of trip chaining the more the number of tours made by the child.

Table 5-4 presents the number of stops made in each tour. It is observed that most of the non-school going children tend to make one intermediate stop in both tour1 and tour2 in both the

Table 5-2. Cross tabulation of number of tours and number of stops for PSID dataset

#Tours	#Stops (PSID)						Total
	0	1	2	3	4	>=5	
1	1.62	60.74	16.96	9.85	4.68	6.14	100
2	5.03	16.67	42.14	20.13	10.69	5.35	100
3	1.9	16.19	22.86	29.52	14.29	15.24	100
>=4	13.11	4.92	9.84	19.67	16.39	36.07	100
Total	36	449	269	168	88	93	1103(100)

Table 5-3. Cross tabulation of number of tours and number of stops for NHTS dataset

#Tours	#Stops (NHTS)							Total
	1	2	3	4	5	6	>=7	
1	54.3	20.56	11.53	6.46	4.22	2.08	0.85	100
2	0.22	38.7	26.17	15.32	9.17	6.04	4.36	100
3	0	0.4	31.62	28.06	16.21	10.67	13.04	100
>=4	0	0	0	29.09	12.73	20	38.18	100
Total	1019	732	530	345	209	131	109	3075(100)

PSID and NHTS datasets i.e., about 56.07% (PSID) and 46.50% (NHTS) for tour1 and about 50.84% (PSID) and 36.06% (NHTS) for tour2.

Table 5-4. Number of stops in each tour

Dataset	PSID		NHTS	
	Tour 1	Tour 2	Tour 1	Tour 2
#Stops			Percent	
0	3.15	5.23	-	-
1	56.07	50.84	46.5	36.06
2	20.3	24.69	25.64	32.27
3	9.55	10.46	13.37	16.34
4	4.82	4.6	7.29	8.76
>=5	6.12	4.18	7.19	6.57
Total	100(1079)	100(478)	100(3073)	100(1187)

Table 5-5 presents the mode chosen for travel for the entire tour in NHTS. It is observed that for the non-school children, the household vehicle is the most likely mode of transport and walk-bike is the second most likely mode of transport. It is also observed that there exists a

significant change of mode i.e., combination of various modes which accounts to about 13.67% and 8.16% in tour1 and tour2 respectively. PSID does not provide information on travel mode.

Table 5-5. Mode chosen for travel for the entire tour

Dataset	NHTS	
Tour(i)	Tour 1	Tour 2
Mode type for Entire Tour	Percent	
Household Vehicle	70.65	69.7
Non-Household Vehicle	5.37	3.54
School Bus	0.65	-
Walk or Bike	9.66	18.6
Other	13.67	8.16
Total	100(3073)	100(1188)

Table 5-6 presents the companion type for the entire tour. It is to be noted that a varied combinations of persons (miscellaneous) are significantly involved and companion arrangement which can be accounted for trip chaining i.e., about 42.83% (PSID) and 28.60% (NHTS) for trip1 and about 34.45% (PSID) and 25.34% (NHTS) for trip2. It is followed by companion type of mother only, mother and sibling and traveling alone. It can be inferred that mothers are more likely to be involved in chauffeuring children’s activities than fathers. It is to be noted that about 43.47% (PSID) and 38.66% (NHTS) of the children make tour2.

Figures 5-1 and 5-2 present the distribution of the time-of-day of the start of the tour1 and tour2 journeys. For tour1, the average start time for travel is about 11:51 am (PSID) and 10:50 am (NHTS); the average end time for travel is about 4:00 pm (PSID) and 3:24 pm (NHTS) with the mean durations of travel being 248.47 minute (PSID) and 273.68 minute (NHTS). For tour1, the median value for the duration of travel is 47.5 minute (PSID) and 189.22 minute (NHTS) and the standard deviation value is 221.03 minute (PSID) and 228.02 minute (NHTS). The 10th and 90th percentile for the duration of travel are 0 minute and 392.1 minute in PSID; 37.16 minute

Table 5-6. Companion type for the entire tour

Dataset Tour(i)	PSID		NHTS	
	Tour 1	Tour 2	Tour 1	Tour 2
Accompanying arrangement for Entire Tour	Percent			
Alone	15.15	11.48	3.38	4.21
Only Mother	16.52	15.87	15.88	11.95
Only Father	2.81	4.8	4.1	5.05
Only Sibling	2.81	7.1	4.91	4.29
Mother & Father	-	-	2.93	4.71
Mother & Sibling	10.8	10.23	22.55	20.54
Father & Sibling	1.81	3.76	3.19	2.61
Mother, Father & Sibling	4.81	8.35	5.17	9.51
Non-Household Members	2.45	3.97	2.67	3.37
Household & Non-Household Members	-	-	6.61	8.42
Miscellaneous	42.83	34.45	28.6	25.34
Total	100(1102)	100(479)	100(3073)	100(1188)

and 615.2 minute in NHTS. It is observed that the mean distance traveled is about 19.61 miles for tour1 in NHTS sample. This data is not being captured in PSID. From the below graph, it can be observed that tour1 takes place in the morning and afternoon hours of the day, in both PSID and NHTS samples.

Similarly, for tour2, the average start time for travel is about 12:09 pm (PSID) and 3:48 pm (NHTS); the average end time for travel is about 2:32 pm (PSID) and 5:45 pm (NHTS) with the mean durations of travel being 142.36 minute (PSID) and 117.52 minute (NHTS). For tour2, the median value for the duration of travel is 40 minute (PSID) and 89.44 minute (NHTS) and the standard deviation value is 120.19 minute (PSID) and 114.02 minute (NHTS). The 10th and 90th percentile for the duration of travel are 0 minute and 224.5 minute in PSID; 20.75 minute and 240.57 minute in NHTS. It is observed that the mean distance traveled is about 15.19 miles for tour2 in NHTS sample. This data is not being captured in PSID. From the below graph, it can be observed that tour2 takes place in the afternoon and evening hours of the day in both PSID and NHTS samples.

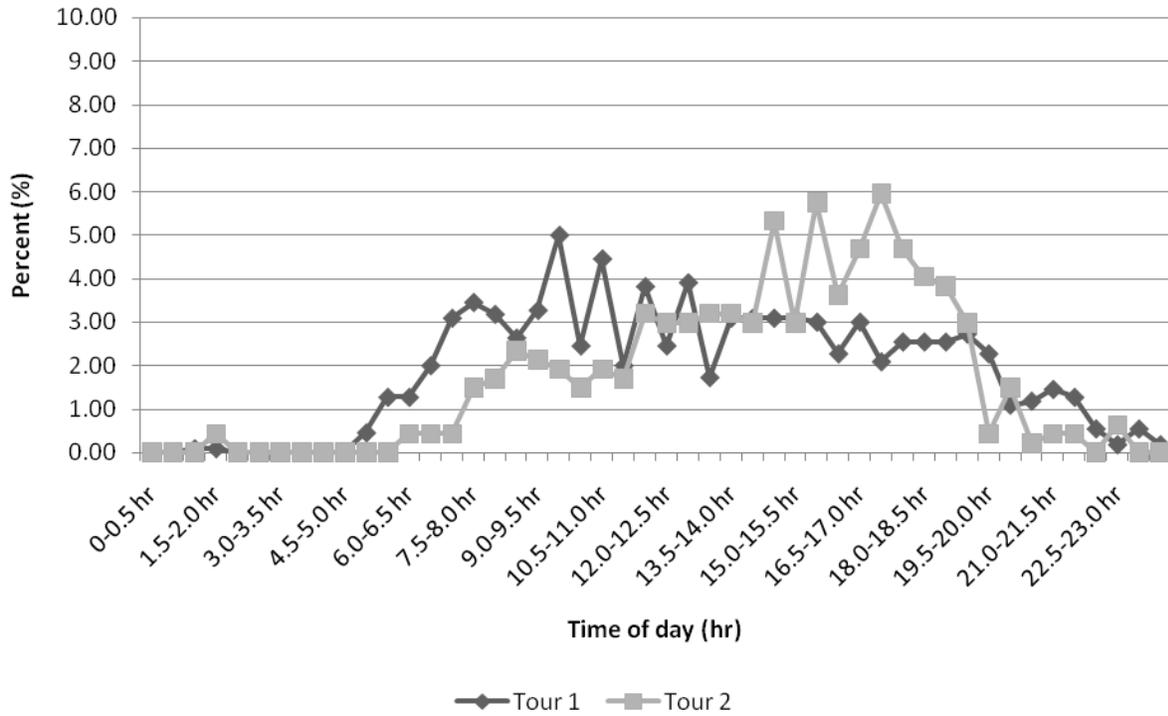


Figure 5-1. Start time of tour1 and tour2 for PSID dataset

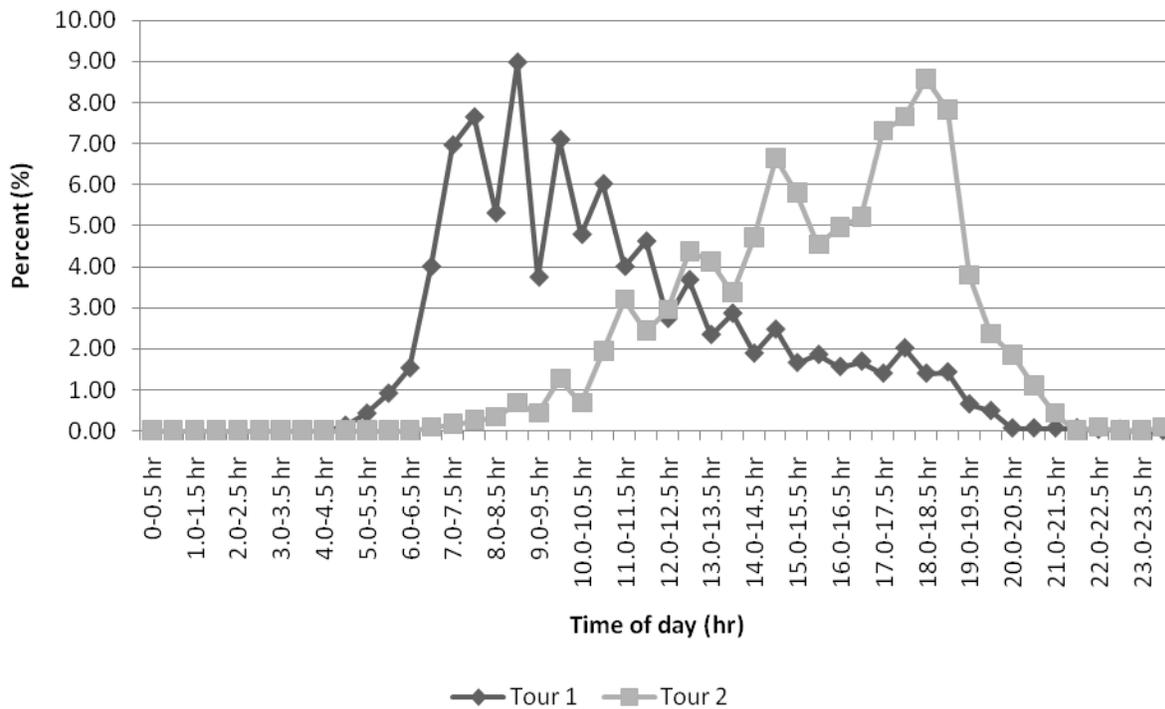


Figure 5-2. Start time of tour1 and tour2 for NHTS dataset

Table 5-7 presents the activity type at each stop in each tour. It can also be noted that the activity types are dispersed over various activity centers. Shopping activity constitutes the major activity with a major share in each stop of each tour which accounts for about 21.51% (at stop1) and 30.47% (at stop2) in tour1; similarly, about 19.88% (at stop1) and 16.15% (at stop2) for tour2 from which one can infer that shopping is undertaken as a major independent activity with much relaxed time and space constraints. Pick-up or drop-off someone constitutes a significant portion which can be accounted for dropping-off or picking-up the sibling(s) or child's friend(s) at the various locations including daycare. Non-school going children are more involved in social visits which accounts for about 11.06% (stop1) and 8.76% (stop2) in tour1; similarly, about 12.97% (at stop1) and 10.19% (at stop2) for tour2 from which one can infer the flexibility in time and space constraints. It is observed that the active recreation and passive recreation constitutes for a lesser fraction when compared to that of school going children. It is observed that about 53.50% of the children undertake various activities at stop2 in tour1; similarly, the values are about 38.63% (at stop1) and 28.41% (at stop2) in tour2.

Table 5-7. Activity type at each stop in each tour

Dataset Tour(i)-Stop(i)	NHTS			
	Tour1-Stop1	Tour1-Stop2	Tour2-Stop1	Tour2-Stop2
Activity	Percent			
Daycare	16.56	4.87	1.94	0.34
Religious	3.77	1.52	4.55	1.15
Shopping	21.51	30.47	19.88	16.15
Active Recreation	6.44	4.5	13.9	4.47
Social visits	11.06	8.76	12.97	10.19
Passive Recreation	6.9	6.14	12.05	7.67
Pickup or Dropoff someone	17.6	18.73	18.11	20.73
Meals	4.82	14.11	7.83	19.24
Others	11.32	10.89	8.76	20.05
Total	100(3073)	100(1644)	100(1187)	100(873)

Table 5-8 presents the location type at each stop in each tour. It is observed that location type is mostly concentrated in the daycare and indoor and outdoor recreational places which can be accounted for dropping-off or picking-up the sibling(s) or child's friend(s) at the daycare center and children engaging themselves at recreational places for leisure time activities; while the activity types are dispersed with shopping being the major activity. It can be inferred that a lot a trip chaining occurs at different locations by the fact that about 42.11% of the children make stops at various locations at stop2 in tour1; similarly, the values are about 43.35% (at stop1) and 20.10% (at stop2) in tour2.

Table 5-8. Location type at each stop in each tour

Dataset Tour(i)-Stop(i)	PSID			
	Tour1-Stop1	Tour1-Stop2	Tour2-Stop1	Tour2-Stop2
Location	Percent			
School	2.3	2.27	2.43	0.95
Babysitting/home based daycare	30.62	19.55	24.06	11.43
Church	0.86	0.23	3.09	0.48
Outdoor recreational places	14.55	11.82	18.98	8.57
Stores, shopping centers, malls and their parking lots, beauty parlor	16.75	21.59	18.1	20.95
Restaurants, bars, fast-food places, and their parking lots	4.59	14.77	5.52	13.33
Indoor recreational places	15.89	17.27	11.04	21.43
Others	14.45	12.5	16.78	22.86
Total	100(1045)	100(440)	100(453)	100(210)

Table 5-9 presents the stop duration in minute for each stop in each tour. It is observed that the mean dwell time for the PSID dataset being 193.37 minute (at stop1) and 121.73 minute (at stop2) for tour1; similarly, about 99.51 minute (at stop1) and 132.97 minute (at stop2) for tour2. For NHTS dataset, the mean dwell time being 166.30 minute (at stop1) and 108.19 minute (at stop2) for tour1; similarly, about 83.53 minute (at stop1) and 126.99 minute (at stop2) for tour2.

It is observed that the children spend more time at stop1 compared to stop2 in tour1 and vice-versa in tour2.

Table 5-9. Stop duration in minute for each stop in each tour

Dataset	Stop Duration (min)	Tour(i)-Stop(i)			
		Tour1-Stop1	Tour1-Stop2	Tour2-Stop1	Tour2-Stop2
PSID	Mean	193.37	121.73	99.51	132.97
	Median	101.00	61.70	60.42	97.86
	Std. Deviation	217.90	151.79	109.50	139.84
	10th percentile	18.75	15.88	14.60	17.50
	90th percentile	536.27	341.25	260.67	347.50
NHTS	Mean	166.30	108.19	83.53	126.99
	Median	73.00	46.50	44.25	69.12
	Std. Deviation	205.99	156.69	136.81	170.74
	10th percentile	2.68	2.87	1.50	5.43
	90th percentile	537.80	324.70	179.29	342.64

CHAPTER 6
EXPLORATORY ANALYSIS OF CHILDREN'S TRAVEL PATTERN ON A WEEKEND
DAY

This chapter presents the exploratory analysis of children's travel pattern on a weekend day. This section describes in detail, the pattern, tour and stop level attributes for children's travel pattern on a weekend day.

Table 6-1 presents the number of tours. It is observed that just about 8.17% of the children do not travel and the remaining 91.83% do travel for the PSID dataset; the corresponding values being 20.22 and 79.78% for the NHTS dataset. It is observed that the higher fraction of higher tours is in PSID when compared to NHTS.

Table 6-1. Number of tours

Dataset	PSID	NHTS
#Tours		Percent
0	8.17	20.22
1	51.09	43.74
2	27.04	26.61
3	8.69	7.63
4	2.36	1.67
>=5	2.65	0.14
Total	100(4786)	100(2819)

Tables 6-2 and 6-3 present cross tabulations of the number of tours against the number of stops. Of all the children who make only one tour 45-46% made only one stop. This indicates that trip chaining (multiple stops in the same tour) is occurring in more than 52% of children making only one tour. On examining children who make two tours, we find that 39-42 % make exactly two stops and hence have no trip chaining. Thus, the results suggest a greater extent of trip chaining the more the number of tours made by the child.

Table 6-2. Cross tabulation of number of tours and number of stops for PSID dataset

#Tours	#Stops (PSID)								Total
	0	1	2	3	4	5	6	>=7	
1	2.82	45.52	20.57	13.95	8.06	4.25	1.96	2.86	100
2	1.08	6.26	42.89	25.27	13.29	6.96	2.55	1.7	100
3	4.33	3.13	9.86	38.22	19.47	13.22	5.77	6.01	100
4	11.5	4.42	3.54	15.93	20.35	23.89	11.5	8.85	100
>=5	47.24	17.32	5.51	3.94	3.15	10.24	7.87	4.72	100
Total	174	1234	1110	850	477	289	128	133	4395(100)

Table 6-3. Cross tabulation of number of tours and number of stops for NHTS dataset

#Tours	#Stops (NHTS)							Total
	1	2	3	4	5	6	>=7	
1	46.63	23.44	14.6	8.68	3.08	1.46	2.11	100
2	0.27	39.07	27.2	17.47	8.4	3.87	3.73	100
3	0	0	39.07	22.79	14.42	13.95	9.77	100
4	0	0	2.13	44.68	21.28	17.02	14.89	100
>=5	0	0	0	0	50	50	0	100
Total	577	582	469	308	144	87	82	2249(100)

Table 6-4 presents the number of stops in each tour. It is observed that most of the children tend to make one intermediate stop in both tour1 and tour2 in both the PSID and NHTS datasets.

Here, an unusual higher fraction is found for stop2 in tour2 than in tour1.

Table 6-4. Number of stops in each tour

Dataset	PSID		NHTS	
	Tour 1	Tour 2	Tour 1	Tour 2
#Stops	Percent			
0	2.82	1.08	-	-
1	45.52	6.26	41.92	38.62
2	20.57	42.89	27.33	31.24
3	13.95	25.27	17.04	18.66
4	8.06	13.29	8.1	7.49
>=5	9.08	11.21	5.61	3.99
Total	100(4395)	100(1918)	100(2247)	100(1002)

Table 6-5 presents the mode chosen for the entire tour in NHTS. It is observed that the household vehicle is the most likely mode of transport and walk-bike is the second most likely

mode of transport. It is also observed that there exists a significant change of mode i.e., combination of various modes for trip chaining travel purposes which accounts to about 13.53% and 7.07% in tour1 and tour2 respectively. PSID does not provide information on travel mode.

Table 6-5. Mode chosen for travel for the entire tour

Dataset	NHTS	
Tour(i)	Tour 1	Tour 2
Mode type for Entire Tour	Percent	
Household Vehicle	73.39	71.91
Non-Household Vehicle	4.18	4.28
Public Transportation	0.45	0.7
School Bus	0.09	-
Walk or Bike	7.88	15.04
Other	0.49	1
Miscellaneous	13.53	7.07
Total	100(2247)	100(1004)

Table 6-6 presents the companion type for the entire tour. It is to be noted that a varied combinations of persons (miscellaneous) are significantly involved and companion arrangement which can be accounted for trip chaining i.e., about 24.18% (PSID) and 21.98% (NHTS) for trip1 and about 23.32% (PSID) and 16.73% (NHTS) for trip2. It is followed by companion type of mother, father and sibling which can be accounted for the flexible time schedule of parents on a weekend when compared to that of a weekday i.e., it can be inferred that both mothers and fathers are more likely to be involved in chauffeuring children’s activities over a weekend day. Even the companion type of mother only and mother and sibling are found to be significant across the datasets. More children tend to travel alone in PSID dataset when compared to that of NHTS on a weekend day. It is to be noted that about 45.01% (PSID) and 44.68% (NHTS) of the children make tour2.

Table 6-6. Companion type for the entire tour

Dataset Tour(i)	PSID		NHTS	
	Tour 1	Tour 2	Tour 1	Tour 2
Accompanying arrangement for Entire Tour	Percent			
Alone	15.19	12.31	3.12	5.68
Only Mother	10.33	11.11	9.52	10.96
Only Father	4.3	4.69	5.3	6.57
Only Sibling	5.56	6.52	3.69	3.39
Mother & Father	-	-	5.56	5.78
Mother & Sibling	13.88	11.68	14.73	10.86
Father & Sibling	2.98	3.76	5.03	5.28
Mother, Father & Sibling	17.37	18.68	19.85	19.82
Non-Household Members	6.2	7.93	2.36	3.49
Household & Non-Household Members	-	-	8.86	11.45
Miscellaneous	24.18	23.32	21.98	16.73
Total	100(4259)	100(1917)	100(2247)	100(1004)

Figure 6-1 and Figure 6-2 present the distribution of the time-of-day of the start of the journey. For tour1, it is observed that the average start time for travel is about 12:33 pm (PSID) and 11:03 am (NHTS) and the average end time for travel is about 4:16 pm (PSID) and 3:08 pm (NHTS) with the mean durations of travel being 219.90 minute (PSID) and 244.36 minute (NHTS). From the above graph, it can be observed that tour1 takes place in the afternoon hours in PSID as against late morning and afternoon hours in NHTS. It is observed that the mean distance traveled is about 26.41 miles for tour1 in NHTS sample. This data is not being captured in PSID. For tour1, the median value for the duration of travel is 62 minute (PSID) and 184.81 minute (NHTS) and the standard deviation value is 211.38 minute (PSID) and 193.07 minute (NHTS). The 10th and 90th percentile for the duration of travel are 15 minute and 400 minute in PSID; 58.03 minute and 526.63 minute in NHTS.

Similarly, for tour2, the average start time for travel is about 3:45 pm (PSID) and 3:20 pm (NHTS) and the average end time for travel is about 5:11 pm (PSID) and 5:56 pm (NHTS) with the mean durations of travel being 82.97 minute (PSID) and 156.06 minute (NHTS). From the

above graph, it can be observed that tour2 takes place in the late afternoon and evening hours as against late afternoon and evening hours of the day in PSID and NHTS samples respectively. It is observed that the mean distance traveled is about 17.84 miles for tour2 in NHTS sample. This data is not being captured in PSID. For tour2, the median value for the duration of travel is 45 minute (PSID) and 133.6 minute (NHTS) and the standard deviation value is 116.89 minute (PSID) and 133.6 minute (NHTS). The 10th and 90th percentile for the duration of travel 10 are minute and 215.4 minute in PSID; 29.93 minute and 315.79 minute in NHTS.

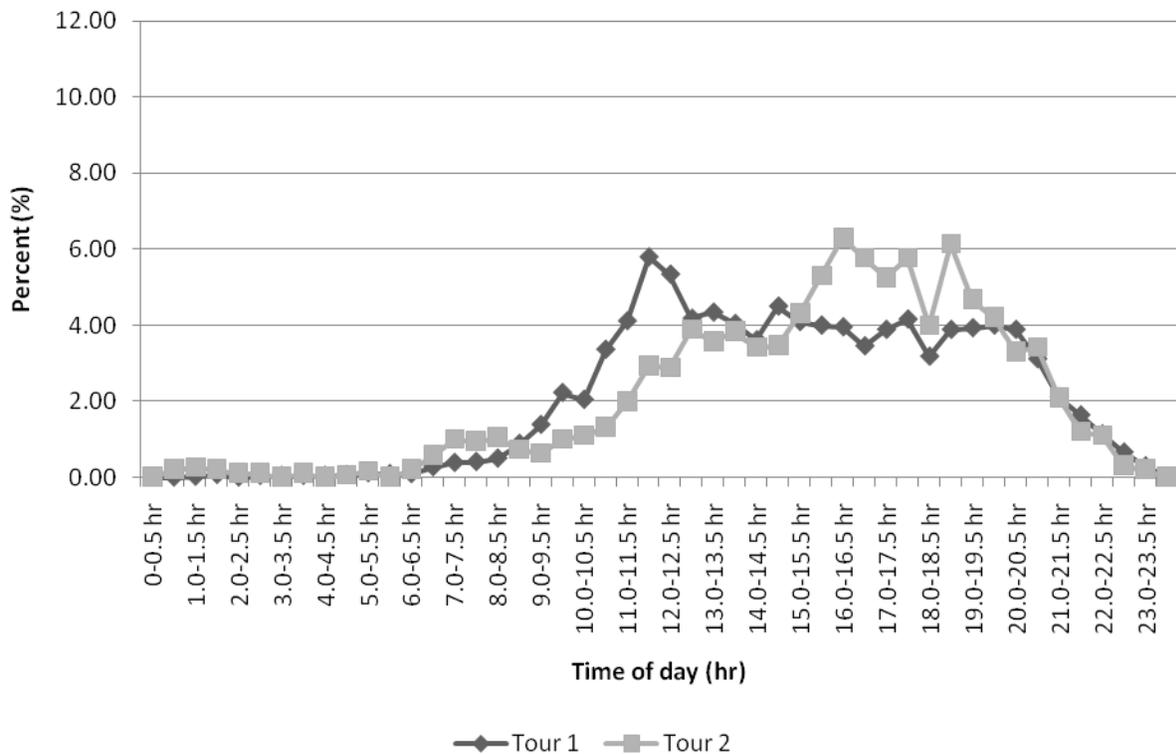


Figure 6-1. Start time of tour1 and tour2 for PSID dataset

Table 6-7 presents the activity type at each stop in each tour. It can also be noted that the activity types are dispersed over various activity centers. Shopping activity constitutes the major activity with a major share in each stop of each tour which accounts for about 23.25% (at stop1) and 33.41% (at stop2) in tour1; similarly, about 23.35% (at stop1) and 18.37% (at stop2) for

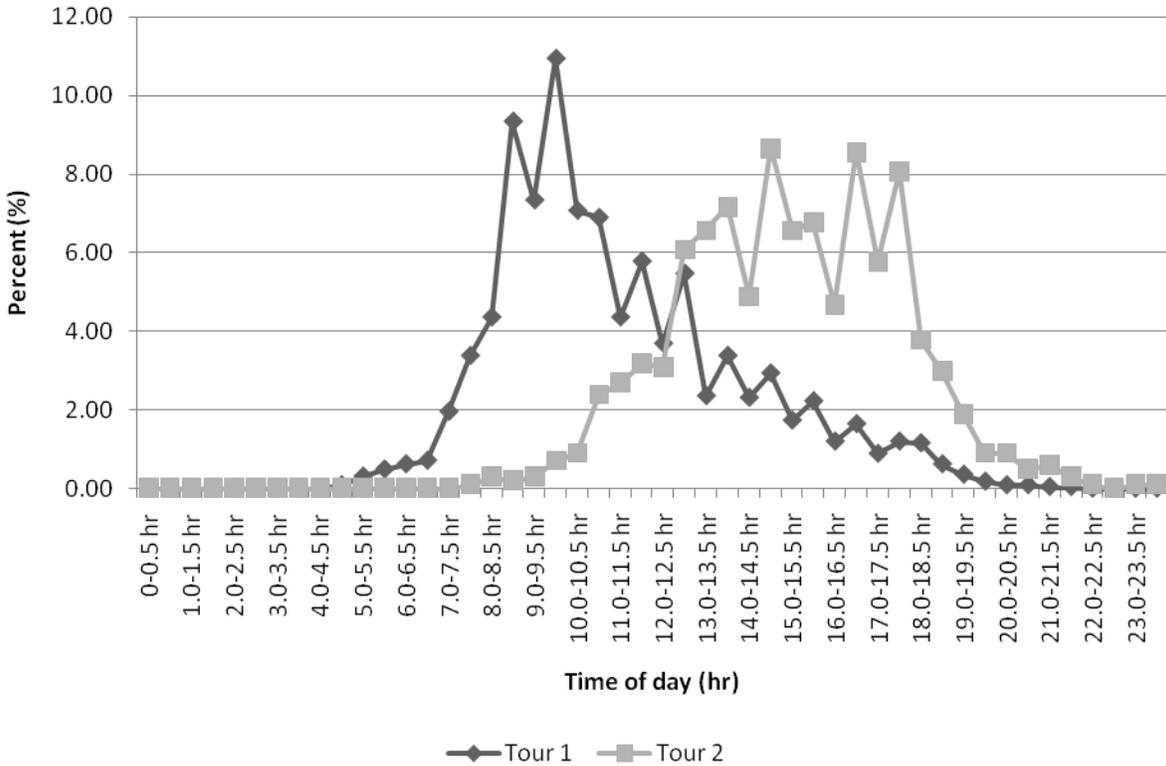


Figure 6-2. Start time of tour1 and tour2 for NHTS dataset

tour2 from which one can infer that shopping is undertaken as a major independent activity with much relaxed time and space constraints. Here it can be noted that active recreation, passive recreation and pick-up or drop-off are found to constitute for a lesser fraction on a weekend day unlike weekday. Religious activity is undertaken a major activity on a weekend day which may involve going to churches, religious centers; children tend to make social visits may with their parents and family members; more likely to go out for meals from which one can infer the flexibility in time and space constraints. It is observed that about 58.03% of the children undertake various activities at stop2 in tour1; similarly, the values are about 44.55% (at stop1) and 27.35% (at stop2) in tour2.

Table 6-7. Activity type at each stop in each tour

Dataset Tour(i)-Stop(i)	NHTS			
	Tour1-Stop1	Tour1-Stop2	Tour2-Stop1	Tour2-Stop2
Activity	Percent			
School	0.58	0.08	0.1	0.16
Daycare	0.89	0.38	0.4	-
Religious	22.41	3.45	7.09	2.28
Shopping	23.25	33.41	23.35	18.37
Active Recreation	8.09	5.21	11.68	6.18
Social visits	13.61	13.49	15.87	10.89
Passive Recreation	9.47	8.58	14.97	10.41
Pick-up or Drop-off someone	6.67	7.43	6.59	8.94
Meals	8.8	21	12.77	31.06
Others	6.22	6.97	7.19	11.71
Total	100(2249)	100(1305)	100(1002)	100(615)

Table 6-8 presents the location type at each stop in each tour. It is observed that location type is mostly concentrated in the indoor and outdoor recreational places which can be accounted for children engaging themselves at recreational places for leisure time activities; while the activity types are dispersed with shopping being the major activity from which one can infer the flexibility in time and space constraints. It is even found that the daycare activity is quite significant which can be accounted for dropping-off or picking-up the sibling(s) or child's friend(s) at the daycare center. It can be inferred that a lot a trip chaining occurs at different locations by the fact that about 54.70% of the children make stops at various locations at stop2 in tour1; similarly, the values are about 43.40% (at stop1) and 24.26% (at stop2) in tour2.

Table 6-9 presents the stop duration in minute for each stop in each tour. It is observed that the mean dwell time for the PSID dataset being 213.26 minute (at stop1) and 147.03 minute (at stop2) for tour1; similarly, about 115.05 minute (at stop1) and 135.94 minute (at stop2) for tour2. For NHTS dataset, the mean dwell time being 126.55 minute (at stop1) and 99.70 minute (at

Table 6-8. Location type at each stop in each tour

Dataset Tour(i)-Stop(i)	PSID			
	Tour1-Stop1	Tour1-Stop2	Tour2-Stop1	Tour2-Stop2
Location	Percent			
School	0.36	0.74	0.71	0.39
Babysitting/home based daycare	11.42	12.13	20.25	10.64
Church	9.36	4.76	6.93	2.83
Outdoor recreational places	11.56	9.09	18.56	8.69
Stores, shopping centers, malls and their parking lots, beauty parlor	18.03	19.84	17.03	19.63
Restaurants, bars, fast-food places, and their parking lots	14.81	24.25	11.03	23.44
Indoor recreational places	17.86	17.02	11.79	16.41
Others	16.61	12.17	13.7	17.97
Total	100(4221)	100(2309)	100(1832)	100(1024)

stop2) for tour1; similarly, about 114.02 minute (at stop1) and 144.27 minute (at stop2) for tour2.

It is observed that the children spend more time at stop1 compared to stop2 in tour1 and vice-versa in tour2.

Table 6-9. Stop duration in minute for each stop in each tour

Dataset	Stop Duration (min)	Tour(i)-Stop(i)			
		Tour1-Stop1	Tour1-Stop2	Tour2-Stop1	Tour2-Stop2
PSID	Mean	213.26	147.03	115.05	135.94
	Median	158.75	119.21	91.20	110.84
	Std. Deviation	177.51	131.90	95.20	118.70
	10th percentile	59.89	30.00	25.21	29.48
	90th percentile	489.26	299.44	229.56	251.00
NHTS	Mean	126.55	99.70	114.02	144.27
	Median	84.60	60.11	71.60	104.00
	Std. Deviation	146.28	129.42	143.46	154.20
	10th percentile	5.50	5.05	4.09	10.00
	90th percentile	285.90	239.67	249.10	302.67

CHAPTER 7 TRAVEL GENERATION MODELS

This chapter presents models for children's travel-generation. Specifically, three choices are modeled: (1) the decision to travel on any day, (2) the number of tours during the day, conditional on choosing to travel, and (3) the number of activity stops during the day, again conditional on choosing to travel. These models may be expected to be the first steps in any comprehensive children's activity-travel forecasting system. The decision to travel is modeled using the binary-probit structure. The number of tours and stops are modeled using the ordered-probit structure recognizing the inherently discrete and ordered-nature of the choice outcomes. These model structures are fairly well known (See, for example, Ben-Akiva and Lerman, 1985) and hence are not described further here. All these choices are modeled independently in this study – the simultaneous modeling of these choices using the joint unordered-ordered econometric structures is an avenue for further research. All models were estimated using the NLOGIT software.

The rest of this chapter is organized as follows. Sections 7.1 and 7.2 present and discuss the three travel-generation models for weekdays. The first section focuses on school-going children whereas the second focused on non-school-going children. Finally, Section 7.3 discusses the models for travel-generation on weekend days.

7.1 Models For Weekday Travel Generation: School-Going Children

This section of the chapter presents the travel-generation models for school-going children. The focus is on the post home-arrival period, i.e., after returning home from school. Exploratory analysis indicates that children are very unlikely to undertake tours both prior to going to school and based at school. Children do undertake activity stops during their journeys to and from school; however, these are not modeled in this section.

The rest of this section is organized as follows. The sample shares are first presented and discussed for each of the three choices. The shares are compared across the two data sets used in this analysis. Next, descriptive statistics on the explanatory variables are provided and compared across the two data sets. Finally, the models estimated from the two data sets are presented and discussed.

Table 7-1 presents the sample shares. In both NHTS and PSID-CDS samples, approximately 39-41% of the school-going children undertake travel in the post-home arrival period. Among the children who travel, most of them (84-86%) undertake only one tour. In terms of the number of stops, differences are observed between the two surveys. Specifically, the NHTS indicates a greater percentage of children making multiple stops compared to the PSID-CDS sample.

Table 7-1. Sample Shares for the Travel Attributes of School-going Children

Travel attributes	PSID Percent	NHTS Percent
Decision to travel		
No	58.71	60.82
Yes	41.29	39.18
Total	100(3323)	100(4357)
# Tours		
1	86.81	84.77
2	13.19	13.59
3	-	1.64
Total	100(1372)	100(1707)
# Stops		
1	71.65	63.39
2	21.21	22.79
3	5.25	9.20
4	1.90	4.63
Total	100(1372)	100(1707)

Table 7-2 presents descriptive statistics on the explanatory variables used in the models. The first major column presents the PSID-CDS data and the second presents the NHTS data.

Within each of these two major columns, there are two columns of results. The first column presents the descriptive statistics for the explanatory variables used in the model for the decision of the children to travel. The second column presents the descriptive statistics for the explanatory variables used in the models the number of tours and stops. The reader will note that the later models were estimated on a subset of children who chose to travel.

These variables are broadly classified into four categories: (1) characteristics of the children, (2) characteristics of the household, (3) temporal characteristics, and (4) location characteristics.

Among the *characteristics of the children*, the distributions of age and gender appear to be similar across the two surveys. However, significant differences are observed in terms of the ethnicity distribution. Specifically, the PSID-CDS sample has a substantially higher percentage of African Americans compared to the NHTS sample and the NHTS sample has a substantially higher percentage of non-Hispanic Whites compared to the PSID-CDS sample.

Among the *characteristics of the household*, both surveys provide information on the household structure. It is interesting to note that the PSID-CDS sample has a higher percentage of single-parent households compared to NHTS sample (correspondingly, the NHTS sample has higher percentage of nuclear families – families with both parents). The “other” category includes households in which adult members other than the parents (such as grand parents) are also present. The PSID-CDS also has a higher percentage of household with multiple children compared to the NHTS. The NHTS also provides details on the vehicle-ownership (measured as the ratio of the number of vehicles to adults), income, and tenure (own versus rent) of the household.

The day-of-the-week and the month-of-the-year (of the survey day) are the *temporal characteristics* available from the two surveys. The PSID-CDS sample has an even distribution (approximately 20% each) across the week days. However, the NHTS has a significantly higher fraction of the sample (30%) from Wednesdays and a corresponding lower share from Thursdays and Fridays. The distribution across the months of the year appears to be the same across the two surveys. Winter constitutes December, January, and February; Spring constitutes March, April, and May; Summer constitutes June, July, and August; and Fall constitutes September, October, and November. The share of the sample from the summer months is small, reflecting the time when school is not in session.

The NHTS also provides some details on the *location characteristics* of the household. Information on whether the household is in an urban or rural region and the population density of the census block-group in which the household is located are used in the models.

The travel-generation models are presented in Tables 7-3 (PSID-CDS) and 7-4 (NHTS). Each of these tables has three models: (1) the decision to travel (first major column in the table), (2) the number of tours (second major column), and (3) the number of stops (third major column). For each of the models, the parameter estimates (coefficients) and the “t” statistics are presented. While most of the parameters presented in the final models are statistically significant at 90% or higher (or t statistic > 1.6), some parameters at a lower significance level are also retained, given the relatively few explanatory variables available in this study.

In the model for the decision to travel, a positive coefficient on a variable indicates that the corresponding variable increases the likelihood of traveling. In the models for the number of tours and stops, a positive coefficient indicates that the corresponding explanatory factor increases the expected number of tours/stops made by the child.

Table 7-2. Descriptive Statistics on the Explanatory Variables used in models for School-going Children

Explanatory variables		PSID		NHTS	
		Decision to travel Percent	# Tours or # Stops Percent	Decision to travel Percent	# Tours or # Stops Percent
Child characteristics					
Age	0-4 yr	7.61	6.12	7.30	6.27
	5-8 yr	39.27	37.10	34.20	33.10
	9-12 yr	42.43	47.45	39.32	41.48
	13-14 yr	10.68	9.33	19.19	19.16
Gender	Male	51.07	51.38	51.53	53.13
	Female	48.93	48.62	48.47	46.87
Ethnicity	Non Hispanic white	47.16	53.94	75.30	81.02
	African American	40.08	32.51	7.73	6.09
	Hispanic	7.46	7.58	10.86	8.03
	Other	5.30	5.98	6.11	4.86
Household characteristics					
HH structure	Single parent	37.50	32.80	10.01	7.67
	Nuclear family	58.14	62.97	72.37	76.33
	Other	4.36	4.23	17.63	15.99
# Children	1	15.86	13.41	38.10	38.20
	>1	84.14	86.59	61.90	61.80
# Vehicles per adult (R)	R=0	-	-	2.98	1.99
	0<R<1	-	-	34.54	32.57
	R>=1	-	-	62.47	65.44
Income	Low (0-35k)	-	-	28.23	23.37
	Medium (35k-65k)	-	-	32.71	32.98
	High (65k-100k)	-	-	39.06	43.64
Home Own/Rent	Owned	-	-	79.92	84.01
	Rented	-	-	20.08	15.99

The explanatory variables are broadly classified into four categories: (1) characteristics of the children, (2) characteristics of the household, (3) temporal characteristics, and (4) location

Table 7-2. Continued

Explanatory variables		PSID		NHTS	
		Decision to travel Percent	# Tours or # Stops Percent	Decision to travel Percent	# Tours or # Stops Percent
Temporal characteristics					
Day of the week	Monday	19.89	19.39	18.84	16.29
	Tuesday	20.82	19.46	19.90	19.63
	Wednesday	20.01	19.53	29.70	32.98
	Thursday	20.16	20.70	16.18	15.82
	Friday	19.11	20.92	15.38	15.29
Month of the year	Winter	35.30	31.34	29.22	27.83
	Spring	35.78	41.11	44.82	45.87
	Summer	2.53	2.48	4.77	6.50
	Fall	26.39	25.07	21.18	19.80
Location characteristics					
Area type	Urban	-	-	73.63	75.75
	Rural	-	-	26.37	24.25
Population density	Low (0-500)	-	-	33.42	30.23
	Medium (500-4k)	-	-	37.80	40.77
	High (4k-999k)	-	-	28.78	29.00
	Total	100(3323)	100(1372)	100(4357)	100(1707)

characteristics. Each of these is discussed in the next several paragraphs. The threshold parameters (for the models for number of tours and stops) and the constant terms are also presented in the tables although these do not have substantial behavioral interpretations beyond defining the propensity bounds that demarcate the different choice alternatives.

Age, gender, and ethnicity are the *characteristics of the children* being examined in the models. Children of age 9-12 years are found to be most likely to make post home-arrival travel based on both the PSID-CDS and the NHTS models. Children of age 0-4 years are least likely to undertake travel. The children belonging to the other age groups are more likely than the

youngest children but less likely than the 9-12 year olds to travel. Conditional on choosing to travel, age does not appear to affect either the number of stops or the tours made during the post home-arrival period. The results are consistent across both surveys.

Gender is found to not affect the decision of children to undertake travel. Conditional on choosing to travel, the number of stops undertaken is not affected by gender, either. Models from both surveys indicate these results. The NHTS model indicates that boys are likely to make more tours than girls.

The effects of ethnicity on travel generation are found to be different across the two surveys. The NHTS models indicate that ethnicity only affects the decision to travel with the Whites being more likely to travel than children of other ethnicities. On the other hand, the PSID-CDS indicates that ethnicity affects all three travel-generation decisions. Specifically, African American children are found to (1) be less likely to travel, (2) make fewer tours, and (3) make fewer stops compared to other children. Hispanic children are also found to make fewer tours and stops; however; they are as likely as the White children to travel during the post home-arrival period.

Household structure, number of children, vehicle availability, income, and tenure are the *characteristics of the households* being examined in the models.

Both the NHTS and PSID-CDS models indicate that children from nuclear-families are more likely to undertake travel compared to children from other types of families (including single-parent households). However, the household structure does not affect the number of tours or stop undertaken. The NHTS indicates that the number of children in the household has no impact on the travel-generation decisions of each child. However, the PSID model suggests that children from households with multiple children (or equivalently, one or more sibling) are more

likely to undertake travel. However, should they undertake travel; they also make fewer stops in the overall. If a child has several siblings, (s)he is likely to undertake more tours.

The NHTS also provides information on the vehicle availability, income, and tenure of the household to which the child belongs. Children in households with vehicles are found to undertake more tours and more stops compared to children in households without vehicles. However, the decision to travel is not affected by the vehicle ownership of the household. Children from higher income households are more likely to travel and are also likely to make more tours (the number of stops, is however, not affected by household income). Children from households in rental dwelling units are less likely to travel compared to children from households in own dwelling units.

The *temporal characteristics* included in the model are the day-of-the week and the month-of-the year of the survey day. Interestingly, the models from the two surveys suggest very different impacts of these variables on the travel-generation choices. For instance, the PSID-CDS models suggest the children are more likely to travel on Fridays whereas the NHTS model suggests greater likelihood of travel during the mid-week (Wednesdays). In contrast, the PSID-CDS models indicate that children are likely to make more tours in the mid-week as opposed to the NHTS which indicates that more tours are undertaken on Fridays. In the context of the month of the year, the NHTS models indicate higher likelihood of traveling and more tours during summer whereas the PSID model indicated fewer tours and stops during the summer. The reasons for these differences are not readily apparent and require further examination.

Finally, area type and population density are the *location characteristics* being examined in the NHTS models (these variables are not available in the PSID-CDS dataset). In general the results suggest that children living in high-density (more than 4000 persons per square mile)

areas are more likely to travel. However children in medium-density (500-4000 persons per square mile) areas are likely to make more tours and stops than both children in low- and high-density areas.

7.2 Models For Weekday Travel Generation: Non-School-Going Children

This section of the chapter presents the weekday travel-generation models for non-school-going children. Unlike in the case of school-going children, the models for non-school-going children determine the decision to travel and the number of tours and stops during the entire day (the focus was on the post-home arrival period in the case of school-going children).

The rest of this section is organized as follows. The sample shares are first presented and discussed for each of the three choices. The shares are compared across the two data sets used in this analysis. Next, descriptive statistics on the explanatory variables are provided and compared across the two data sets. Finally, the models estimated from the two data sets are presented and discussed.

Table 7-5 presents the sample shares. Non-school-going children from the NHTS sample are found to be more likely to travel on weekdays and also likely to make more stops compared to the PSID-CDS sample. However, the NHTS indicates a lower possibility for multiple tours compared to the PSID-CDS.

Table 7-6 presents descriptive statistics on the explanatory variables used in the models. This table has the same structure as Table 7-2 already discussed.

These variables are broadly classified into four categories: (1) characteristics of the children, (2) characteristics of the household, (3) temporal characteristics, and (4) location characteristics. The similarities between the two surveys (PSID-CDS and NHTS) in terms of the

Table 7-3. PSID-CDS Models for School-going children

Variables	Decision to travel		# Tours		# Stops	
	Co-efficient	t-stat	Co-efficient	t-stat	Co-efficient	t-stat
(Constant)	-0.66	-5.95	-1.07	-15.78	-0.27	-2.60
Child characteristics						
Age - age 0-4 yr (Base)						
age 5-8 yr	0.17	1.86	-	-	-	-
age 9-12 yr	0.36	3.92	-	-	-	-
age 13-14 yr	0.16	1.45	-	-	-	-
Gender - Female (Base)						
Male	-	-	-	-	-	-
Ethnicity - White non - Hispanic (Base)						
Black non - Hispanic	-0.32	-6.39	-0.21	-2.13	-0.15	-1.95
Hispanic	-	-	-0.57	-2.77	-0.38	-2.52
Other	-	-	-	-	-	-
Household characteristics						
HH Structure - Single parent (Base)						
Nuclear Family	0.09	1.83	-	-	-	-
Other	-	-	-	-	-	-
Number of Siblings - nsibb >= 0 (Base)						
nsibb >= 1	0.11	1.81	-	-	-0.23	-2.40
nsibb >= 2	-	-	-0.17	-1.60	-	-
nsibb >= 3	-	-	0.59	4.11	-	-
Temporal characteristics						
Day of the week - Monday (Base)						
Tuesday	-	-	-	-	-	-
Wednesday	-	-	0.21	1.99	-	-
Thursday	-	-	-	-	-	-
Friday	0.12	2.20	-	-	0.16	1.90
Month of the year - Winter (Base)						
Spring	0.31	5.82	-	-	-	-
Summer	0.22	1.48	-0.70	-1.58	-0.48	-1.75
Fall	0.12	1.99	-	-	-0.22	-2.66
Threshold parameters for index						
Mu(1)	NA		NA		0.91	18.47
Mu(2)					1.53	18.38
Number of Observations	3323		1372		1372	
Initial Loglikelihood	-2252.63		-535.12		-1094.33	
Final Loglikelihood	-2186.23		-519.03		-1080.86	
rho^2 value	0.029		0.030		0.012	

Table 7-4. NHTS Models for School-going children

Variables	Decision to travel		# Tours		# Stops	
	Co-efficient	t-stat	Co-efficient	t-stat	Co-efficient	t-stat
(Constant)	-0.75	-7.52	-2.07	-5.02	-1.25	-5.19
Child characteristics						
Age - age 0-4 yr (Base)						
age 5-8 yr	0.15	1.87	-	-	-	-
age 9-12 yr	0.24	2.94	-	-	-	-
age 13-14 yr	0.17	1.99	-	-	-	-
Gender - Female (Base)						
Male	-	-	0.14	1.85	-	-
Ethnicity - White non - Hispanic (Base)						
African American	-0.21	-2.64	-	-	-	-
Hispanic	-0.30	-4.35	-	-	-	-
Other	-0.30	-3.58	-	-	-	-
Household characteristics						
HH Structure - Single parent (Base)						
Nuclear family	0.14	3.02	-	-	-	-
Other	-	-	-	-	-	-
# Children in household - nchild = 1 (Base)						
nchild > 1	-	-	-	-	-	-
# Vehicles per adult - nvehad = 0 (Base)						
0 < nvehad < 1	-	-	0.71	1.90	0.75	3.09
nvehad >= 1	-	-	0.59	1.57	0.81	3.37
Household Income - Low income (0-35k)(Base)						
Medium (35k-65k)	0.09	1.65	-	-	-	-
High (65k-100k)	0.15	2.71	0.17	2.24	-	-
Housing unit owned or rented - Owned (Base)						
Rented	-0.14	-2.49	-	-	-	-
Temporal characteristics						
Day of the week - Monday (Base)						
Tuesday	0.12	1.89	-	-	-	-
Wednesday	0.27	4.64	-	-	-	-
Thursday	0.13	1.97	-	-	-0.12	-1.58
Friday	0.14	2.14	0.18	1.67	-	-
Month of the year - Winter (Base)						
Spring	-	-	0.18	1.85	-	-
Summer	0.45	4.94	0.55	3.96	-	-
Fall	-	-	0.16	1.40	-	-

Table 7-4. Continued

Variables	Decision to travel		# Tours		# Stops	
	Co-efficient	t-stat	Co-efficient	t-stat	Co-efficient	t-stat
Location characteristics						
Area Type - Urban (Base)						
Rural	-	-	-0.21	-1.31	-	-
Population per square mile - Low density (0-500)(Base)						
Medium (500-4k)	-	-	0.21	1.46	0.22	3.44
High (4k-999k)	0.11	2.49	-0.12	-1.37	-	-
Threshold parameters for index						
Mu(1)	NA		1.15	14.14	0.75	21.93
Mu(2)			NA		1.35	25.61
Number of Observations	4357		1707		1707	
Initial Loglikelihood	-2917.18		-817.21		-1686.02	
Final Loglikelihood	-2844.83		-790.73		-1673.99	
rho^2 value	0.025		0.032		0.007	

Table 7-5. Sample Shares for the Travel Attributes of Non School-going Children

Travel attributes	PSID	NHTS
	Percent	Percent
Decision to travel		
No	18.36	23.89
Yes	81.64	76.11
Total	100(1351)	100(4040)
# Tours		
1	56.12	60.91
2	28.83	29.07
3	9.52	8.23
4	5.53	1.79
Total	100(1103)	100(3075)
# Stops		
1	43.97	33.14
2	24.39	23.80
3	15.23	17.24
4	7.98	11.22
5	8.43	6.80
6	-	4.26
7	-	3.54
Total	100(1103)	100(3075)

age and gender distributions and differences in terms of the ethnicity and household structure distributions have already been discussed. It is useful to point out the differences between the two surveys in the distribution of the data across the different months of the year. The NHTS has significantly larger samples from the summer (May-July) and winter (November-January) months compared to the PSID-CDS. Consequently, there is more data in the NHTS for time periods when schools are not in session compared to the PSID-CDS.

The travel-generation models are presented in Tables 7-7 (PSID-CDS) and 7-8 (NHTS). These tables have the same structure as Tables 7-3 and 7-4 discussed in the previous section.

The explanatory variables are broadly classified into four categories: (1) characteristics of the children, (2) characteristics of the household, (3) temporal characteristics, and (4) location characteristics. Each of these is discussed in the next several paragraphs. The threshold parameters (for the models for number of tours and stops) and the constant terms are also presented in the tables although these do not have substantial behavioral interpretations beyond defining the propensity bounds that demarcate the different choice alternatives.

Age, gender, and ethnicity are the characteristics of the children being examined in the models. The impact of age on travel generation is found to be very different across the two surveys. In the case of PSID-CDS, children of age 0-4 years are found to be least likely to travel whereas in the case of NHTS, they are found to be most likely to travel. The NHTS also indicates that children of age greater than 4 years make more tours and stops than children of age ≤ 4 years (conditional on deciding to travel). The PSID-CDS, on the other hand does not indicate such an effect. In fact, this dataset suggests that children of age 9 years or older make fewer tours than younger children.

Table 7-6. Descriptive Statistics on the Explanatory Variables used in models for Non School-going Children

Explanatory variables		PSID		NHTS	
		Decision to travel Percent	# Tours or # Stops Percent	Decision to travel Percent	# Tours or # Stops Percent
Child characteristics					
Age	0-4 yr	61.21	59.93	56.76	57.76
	5-8 yr	17.99	19.04	18.27	17.85
	9-12 yr	15.69	15.78	17.10	17.30
	13-14 yr	5.11	5.26	7.87	7.09
Gender	Male	51.30	50.41	50.22	50.18
	Female	48.70	49.59	49.78	49.82
Ethnicity	Non Hispanic white	52.11	53.49	77.40	79.06
	African American	34.94	33.64	5.97	5.82
	Hispanic	7.62	7.52	10.47	9.69
	Other	5.33	5.35	6.16	5.43
Household characteristics					
HH structure	Single parent	32.42	32.18	7.62	7.77
	Nuclear family	64.10	64.28	76.36	77.63
	Other	3.48	3.54	16.01	14.60
# Children	1	24.80	26.29	42.00	44.26
	>1	75.20	73.71	58.00	55.74
# Vehicles per adult (R)	R=0	-	-	3.59	3.45
	0<R<1	-	-	33.61	33.76
	R>=1	-	-	62.80	62.80
Income	Low (0-35k)	-	-	31.11	29.92
	Medium (35k-65k)	-	-	34.08	33.59
	High (65k-100k)	-	-	34.80	36.49
Home Own/Rent	Owned	-	-	76.29	77.40
	Rented	-	-	23.71	22.60

Table 7-6. Continued

Explanatory variables		PSID		NHTS	
		Decision to travel Percent	# Tours or # Stops Percent	Decision to travel Percent	# Tours or # Stops Percent
Temporal characteristics					
Day of the week	Monday	21.76	21.12	21.71	20.26
	Tuesday	19.54	18.13	20.00	19.61
	Wednesday	17.84	17.59	24.36	25.30
	Thursday	18.13	19.13	15.87	16.42
	Friday	22.72	24.03	18.07	18.41
Month of the year	Winter	18.80	19.22	25.42	22.57
	Spring	47.52	46.96	30.84	31.58
	Summer	11.62	11.15	28.61	30.57
	Fall	22.06	22.67	15.12	15.28
Location characteristics					
Area type	Urban	-	-	74.93	76.39
	Rural	-	-	25.07	23.61
Population density	Low (0-500)	-	-	31.66	30.63
	Medium (500-4k)	-	-	37.23	38.89
	High (4k-999k)	-	-	31.11	30.47
	Total	100(1351)	100(1103)	100(4040)	100(3075)

Gender is generally found to not affect the travel generation decisions of children. The only exception is the PSID model for stop generation which indicates that boys are likely to make more stops than girls.

The impact of ethnicity is also found to be not consistent across the two surveys. Specifically, African Americans are found to be less likely (compared to other ethnicities) to travel and found to make fewer tours and stops in the PSID-CDS model. However, the NHTS model indicates such a negative impact only for the number of tours. In contrast to the PSID-

CDS model, the Hispanics and “other” ethnicity children are the ones found to be least likely to travel.

Household structure, number of children, vehicle availability, income, and tenure are the *characteristics of the household* being examined in the models. The NHTS models indicate that children in nuclear family households are likely to make more tours and stops compared to children in other family types. Children in “other” households are found to make fewer stops in the PSID and found to be less likely to travel in the NHTS. In household with multiple children, any child is less likely to travel (indicated by both models). However, the PSID-CDS model indicates that children in households with multiple children make more tours which is contradictory to the result from the NHTS models.

The NHTS also provides information on the vehicle availability, income, and tenure of the household to which the child belongs. Children in households that share cars ($0 < \text{cars per adult} < 1$) are found to make more tours and more stops compared to both children in households without cars and children in households with at least as many cars as adults. Children from high-income households are found to be more likely to travel as well as likely to make more stops. In contrast, children living in rental dwelling units are less likely to travel and make fewer tours.

The *temporal characteristics* included in the model are the day-of-the week and the month-of-the year of the survey day. Models from both surveys indicate that children are more likely to travel on Thursdays and Fridays and make more stops on Fridays. The NHTS model also suggests more tours during the mid-week (Wednesday); however the day-of-the-week is found to be insignificant in the PSID-CDS models. On examining the month of the year effects, we find that children are more likely to travel and make more stops and tours during the summer months (May – July) relative to the rest of the year. However, the month of the year effects were largely

found to be insignificant in the PSID-CDS models. As already discussed, the NHTS sample has a significantly larger fraction of children from the summer months compared to the PSID-CDS sample.

Finally, area type and population density are the *location characteristics* being examined in the NHTS models (these variables are not available in the PSID-CDS dataset). Children living in rural areas are found to be less likely to travel and make fewer tours compared to children in urban locations. At the same time, children in areas of high population density are also found to travel less compared to children from areas of lesser population density.

7.3 Models For Weekend Travel Generation

This section of the chapter presents the weekend travel-generation models. School-travel does not happen on weekend days and hence all children are treated as non school-going. As in the case of weekday models for non school-going children, the models for weekend travel generation determine the decision to travel and the number of tours and stops during the entire day (the focus was on the post-home arrival period in the case of school-going children). The rest of this section is organized in the same way as the preceding sections.

Table 7-9 presents the sample shares. Children from the PSID sample are found to be significantly more likely to travel compared to the NHTS sample (91% versus 80%). However, the distribution of the number of tours and stops appear to be comparable across the two surveys with the exception that children from the NHTS sample are found to be more likely to make multiple stops.

Table 7-10 presents descriptive statistics on the explanatory variables used in the models. This table has the same structure as Tables 7-2 and 7-6 already discussed.

Table 7-7. PSID-CDS Models for Non School-going children

Variables	Decision to travel		# Tours		# Stops	
	Co-efficient	t-stat	Co-efficient	t-stat	Co-efficient	t-stat
(Constant)	1.02	10.19	-0.05	-1.00	0.24	2.68
Child characteristics						
Age - age 0-4 yr (Base)						
age 5-8 yr	0.31	2.72	-	-	-	-
age 9-12 yr	0.19	1.85	-0.19	-2.16	-	-
age 13-14 yr					-	-
Gender - Female (Base)						
Male	-	-	-	-	0.12	1.79
Ethnicity - White non - Hispanic (Base)						
Black non - Hispanic	-0.18	-2.15	-0.35	-4.61	-0.26	-3.58
Hispanic	-	-	-	-	-0.24	-1.72
Other	-	-	-	-	-0.40	-2.43
Household characteristics						
HH Structure - Single parent (Base)						
Both parents	-	-	-	-	-	-
Other	-	-	-	-	-0.41	-1.97
Number of Siblings - nsibb >= 0 (Base)						
nsibb >= 1	-0.25	-2.29	-	-	-0.15	-1.97
nsibb >= 2	-0.17	-1.86	0.18	2.36	-	-
nsibb >= 3	-	-	-	-	-	-
Temporal characteristics						
Day of the week - Monday (Base)						
Tuesday	-	-	-	-	-0.15	-1.65
Wednesday	-	-	-	-	-	-
Thursday	0.29	2.61	-	-	-	-
Friday	0.28	2.69	-	-	0.16	2.09
Month of the year - Winter (Base)						
Spring	-	-	-	-	0.20	2.95
Summer	-	-	-	-	-	-
Fall	-	-	-	-	-	-
Threshold parameters for index						
Mu(1)			0.90	20.12	0.64	18.30
Mu(2)	NA		1.47	23.07	1.16	24.11
Mu(3)			NA		1.57	26.15
Number of Observations	1351		1103		1103	
Initial Loglikelihood	-644.10		-1176.63		-1546.73	
Final Loglikelihood	-625.62		-1161.56		-1521.75	
rho^2 value	0.029		0.013		0.016	

Table 7-8. NHTS Models for Non School-going children

Variables	Decision to travel		# Tours		# Stops	
	Co-efficient	t-stat	Co-efficient	t-stat	Co-efficient	t-stat
(Constant)	0.74	10.66	-0.42	-5.88	0.15	2.36
Child characteristics						
Age - age 0-4 yr (Base)						
age 5-8 yr	-0.10	-1.63	0.17	2.79	0.18	3.45
age 9-12 yr	-0.14	-2.56	0.18	3.37	0.19	3.88
age 13-14 yr						
Gender - Female (Base)						
Male	-	-	-	-	-	-
Ethnicity - White non - Hispanic (Base)						
African American	-	-	-0.28	-2.54	-	-
Hispanic	-0.13	-1.74	-	-	-0.17	-2.50
Other	-0.29	-3.27	-	-	-	-
Household characteristics						
HH Structure - Single parent (Base)						
Nuclear family	-	-	0.18	3.25	0.15	3.16
Other	-0.25	-4.22	-	-	-	-
# Children in household - nchild = 1 (Base)						
nchild > 1	-0.27	-5.68	-0.17	-3.70	-	-
# Vehicles per adult - nvehad = 0 (Base)						
0 < nvehad < 1	-	-	0.24	5.01	0.24	5.86
nvehad >= 1	-	-	-	-	-	-
Household Income - Low income (0-35k)(Base)						
Medium (35k-65k)	-	-	-	-	-	-
High (65k-100k)	0.10	2.08	-	-	0.09	2.17
Housing unit owned or rented - Owned (Base)						
Rented	-0.10	-1.81	-0.18	-3.34	-	-
Temporal characteristics						
Day of the week - Monday (Base)						
Tuesday	-	-	-	-	-	-
Wednesday	0.16	2.86	0.10	1.91	-	-
Thursday	0.18	2.73	-	-	-	-
Friday	0.12	1.86	-	-	0.14	2.80
Month of the year - Winter (Base)						
Spring	0.29	4.98	-	-	0.08	1.65
Summer	0.49	7.96	0.20	4.02	0.10	2.04
Fall	0.29	4.08	-	-	-	-

Table 7-8. Continued

Variables	Decision to travel		# Tours		# Stops	
	Co-efficient	t-stat	Co-efficient	t-stat	Co-efficient	t-stat
Location characteristics						
Area Type - Urban (Base)						
Rural	-0.24	-4.34	-0.25	-4.35	-	-
Population per square mile - Low density (0-500)(Base)						
Medium (500-4k)	-	-	-	-	-0.08	-1.62
High (4k-999k)	-0.10	-1.94	-0.11	-2.09	-0.09	-1.83
Threshold parameters for index						
Mu(1)			1.04	33.37	0.62	30.08
Mu(2)			1.88	32.43	1.10	41.96
Mu(3)	NA				1.52	48.41
Mu(4)			NA		1.89	50.47
Mu(5)					2.29	47.71
Number of Observations	4040		3075		3075	
Initial Loglikelihood	-2221.05		-2886.19		-5202.01	
Final Loglikelihood	-2127.71		-2820.55		-5151.16	
rho ² value	0.042		0.023		0.010	

These variables are broadly classified into four categories: (1) characteristics of the children, (2) characteristics of the household, (3) temporal characteristics, and (4) location characteristics. The similarities between the two surveys (PSID-CDS and NHTS) in terms of the age and gender distributions and differences in terms of the ethnicity and household structure distributions have already been discussed. It is useful to point out the differences between the two surveys in the temporal distribution of the data. The NHTS has significantly larger samples from the summer (May-July) months compared to the PSID-CDS. The NHTS data also has a slightly greater share of the samples from Sundays.

The travel-generation models are presented in Tables 7.11 (PSID-CDS) and 7.12 (NHTS). Each of these tables has three models: (1) the decision to travel (first major column in the table), (2) the number of tours (second major column), and (3) the number of stops (third major

Table 7-9. Sample Shares for the Travel Attributes of Children on a Weekend day

Travel attributes	PSID Percent	NHTS Percent
Decision to travel		
No	8.17	20.22
Yes	91.83	79.78
Total	100(4786)	100(2819)
# Tours		
1	55.63	54.82
2	29.44	33.35
3	9.47	9.56
4	2.57	2.27
5	2.89	-
Total	100(4395)	100(2249)
# Stops		
1	32.04	25.66
2	25.26	25.88
3	19.34	20.85
4	10.85	13.69
5	6.58	6.40
6	2.91	3.87
7	3.03	3.65
Total	100(4395)	100(2249)

column). The threshold parameters and the constant term are not presented in the tables as these do not have substantial behavioral interpretations beyond defining the propensity bounds that demarcate the different choice alternatives.

The explanatory variables are broadly classified into four categories: (1) characteristics of the children, (2) characteristics of the household, (3) temporal characteristics, and (4) location characteristics. Each of these is discussed in the next several paragraphs. The threshold

Table 7-10. Descriptive Statistics on the Explanatory Variables used in models for Children on a Weekend day

Explanatory variables		PSID		NHTS	
		Decision to travel Percent	# Tours or # Stops Percent	Decision to travel Percent	# Tours or # Stops Percent
Child characteristics					
Age	0-4 yr	22.86	22.91	29.58	28.46
	5-8 yr	33.24	33.24	27.92	27.70
	9-12 yr	35.04	35.22	27.67	28.90
	13-14 yr	8.86	8.62	14.83	14.94
Gender	Male	50.90	50.63	50.55	51.22
	Female	49.10	49.37	49.45	48.78
Ethnicity	Non Hispanic white	48.64	49.49	73.71	74.03
	African American	38.57	37.47	8.12	7.83
	Hispanic	7.50	7.71	12.49	12.76
	Other	5.29	5.32	5.68	5.38
Household characteristics					
HH structure	Single parent	35.77	34.65	8.41	8.31
	Nuclear family	60.15	61.32	72.22	73.41
	Other	4.07	4.03	19.37	18.27
# Children	1	18.76	19.16	27.74	26.99
	>1	81.24	80.84	72.26	73.01
# Vehicles per adult (R)	R=0	-	-	2.84	2.76
	0<R<1	-	-	24.30	23.34
	R>=1	-	-	72.86	73.90
Income	Low (0-35k)	-	-	29.05	28.68
	Medium (35k-65k)	-	-	33.27	32.41
	High (65k-100k)	-	-	37.67	38.91
Home Own/Rent	Owned	-	-	78.43	78.43
	Rented	-	-	21.57	21.57

parameters (for the models for number of tours and stops) and the constant terms are also presented in the tables although these do not have substantial behavioral interpretations beyond defining the propensity bounds that demarcate the different choice alternatives.

Table 7-10. Continued

Explanatory variables		PSID		NHTS	
		Decision to travel Percent	# Tours or # Stops Percent	Decision to travel Percent	# Tours or # Stops Percent
Temporal characteristics					
Day of the week	Saturday	50.38	50.56	46.01	45.31
	Sunday	49.62	49.44	53.99	54.69
Month of the year	Winter	30.00	29.15	31.47	30.06
	Spring	39.39	39.98	30.72	30.72
	Summer	5.24	5.44	19.30	20.01
	Fall	25.37	25.44	18.52	19.21
Location characteristics					
Area type	Urban	-	-	75.88	76.75
	Rural	-	-	24.12	23.25
	Total	-	-	100	100
Population density	Low (0-500)	-	-	29.83	29.08
	Medium (500-4k)	-	-	38.38	39.13
	High (4k-999k)	-	-	31.78	31.79
	Total	100(4786)	100(4395)	100(2819)	100(2249)

Age, gender, and ethnicity are the *characteristics of the children* being examined in the models. In general, both PSID-CDS and NHTS models suggest that elder children are more likely to travel and make more tours and stops compared to younger children. More specifically, children younger than 4 years of age have the least amount of travel on weekend days. Children of age 5-8 years travel more and children of age 9 years or more have an even greater propensity to travel.

Gender is found to not impact the travel-generation decisions on weekend days (the few effects are only marginally significant).

African American children in PSID sample are less likely to travel and they make fewer tours and stops on weekend days. In the case of the NHTS sample, the negative impact is found only in the case of the number of stops. Hispanic children are found to travel more on weekend days. The PSID-CDS sample indicates that they are more likely to travel whereas the NHTS sample suggests that they make more tours and stops.

Household structure, number of children, vehicle availability, income, and tenure are the *characteristics of the households* being examined in the models. Both NHTS and PSID samples indicate that children from nuclear families are more likely to travel and undertake more tours on weekend days compared to children from other household structures. At the same time, when multiple children are present in the household, children are found to be less likely to travel on weekends. Children in households with vehicles are found to make more stops although children in car-sharing households are found to be less likely to travel. Children from high income homes are more likely to undertake weekend travel and those living in rental dwelling units undertake fewer tours.

The *temporal characteristics* included in the model are the day-of-the week and the month-of-the year of the survey day. Both surveys indicate the more stops are undertaken on Saturdays compared to Sundays. Similarly, both surveys indicate more travel during the summer months compared to the rest of the year.

Finally, area type and population density are the *location characteristics* being examined in the NHTS models (these variables are not available in the PSID-CDS dataset). Children in rural areas are less likely to travel on weekends and those living in areas of medium population-density make more tours.

Table 7-11. PSID-CDS Models for Children on a Weekend day

Variables	Decision to travel		# Tours		# Stops	
	Co-efficient	t-stat	Co-efficient	t-stat	Co-efficient	t-stat
(Constant)	1.10	11.43	-0.40	-8.60	0.21	3.54
Child characteristics						
Age - age 0-4 yr (Base)						
age 5-8 yr	0.16	2.08	-	-	0.24	5.07
age 9-12 yr	0.20	2.70	0.17	4.82	0.42	9.05
age 13-14 yr					0.27	3.97
Gender - Female (Base)						
Male	-	-	-	-	-0.05	-1.46
Ethnicity - White non - Hispanic (Base)						
Black non - Hispanic	-0.16	-2.63	-0.21	-5.28	-0.22	-6.13
Hispanic	0.20	1.66	-	-	-	-
Other	-	-	-	-	-0.13	-1.82
Household characteristics						
HH Structure - Single parent (Base)						
Both parents	0.23	3.81	0.23	5.64	0.05	1.42
Other	-	-	0.19	1.99	-	-
Number of Siblings - nsibb >= 0 (Base)						
nsibb >= 1	-	-	-	-	-	-
nsibb >= 2	-0.23	-3.63	-	-	-0.17	-4.85
nsibb >= 3	-0.14	-1.74	-	-	-	-
Temporal characteristics						
Day of the week -Sunday (Base)						
Saturday	-	-	-	-	0.15	4.51
Month of the year - Winter (Base)						
Spring	0.33	4.88	0.25	6.72	0.20	6.04
Summer	0.48	3.18	0.14	1.84	0.20	2.64
Fall	0.22	3.10	-	-	-	-
Threshold parameters for index						
Mu(1)			0.92	40.91	0.67	37.28
Mu(2)			1.49	46.35	1.22	52.69
Mu(3)	NA		1.79	45.37	1.66	59.67
Mu(4)			NA		2.08	60.65
Mu(5)					2.40	57.67
Number of Observations	4786		4395		4395	
Initial Loglikelihood	-1353.93		-4860.52		-7290.47	
Final Loglikelihood	-1305.31		-4785.17		-7194.08	
rho^2 value	0.036		0.016		0.013	

Table 7-12. NHTS Models for Children on a Weekend day

Variables	Decision to travel		# Tours		# Stops	
	Co-efficient	t-stat	Co-efficient	t-stat	Co-efficient	t-stat
(Constant)	0.50	5.43	-0.29	-3.10	0.16	1.03
Child characteristics						
Age - age 0-4 yr (Base)						
age 5-8 yr	0.11	1.57	0.12	1.80	-	-
age 9-12 yr	0.29	4.03	0.16	2.54	0.08	1.73
age 13-14 yr	0.16	1.86				
Gender - Female (Base)						
Male	0.08	1.40	-	-	-	-
Ethnicity - White non - Hispanic (Base)						
African American	-	-	-	-	-0.24	-2.68
Hispanic	-	-	0.14	1.82	0.24	3.41
Other	-	-	-	-	-	-
Household characteristics						
HH Structure - Single parent (Base)						
Nuclear family	0.16	2.67	0.09	1.57	-	-
Other	-	-	-	-	-	-
# Children in household - nchild = 1 (Base)						
nchild > 1	-	-	-0.07	-1.31	-0.08	-1.50
# Vehicles per adult - nvehad = 0 (Base)						
0 < nvehad < 1	-0.12	-1.90	-	-	0.27	1.79
nvehad >= 1	-	-	-	-	0.31	2.08
Household Income - Low income (0-35k)(Base)						
Medium (35k-65k)	-	-	-	-	-	-
High (65k-100k)	0.13	2.21	-	-	-	-
Housing unit owned or rented - Owned (Base)						
Rented	-	-	-0.23	-3.32	-	-
Temporal characteristics						
Day of the week -Sunday (Base)						
Saturday	-0.10	-1.74	-0.10	-2.00	0.21	4.52
Month of the year - Winter (Base)						
Spring	0.11	1.66	-	-	0.15	2.62
Summer	0.22	2.81	0.20	3.37	0.29	4.65
Fall	0.22	2.79	-	-	0.24	3.59

Table 7-12. Continued

Variables	Decision to travel		# Tours		# Stops	
	Co-efficient	t-stat	Co-efficient	t-stat	Co-efficient	t-stat
Location characteristics						
Area Type - Urban (Base)						
Rural	-0.14	-2.18	-	-	-	-
Population per square mile - Low density (0-500)(Base)						
Medium (500-4k)	-	-	0.12	2.20	-	-
High (4k-999k)	-	-	-	-	-0.07	-1.42
Threshold parameters for index						
Mu(1)			1.08	31.21	0.71	27.10
Mu(2)			1.91	30.87	1.27	39.06
Mu(3)	NA				1.77	45.29
Mu(4)			NA		2.13	46.49
Mu(5)					2.50	44.01
Number of Observations	2819		2249		2249	
Initial Loglikelihood	-1419.19		-2262.54		-3869.52	
Final Loglikelihood	-1392.24		-2240.20		-3828.36	
rho^2 value	0.019		0.010		0.011	

CHAPTER 8 SUMMARY AND CONCLUSIONS

Children contribute for a significant number of trips made by the households. Even though the travel pattern of children are quite different from that of adult's travel pattern, they are understudied and neglected whose travel needs directly affect the other member's travel pattern present in the households. Children's travel is derived as a result to satisfy a variety of activities occurring at different locations and varied time of the day. Hence, a need to better understand the linkage between the activity travel pattern of children and their direct implication on that of adult's travel pattern i.e., the inter-household and the intra-household interactions helps better predict and forecast travel demand modeling systems. Most of the earlier researches have focused on the travel pattern of adults without giving much importance to children. Therefore, the goal of this research is to contribute to the area of travel demand analysis by comprehensively examining children's activity travel patterns and developing a framework for incorporating children within the activity-based travel demand modeling systems.

The travel pattern of children is quite different from that of adult's travel pattern which is age and gender specific. The present analysis uses the child centric approach in modeling the activity travel pattern of children. The present study uses the data from 2001 National Household Travel Survey (NHTS) and 1997 and 2002 Panel Study of Income Dynamics – Child Development Supplement (PSID-CDC). The present study gives a detailed exploratory analysis of activity travel pattern of school going and non-school going children below age 14 years on weekdays and weekends from two surveys namely trip based survey (NHTS) and time-use survey (PSID-CDS). The present study has detailed the sequential framework of daily activity travel patterns of children (school going and non-school going separately) with respect to temporal (time of the day, weekday, weekend day) and spatial constraints (location type, activity

purpose, companion type, mode choice) especially the finer aspects of the pattern, the tour and the stop level attributes and their characteristics. By doing so, one would be able to get a better understanding of children's activity-travel behavior in a broader perspective and help to accurately predict and forecast efficient models. Further, models for trip-generation are built for school going and non-school going children on weekdays and weekend days separately. Binary probit model structure and ordered response probit model structure is being used in the models. Binary probit models are used to determine whether the child makes the decision to travel or not; on the condition he child decides to travel, ordered probit models are used to build trip-generation models for number of tours and number of stops. Finally, the present study tries to compare the similarities and the differences between the results obtained from two surveys.

Section 8.1 will provide a brief summary of the empirical results followed by the limitations and directions for further research in Section 8.2.

8.1 Summary Of Empirical Results

It is observed that about 92% of the total sample of children in PSID and about 88.30% in NHTS are found to make at least one trip(tour). This confirms the importance of examining children's activity-travel patterns in detail.

The first finding from this thesis is that, the activity travel patterns of children are unique. The activity travel patterns of school going children on a weekday, non-school going children on a weekday and children on weekend day are found to quite different from one another.

The second finding from this thesis is that, the activity travel patterns vary across the two datasets (PSID and NHTS).

The third finding from this thesis is that, the activity travel patterns vary across the three categories of children under consideration i.e., weekday travel: school-going children, weekday travel: non school-going children and children's weekend travel.

The fourth finding from this thesis is that, child demographics determine the activity travel patterns of children.

The fifth finding is that, the location and activity type has an effect on the activity travel patterns on the school going and non-school going children on a weekday and weekend day in terms of making tours and stops. For school going children on a weekday, school is a fixed activity. This constraints children from pursuing activities at other locations during school hours and less time available for pursuing activities at different locations after the school hours unlike non-school going children. School going children tend to make stops and tours in the school to home journey or the post home arrival period rather than home to school journey. Based on the time and space constraints, children tend to make tours and stops at various locations on a weekday and weekend day.

The sixth finding is that, the companion type has an effect on the activity travel patterns on the school going and non-school going children on a weekday and weekend day in terms of making tours and stops. Mothers are more likely to act as chauffeurs to cater to the need of children for weekday pattern. It is observed that the children'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 tours and stops, and a significant proportion of these joint participations are with individuals who are not family members. It is

The seventh finding is that, the day of the week and the time of the day have an impact on the activity travel patterns on the school going and non-school going children on a weekday and weekend day in terms of making tours and stops. Flexibility in time constraints allows child to make tours and stops in an evenly manner. Variability in morning, afternoon and evening peaks for start time and end time are observed for non-school going children on weekdays and children

on weekend days as opposed to two sharp peaks for school going children, one for home to school journey and the other for school to home journey on weekdays. It is even found that the duration of travel and dwell time at locations has an effect on the start time of travel activities.

The eighth finding is that, the season of the year has an impact on the activity travel patterns on the school going and non-school going children on a weekday and weekend day in terms of making tours and stops. This may be attributed to the season when school is closed (summer) or opened (fall, spring and winter). Even the climatic conditions, which varies with the seasons may have an effect on the tour and stop making propensity.

The ninth finding is that, in addition to the aggregate exploratory analyses performed, the disaggregate models which are developed to describe the travel-generation of children using socio-economics, location- and temporal- characteristics as explanatory factors have an effect on the activity travel patterns on the school going and non-school going children on a weekday and weekend day in terms of making tours and stops in the trip-generation models. These models are the first steps in the development of comprehensive activity-travel forecasting models for children. But these variables under consideration do not seem to have a stronger effect on the decision to travel, tour and stop making propensities as their model's rho-squared values are very small.

Most of the weekday school-going children are found to make home to school and school to home travel without any intermediate stops. There exists a lot a trip chaining in the post home arrival travel pattern. Children are more likely to choose the same mode of travel for H-S and S-H journey (school bus and household vehicle), but there exists change in mode for post home arrival travel pattern. Mothers act as chauffeurs for H-S and S-H journeys. Higher percentage of children is found to travel alone during H-S and S-H journeys in NHTS compared to PSID.

About 23.89% (PSID) and 18.36% (NHTS) of the weekday non school-going children do not travel. They are more likely to travel in household vehicle followed by walk/bike. Varied combination of persons is involved in the companion type which has to be looked in detail. Non school going children are engaged in a variety of activities when compared to that of school going children.

Weekend travel of children is quite unique compared to that of weekday travel. Children involve more in leisure and recreational activities as opposed to school activities on a weekday. There exist varied combinations of companion type and trip chaining. Entire family happens to travel together on a weekend day as opposed to weekday travel. More children happen to travel alone in PSID compared to NHTS.

This approach in which the travel patterns described in terms of the characteristics of each of the tours (mode, companion type, time of the day, duration, and number of stops) and the characteristics of each of the stops (duration, location, and activity type) undertaken is directly useful for activity-based modeling as the focus of such models is to predict the number and nature of the tours and stops undertaken by travelers.

8.2 Limitations And Directions For Further Research

The variables under consideration do not have stronger effect although they are significant; hence one needs to consider more set of explanatory variables which may have stronger effect on trip(tour and stop)-generation models so as to improve their rho-squared valued. Bias in data collection – PSID collected more data for African Americans; NHTS has higher percentage of non-Hispanic whites; PSID has more single parent households; NHTS has a higher percentage of nuclear households; NHTS has a higher percentage of owned houses and those residing in urban areas. Some of the variables under consideration in NHTS are not being captured in PSID as their purposes for data collection were different in the two surveys.

This research, however, focuses only the out-of-home activity-travel patterns of children. The consideration of the in-home activities is identified as an important extent to this study.

“Child-centric” approach is adopted in this research. That is, the focus is only on the travel behavior of the children; the patterns of the other members of the household including the parents are not considered. The simultaneous modeling and analysis of all household members, including both adults and children, is an important and emergent area of research.

In the Modeling Building Process, in the present study, we have conducted our analysis for the first step of model building process i.e., the development of trip(tour and stop)-generation models. Hence, other stages of the model building process – mode choice, time of the day, etc which are characteristics features of activity-based travel demand modeling have to be carried out. This would certainly help get a better understanding of children’s activity travel patterns in a broader perspective and even help policy makers to accurately predict and forecast efficient models.

All the choices namely, (1) the decision to travel on any day, (2) the number of tours during the day, conditional on choosing to travel, and (3) the number of activity stops during the day, again conditional on choosing to travel are modeled independently in this study – the simultaneous modeling of these choices using the joint unordered-ordered econometric structures is an avenue for further research.

With the need to understand the effects of policy actions on both activity travel patterns as well as children’s health, we wish to suggest an improvement in the questionnaire for data collection which has to incorporate the data for supporting travel-demand forecasting as well as the data on children’s time use and health to support public-health policy making. It should also

ensure that the sample data is nationally representative and should be in close par with the recent census (census 2000) with respect to child, household, temporal, location, etc characteristics.

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