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**An empirical analysis of internet use among teenagers and its impact on
their activity travel behavior during weekdays**

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Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science in Engineering

The University of Texas at Austin

August 2011

Dedication

Dedicated to my husband, Alejandro R. Avendaño, for his unconditional support that encouraged me to accomplish the step of my life.

Acknowledgements

I would like to thank my advisor, Dr. Chandra Bhat, for his help through my education here at The University of Texas at Austin. He has been an unconditional mentor and supporter, who was always concerned about my academic pursuits and well-being.

Special thanks to Rajesh Paleti, who contributed immeasurably to this thesis and research. I truly appreciate all his willingness, patience, and dedication to help me understand this subject. I would like to thank Lisa Macias for all her guidance during these two years on everything related to administrative procedures.

I would like to thank my sponsor from Panama; the National Secretariat of Science, Technology and Innovation (SENACYT), for granting me a scholarship and making this achievement possible. SENACYT gave me the opportunity to expand my education and improve my professional development.

Finally, I would like to thank my husband and family, who have been my greatest support during these two years. I would not be able to complete the step of my life without them.

Abstract

An empirical analysis of internet usage among teenagers and its impact on their activity travel behavior during weekdays

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The University of Texas at Austin, 2011

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This research examines the time used by teenagers, aged 16 to 19 years, the types of activities teenagers do, and the impact of internet usage on their non-fixed activities during weekdays. The data employed for this research is the 2009 National Household Travel Survey (NHTS 2009). For this study, socio-demographic factors (such as age, gender, race, work status, immigrant status, number of individuals in the household, number of children in the household, number of workers in the household, household income, and others), non-fixed activities (at home, shopping, personal business, physical, recreational and social, meals, religious, and others), time spent on non-fixed activities, and internet use among teenagers were taken into consideration.

The methodology in this research uses an ordered response model to analyze internet usage, and a Multiple Discrete Continuous Extreme Value model (MDCEV) to analyze the activity participation. The results show that individual and household demographic characteristics have an impact on internet usage, as well as, internet usage is found to have a significant impact on the activity participation behavior of teenagers.

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Chapter 1: Introduction

There has been substantial research on how activity choice is impacted by Information and Communication Technologies (ICTs) in the context of changing decisions, routes, travel time, location, and/or replacing trips (Salomon, 1986; Golob, 2000; Mokhtarian, 2003). In particular, different types of ICTs in the market, such as telecommuting, telecommunication, and e-commerce, can influence human activity choice and travel patterns. ICTs can potentially reduce or increase the number of trips. That is, individuals can stay at home searching on the internet using social networks, shopping from the web, *etc.*, or delivery trips can be generated by individuals who buy products on the internet.

Separately, researchers have been studying the activity-travel patterns of children and teenagers to understand how their travel patterns affect traffic and how they are different than those of adults (Sener et al., 2008; Copperman and Bhat, 2010; McCray and Mora, 2011). Since the introduction of ICTs, several researchers have studied how attached teenagers are to these technologies, what they do on the internet, and its impact on their overall lifestyle (Subrahmanyam et al., 2000; Anderson, 2001; Gould et al., 2002; Gross et al., 2002; Caplan, 2003; Campbell et al., 2006). Teenagers have their own travel patterns during weekdays and weekends, and they can be influenced by the use of ICTs as well. By using the internet, one of the most popular forms of ICTs, teenagers can easily influence their activity-travel patterns. For example, they can find bus schedules, search for alternative routes to develop their activities, search different locations to perform their activities, and others.

In the fields of travel behavior, activity purposes are commonly divided into three types¹: maintenance, discretionary, and subsistence. Maintenance activities are those activities that are required for the maintenance of the household, such as shopping, personal chores, buying goods, banking services, and others. Discretionary (or leisure) activities are performed depending on the desire and/or need of each individual. These activities involve social, physical and recreational activities, such as playing sports, going to the gym, exercising, going to the movie theater, visiting friends and/or relatives, going to the museum, and others. This concept of leisure activity involves two main characteristics: “freedom of choice” (the ability of an individual to select any activity during that period) and “frequency of participation” (the regularity with which an individual performs a determined activity) (Tinsley *et al.*, 1993). In other words, leisure activities should be considered as an activity where an individual can choose freely, and as an enjoyable activity that an individual can perform regularly. Subsistence activities are fixed activities that individuals perform daily, such as work and school. Usually, these activities do not allow changes in location and time as they tend to be adapted for each individual (Athuru, 2004). The non-fixed nature of maintenance and discretionary activities makes them more sensitive to the use of ICTs. Thus, this research will focus on these two activity types. Aside from influencing daily travel trips, ICTs can lead people to select or change their non-fixed activities. ICTs allow people to do and perform more non-fixed activities by showing information of new places and locations (Kwan *et al.*, 2007).

It is well-known that there are many activities that teenagers like to do during their free hours, such as sports, shopping, visiting friends, *etc.*, but there are many

¹ Examples of the studies on the activity type include Tinsley *et al.* (1993), Passmore and French (2001), Athuru (2004), and Mokhtarian *et al.* (2004).

unanswered questions about how ICTs impact these activities. Non-fixed activities are an important part of the teenagers' daily life. Currently, teenagers live in a world that is evolving at a high rate and accessibility to information is increasing rapidly. Not too long ago, the internet being available at schools and households was a novelty. Nowadays, the majority of households have internet access, providing instant and on-the-spot access to unlimited information. This research investigates the influence of the internet as an ICT and its impact on teenagers' non-fixed activities using the information provided by the 2009 National Household Travel Survey (NHTS 2009).

1.1 MOTIVATION

This research aims to analyze activity participation for teenagers in the United States of America for transportation planning purpose, especially for future development of safety policies targeted of the teenager population. Activity participation is important because it leads to travel. Thus, we will focus on the interaction of teenagers' activity choices with the use of ICTs, particularly the internet.

The first motivation of this research is to analyze teenagers' selection of activities from a behavioral perspective that at the same time are connected to travel and time use. The understanding of this behavior could help to improve daily transportation problems such as congestion, environmental problems, and forecasting and planning issues. The second motivation is to understand whether internet use increase or decreases participation in out-of-home activities during the week. Teenagers can obtain benefits from internet use, but when they became too attached to this tool, it could lead to health problems, sleep problems, and/or lack of concentration in their daily activities. Thus, knowing how adolescents interact with the internet in their daily life and its influence on

decision making for new and/or other activities could bring several benefits for future generations to help them promote healthy adolescent development.

1.2 RESEARCH OBJECTIVES

Supporting the motivation described above, the first objective of this research is to study teenagers' activity participation in non-fixed activities during weekdays. Specifically, the focus is on where they go and what they like to do during their non-fixed hours, using socio-demographics factors and time spent on non-fixed activities. The second objective is to study the interaction between the teenagers' activity choice during the weekdays and internet usage. The research intends to understand if the internet interferes with the teenagers' non-fixed activities, or if teenagers are able to manage both the internet and their non-fixed activities simultaneously.

The rest of the document is organized as follows. The next chapter, which is divided into 3 sub-sections, will review studies on teenagers' non-fixed activities, teenagers' internet usage, and the interaction between human activity participation and travel. Chapter 3 presents the data source and describes the sample used for the analysis. Section 4 discusses the modeling structure of the analysis. The results are explained in Chapter 5. The last chapter concludes the final findings of the research.

Chapter 2: Literature Review

In Chapter 2, we present a literature review on teenagers' daily activities, travel patterns, and health issues. In addition, this chapter includes a review of research developed on internet use and its impact on individuals' well being and activity participation.

2.1 CHARACTERISTICS OF TEENAGERS' ACTIVITY PARTICIPATION

Teenagers can behave unpredictably when they start experiencing independent mobility and participating in non-fixed activities (Clifton, 2003). The way teenagers use their time is an important concern, not only for their parents, but also for their teachers, planners, policy makers, other professionals and inclusively, other adolescents (Larson, 2001; Huebner and Mancini, 2003; Sener *et al.*, 2008; Wight *et al.*, 2009; McCray and Mora, 2011). Essentially, the interest of parents, teachers, planners, policy makers and others is to understand the amount of time adolescents spends on their non-fixed activities, the factors that influence those activities, and their travel patterns during those activities. By understanding these, safer environments can potentially be developed for future generations to improve their quality of life.

Typically, teenagers have fixed activities that they must perform daily, such as going to school or work (for this case, it is common to see teenagers having part-time jobs). Aside from the fixed activities, there are other activities that adolescents perform during their out-of-school and/or out-of-work hours, which include maintenance and discretionary (or leisure) activities. Teenagers' maintenance activities will vary according to several factors such as the responsibilities they have been assigned at home, personal care, and others. Thus, it can be said that teenagers will perform maintenance activities depending if it is a task they must do (*i.e.* housework, buy groceries) or if it is important

to their well-being (*i.e.* dentist appointment). On the other hand, leisure activities are considered part of the culture of adolescents for several years, because it gives them the opportunity to interact with society and allows them to choose activities they like and can perform freely. Leisure activities have direct benefits to teenagers' health and academic achievement (Jordan and Nettles, 1999). Lloyd and Auld (2001) documented in their research that individuals who are involved in leisure activities frequently manifest a high level of satisfaction from these activities, as well as psychological benefits. The leisure activities in which teenagers are involved include social, recreational, physical, and others (Larson, 2001; Zick, 2010).

In contrast to children, teenagers usually are given more freedom by their parents to develop activities on their own (Jordan and Murray, 1999; Huebner and Mancini, 2003), especially, because at this age they prefer to spend more time with their friends than with their parents (Crosnoe and Trinitapoli, 2008; Zick, 2010). The freedom to perform activities starts when teenagers are experiencing the transition from childhood to adolescence and it varies with individual's age. For example, adolescents between the ages of 16 and 19 years will probably have more freedom than 13 to 15 year old individuals. Most parents believe that the freedom given to teenagers is their first step in appreciating responsibility, which could help them in their path to become future professionals. However, with the responsibility given, it becomes the parents' concern of how their children spend their time, not only for health and safety reasons, but also to encourage behavior that promotes future achievement and success (Hilbrecht *et al.*, 2007; Wight *et al.*, 2009). There are several activities that parents approve for their children, especially if those activities benefit their development. For instance, several health and psychological studies discovered that these activities could include: reading, performing healthy recreational activities, volunteer activities, helping with the housework, and

developing other good habits such as going to bed at a reasonable hour (Huebner and Mancini, 2003; Wight *et al.*, 2009). Nevertheless, activities considered acceptable by adolescents may differ from activities parents consider to be more beneficial to adolescents. For instance, studies have revealed that many teenagers would prefer being at a party, playing or practicing a sport, spending time with friends, or even being on a romantic date (Gibbons *et al.*, 1997; Wight *et al.*, 2009).

For several years, public health professionals have been emphasizing how important physical, social, and recreational activities are for the development of both children and teenagers (Kohl and Hobbs, 1998; Larson, 2001; Copperman and Bhat, 2007). The Centers for Disease Control and Prevention (2009) reported that “23.1% of students, grades 9 to 12, did not participate (for at least 60 minutes) in any kind of physical activity, for at least 1 day of the 7 days of the week”. In addition, the report found that “the prevalence of not participating in at least 60 minutes of physical activity on any day was higher among female (29.9%) than male (17.0%) students” (Centers for Disease Control and Prevention 2009, p.26). Nevertheless, there are still a significant percentage of teenagers that participate in several types of physical activities and also social and recreational activities during out-of-school and/or out-of-work hours (Dunton *et al.*, 2010). Participation in these activities generally differs by age and gender (Gibbons *et al.*, 1997; Kohl and Hobbs, 1998; McCray and Mora, 2011). In their research, Hilbrecht *et al.*, 2007 studied Canadian students from early and late adolescence, and they discovered that the participation in some activities decreases as age increases. For example, younger teens (12-14 years old) perform more physical activities than older teens (15-18 years old). On the other hand, the same study reveals that girls experienced higher levels of pressure than boys for pursuing some activities (girls expressed they had to spend more time on housework, homework, and paid employment). In Wight *et al.*

(2009), it was found that adolescents spent most of their time sleeping, going to school, and watching television. However, the research did not mention any significant participation among teens on any social, recreational, or physical activity during their leisure time. McCray and Mora (2011) explored the activity pattern of one specific low income inner-city population of teenagers from a high school in Providence, RI, and one of their objectives was to study what teenagers do in their free time. Their study sample contained students from 9th to 12th grades (N=122). They revealed that the two most popular activities for both genders were visiting family and friends and making trips to fast food restaurants. During the survey, teenagers expressed that these two activities are significant places where they socialize with friends. Most of these studies show that current teenagers prefer to perform social and recreational activities (some of them considered sedentary activities such as watching TV or playing video games) rather than physical activities (Biddle *et al.*, 2009). In fact, the rapid spread of technology and easy access to private transportation has directly impacted the way teenagers develop and become engaged in several activities.

2.2 THE IMPORTANCE OF INTERNET USAGE ON TEENAGERS' NON-FIXED ACTIVITIES

For several years, people have been trying to understand how different types of technologies, such as telephone, internet use, etc., affect human behavior, daily routine, and travel (Mokhtarian, 2003). The ICTs' growth has increased rapidly over the last few decades and it is expected to keep growing in future years, along with its use between the world populations, especially between individuals that prefer to use these technologies to reduce the time spent on daily activities or just simply to have access to more information. Several studies have revealed that younger individuals are more likely to use these technologies (Hjorthol, 2002; Wang *et al.*, 2005), most of all internet use.

Researchers agree that the attraction for the internet depends mostly on age and gender. According to Hjorthol (2002), young men, between the ages of 13 and 24 years, are more likely to use the computer than women. However, over the years women have become more involved in computer use due to the quick evolution of the current demand for jobs.

The internet can be considered a tool that has been diffused quickly and widely into American society, especially into families (Anderson, 2001; Kraut *et al.*, 2001; Wang *et al.*, 2005; Contrino and McGuckin 2006), due to the several benefits they have found in its implementation, such as providing useful information, online shopping, e-mailing, instant messaging, and listening to music. Since the introduction of the internet to the world, families have been adopting this tool. However, parents have shown both positive and negatives concerns about having the internet at home. The main concern is to know how healthy internet use is for teenagers and children, especially with the introduction of many video games and other activities that can be performed through the web. The Centers for Disease Control and Prevention (2009) reported that “24.9% of students used a computer (including playing video or computer games) for something that was not school work related for 3 or more hours per day on an average school day”. Studies revealed that parents consider it important that their children have access to the information available on the web in order to help them with their education. They think that having access to this tool will improve their performance in school, and their personal and academic achievement will be superior (Larson, 2001; Jackson *et al.*, 2006). However, the question remains whether the use of computers is associated with an increase in academic skills among children because there has not been strong evidence to establish that connection (Jackson *et al.*, 2006). On the other hand, some parents consider the internet to be an easy window to specific information, which may not be appropriate for their children. Plus, there is the concern for parents about the possibility of isolating

the child from physical activities and interacting with other persons (Anderson, 2001). Several authors still agree that the use of the internet is associated with problems related to psychological health (i.e. depression, tiredness, loneliness and/or aggressiveness) and even lack of performance in school and work for teenagers and children (Kubey *et al.*, 2001; Campbell *et al.*, 2006). The association between internet use and psychological health is an issue that has created debate in both popular and academic literature (Subrahmanyam *et al.*, 2000; Gould *et al.*, 2002; Gross *et al.*, 2002; Kraut *et al.*, 2002; Caplan, 2003; Campbell *et al.*, 2006; Whitlock *et al.*, 2006; Shelfhout *et al.*, 2009). Over time, studies have found that both depression and loneliness increased with the amount of time children spent online (Gould *et al.*, 2002; Kraut *et al.*, 2002; Subrahmanyam *et al.*, 2000). Additionally, Gould *et al.* (2002) and Caplan (2003) agreed that individuals' need for social interaction and the constant search for help to their problems on the internet could explain their excessive and compulsive behavior. According to Gould *et al.* (2002), individuals who suffer from loneliness and depression are likely to perceive themselves as low competence in the interpersonal field. That is commonly why those depressed avoid dealing with face-to-face interaction and prefer hiding behind the curtain of the internet because it seems to be a safer and less threatening alternative (Gross *et al.*, 2002; Whitlock *et al.*, 2006). However, studies on children and teenager's well-being have been discussed over the years and have concluded that the impact of computer use still remains unclear and needs deeper research (Gross, 2004, Whitlock *et al.*, 2006). Moreover, Kenyon (2010) in her study of the impact of internet use in activity participation, found that there was no evidence of a correlation between internet use (time spent online) and the consequent decline in social interaction. Instead, the study showed that the time spent online allowed for social interaction through the use of social networks. In other words, she found that internet use complemented people's social skills.

Regarding teenagers, their perception of the internet is that it is a socializing window. They considered the internet as being a highly important tool of their everyday social life, whether used as to a means to maintain social relationships or to not be alone (Gross *et al.*, 2002; Gross, 2004; Selfhout *et al.*, 2009). Studies revealed that adolescents considered internet use to improve their self-esteem and well-being because it allowed them to be in constant contact with their friends (Gross, 2004; Selfhout *et al.*, 2009). In her research, Gross (2004) reported that between 40% and 65% of individuals (that included 7th to 10th graders, average age 12 to 15 years, respectively) use the internet; but there were no gender differences observed. Additionally, the study revealed that while online, they engage in simultaneous online activities, like instant messaging, downloading music, and others. These high percentages of teenagers using the internet give an idea of how this new generation is adapting their lives quickly to this tool. Clearly, more changes in the technology, education, and culture sectors will come, offering innovative services and options for users. As users, teenagers will definitely need appropriate guidance to help them in their development in order to face all the new changes, challenges, and obstacles in their futures.

2.3 INTERACTION BETWEEN HUMAN ACTIVITY PARTICIPATION AND TRAVEL BEHAVIOR WITH THE INTERNET

There are several studies about the interaction between ICTs and its impact on human travel behavior². For several years, authors have examined the impact of ICTs on human travel behavior in different ways. They concluded that these technologies allow

² Examples of the studies on the effects of ICTs on travel behavior include Farag *et al.* (2003), Mokhtarian (2003), Bhat *et al.* (2003) in the context of telecommuting, e-shopping and teleconference. Examples of the impact of ICTs on human travel behavior include Golob (2000), Srinivasan and Athuru (2004), Zwerts *et al.* (2004); Mokhtarian *et al.* (2004), Zhang *et al.* (2005), Mokhtarian *et al.* (2006), Contrino and McGuckin (2006), Kwan *et al.* (2007), Wang and Law (2007), Ren and Kwan (2009), and Kenyon (2010) in the context of the impact of ICTs on non-fixed activity-travel behavior.

people to select diverse alternatives that impact directly and indirectly to their daily activities. Four types of impacts related to the interaction between ICT and travel can be found in literature: substitution (which also could be considered as a replacement or elimination of the travel), complementary (which also could be considered as generation of travel), modification, and neutrality (Salomon, 1986; Mokhtarian, 2003; Athuru, 2004; Mokhtarian *et al.*, 2004; Zwerts *et al.*, 2004; Zhang *et al.*, 2005; Contrino and McGuckin 2006; Mokhtarian *et al.*, 2006; Ren and Kwan, 2009). All four types impact travel in one way or another. From these studies, ICTs not only replace, generate and/or modify travel patterns, but also give individuals the opportunity to be involved in new activities that maybe he or she has not contemplated before (Mokhtarian *et al.*, 2006).

From all the studies examined, there is some broad research examining the impact of the internet on teenagers' activity-travel behavior, but nothing specific. Most of these studies have included teenagers (mostly 16 years old and up), but mixed with adults that go from 18 years old to seniors (age 65 and up). As mentioned above, adolescents perform out-of-school and/or out-of-work activities during leisure time. Therefore, there is the need for mobility in order to perform these activities, which results in different travel patterns. Teenagers can travel by themselves or be accompanied by someone (i.e. parents, relatives, siblings, or friends). Studies have observed that changes in teenagers travel patterns usually differ by gender, age, income, and geographic location (Bhat *et al.*, 2003), and also when they start to experience independent mobility to perform their own activities (Clifton, 2003). In addition, the current growth and use of ICTs between adolescents are impacting their daily activities.

Several studies have established the relationship between ICTs and leisure activities. Referring specifically to the impact of the internet on non-fixed activities, there are different ways that it can affect and/or influence travel (i.e. replacing a traditional

activity by doing it online). In other words, the main effect of the internet on non-fixed activities is the given opportunity that individuals have to select a broad range of choices to replace and/or discover more activities that they could perform. At the end, the main purpose for internet users is to seek and find the information that fulfills their needs of activity participation (Ren and Kwan, 2009). The relationship between internet use and human travel behavior is complex, because it could involve multiple changes over time.

As mentioned in the Sub-section 2.2, teenagers are one of the primarily users of the internet. In their study, Contrino and McGuckin (2006) found (using the NHTS series in conjunction with the Current Population Survey, American Time Use Survey, and the USPS Household Diary Study) that individuals between the ages of 16 to 30 years with internet at home spent fewer time in out-of-home activities (comparison between the years 1995 and 2001). As a result, the time spent at home for this age group increased approximately 43 minutes. This indicates that over the years people became more and more involved in ICTs tools, putting some of their other activities as a second priority in their value scale. This issue promotes the idea that internet use is associated with the increase and decrease of travel trips of individuals. According to Srinivasan and Athuru (2004) and Wang and Law (2007), the use of ICT could lead individuals to spend more time in travel. Both studies model the interaction between ICT use, activity participation and travel patterns. Using a sample from Hong Kong, Wang and Law's (2007) results are consistent with other studies where younger individuals are more likely to use ICT than older individuals. In addition, using a sample from the San Francisco Bay Area, Srinivasan and Athuru (2004) expressed in their study that people who possess a driver's license are more likely to use the internet than those who do not have one. This result suggests a connection between mobility and web use. However, Wang and Law disagreed with the results of Srinivasan and Athuru by showing that the driver's license variable is

insignificant and does not influence internet use. This disagreement leads us to raise the question about how significant the driver's license variable is amongst teenagers that start experiencing independent mobility, who at the same time are part of the primary group of internet users.

There is definitely a connection between internet use and human travel behavior. Research theories such as Salomon (1986), Golob (2000), Mokhtarian (2003), Srinivasan and Athuru (2004), Zwerts et al. (2004), Wang and Law (2007) and others have indicated that the internet and other forms of ICT impact travel and activity participation. However, other studies like Kenyon (2010) have found that the amount of time ones uses the internet does not interfere significantly in the activity participation and mobility of individuals. Both arguments are valid, and it is important to take them into consideration to complement future studies on teenagers' activity-travel patterns and time they spend immersed in this technology, which is expanding every day.

Chapter 3: The Data

In Chapter 3, the data source used to analyze the impact of the internet on teenager's non-fixed activities is presented. Additionally, this chapter details a description of the sample used and its characteristics.

3.1 DATA SOURCE

The data source used for this analysis is the National Household Travel Survey (NHTS) conducted in 2009. This survey is an effort of the U.S. Department of Transportation (DOT) and it is sponsored by the Bureau of Transportation Statistics (BTS), the Federal Highway Administration (FHWA), and the National Highway Traffic Safety Administration. The 2009 NHTS was conducted using Computer Assisted Telephone Interviewing (CATI) technology. The survey collected information of about all the trips, modes, purposes, trip lengths, and demographic factors from individuals within 150,000 households in the United States (see 2009 NHTS for more details on the survey, sampling, and other administration procedures). All the travel related information is linked to the demographic, geographic, and economic information provided by the responder. The information collected includes age, gender, income, worker status, education level, type of housing, location, and other factors, as well as, internet usage.

The survey was conducted from April 2008 through April 2009. Each household was assigned a day of the week randomly, Monday through Sunday, including holidays. Each household was provided of diary to record their information of the travel day they were assigned (i.e. each household was assigned a 24 hour travel day, which means that one household could be assigned to record their travel information on Monday and another on Tuesday and so on). Respondents kept the diaries to record all travel made by all household members for the assigned day (2009 NHTS).

3.2 SAMPLE USED AND DESCRIPTION

The sample used for this research consists of individuals aged 16 through 19 years from all the United States of America. The analysis was developed for the weekdays (Monday through Friday). To understand the activity participation for this sample, it is helpful to evaluate the socio-economic and demographic profile of the sample of 7492 teenagers. In the sample, 3924 (52.4%) are male and 3568 (47.6%) are female. In addition, 6216 (83.0%) are Caucasian, 464 (6.2%) are African American, 222 (3.0%) are Asian, and 590 (7.9%) are other races. The age distribution shows that 2,340 (31.2%) are 16 years, 2286 (30.5%) are 17 years, 1,723 (23.0%) are 18 years, and 1,143 (15.3%) are 19 years. From this sample, it was found that 3801 (50.7%) teenagers are from households that have an annual income of US \$75,000 dollars or more. The descriptive statistics of the sample used are detailed in Table 3.1.

Table 3.1: Descriptive statistics of individuals and households

Sample Size = 7492		Number of individuals (%)	
Variable			
Age (mean = 17.22)			
16		2340	(31.2)
17		2286	(30.5)
18		1723	(23.0)
19		1143	(15.3)
Gender			
Male		3924	(52.4)
Female		3568	(47.6)
Race			
Caucasian		6216	(83.0)
African American		464	(6.2)
Asian		222	(3.0)
Other		590	(7.9)
Worker Status			
Yes		2808	(37.5)
No		4684	(62.5)

Table 3.1 (Continued): Descriptive statistics of individuals and households

Variable	Number of individuals (%)	
Immigrant Status		
Not an immigrant	7080	(94.5)
It is an immigrant	412	(5.5)
Household size (mean = 4.07)		
1 person household	18	(0.2)
2 person households	432	(5.8)
3 person households	2237	(29.9)
4 person households	2677	(35.9)
>= 5 person households	2128	(28.3)
Number of adults in the household (mean = 3.22)		
1 person household	51	(0.7)
2 person households	1136	(15.2)
3 person households	4056	(54.1)
4 person households	1712	(22.9)
>= 5 person households	537	(7.1)
Number of children in the household		
Children between 0 to 5 years old	126	(1.6)
Children between 6 to 10 years old	928	(12.4)
Children between 11 to 15 years old	2675	(35.7)
Vehicles per Household (mean = 3.02)		
0 vehicle per household	131	(1.7)
1 vehicle per household	647	(8.6)
2 vehicles per household	1896	(25.3)
3 vehicles per household	2511	(33.5)
>= 4 vehicles per household	2307	(30.8)
Household income		
<= \$19,999	673	(9.0)
\$20,000 - \$44,999	1275	(17.0)
\$45,000 - \$59,999	979	(13.1)
\$60,000 - \$74,999	764	(10.2)
>= \$75,000	3801	(50.7)

Table 3.1 (Continue): Descriptive statistics of individuals and households

Variable	Number of individuals (%)	
Number of workers in the household (mean = 1.97)		
0 person household	501	(6.7)
1 person household	1942	(25.9)
2 person households	2908	(38.8)
3 person households	1642	(21.9)
>= 4 person households	499	(6.7)
Highest education at home		
Less than High School	172	(2.3)
High school	1111	(14.8)
Some College education	2302	(30.7)
Bachelor Degree	2101	(28.0)
Post Graduate studies	1806	(24.1)
House Unit		
Own	6660	(88.9)
Rent	832	(11.1)
Urban Area		
Household is located in an urban area	5217	(69.6)
Not in urban area	2275	(30.4)

The types of non-fixed activities were reclassified from 27 original purposes into 8 activities types: (1) At Home, (2) Shopping and Errands (*i.e.* buying goods, buying clothes, video rentals, buying gas), (3) Personal Business (*i.e.* medical and dental services, pet care), (4) Physical (*i.e.* going to the gym, exercising, playing sports), (5) Recreational and Social (*i.e.* visiting friends and relatives, social events, visiting museums), (6) Meals (*i.e.* eating a meal, eating ice cream, snacks), (7) Religious, and (8) Other. The number of adolescents who performed these activities and the mean time they spent in each non-fixed activity is detailed in Table 3.2.

Table 3.2: Number of individuals in each activity and mean duration per activity

Activity No.	Type of Activity	Total number of teenagers participating per activity (%)	Mean duration of participation (min)
1	At Home	7492 (100.0)	984.02
2	Shopping	1675 (22.4)	10.63
3	Personal Business	654 (11.2)	6.44
4	Physical	896 (13.1)	14.87
5	Recreational and Social	1942 (29.4)	48.66
6	Meals	1292 (23.3)	7.81
7	Religious	186 (3.0)	3.26
8	Other	689 (11.9)	5.60

With regard to internet usage, individuals had to answer in the 2009 NHTS survey how often they use the internet in a week. The options given by the survey were: (1) Almost every day, (2) Several times a week, (3) Once a week, (4) Once a month, and (5) Never. The cross tabulation of the number of adolescents by age and internet use is presented in Table 3.3. It can be observed from Table 3.3 that more than 70% of teenagers between 16 to 19 years use the internet almost every day.

Table 3.3: Cross tabulation of age and internet use

Internet use	Age (%)			
	16	17	18	19
Almost everyday	1736 (74.2)	1683 (73.6)	1310 (76.0)	850 (74.4)
Several times a week	367 (15.7)	347 (15.2)	230 (13.3)	147 (12.9)
Once a week	116 (5.0)	133 (5.8)	72 (4.2)	56 (4.9)
Once a month	44 (1.9)	46 (2.0)	37 (2.1)	30 (2.6)
Never	77 (3.3)	77 (3.4)	74 (4.3)	60 (5.2)

Chapter 4: The Methodology

In Chapter 4, the methodology used to develop the analysis of both the internet response and the activity participation is presented. The internet usage was analyzed using an ordered response model and the activity participation was analyzed using a Multiple Discrete Continuous Extreme Values (MDCEV) model.

4.1 INTERNET USAGE

Let q ($q = 1, 2, \dots, Q$) be an index to represent individuals, and let k ($k = 1, 2, 3, \dots, K$) be an index to represent internet usage. The index k in the current empirical context takes values of “Almost daily” ($k = 1$), “Several times a week” ($k = 2$), “Once a week” ($k = 3$), “Once of month” ($k = 4$), and “Never” ($k = 5$). The equation for internet usage can be written as:

$$y_q^* = \alpha'_q z_q + \xi_q, \quad y_q = k \text{ if } \psi_{k-1} < y_q^* < \psi_k \quad (1)$$

The equation (1) is associated with the latent propensity y_q^* associated with the internet usage of individual q . This latent propensity y_q^* is mapped to the actual internet usage level y_q by the ψ thresholds ($\psi_0 = -\infty$ and $\psi_k = \infty$) in the usual ordered-response fashion. z_q is an ($L \times 1$) column vector of attributes (not including a constant) that influences the propensity associated with internet usage. α is a corresponding ($L \times 1$)-column vector of coefficients to be estimated, ξ_q is an idiosyncratic random error term assumed to be independently standard logistic distributed across individuals q .

4.2 ACTIVITY PARTICIPATION

Let t_1 be the non-zero amount of time invested in the non out-of-home (OH) activities and t_k be the time invested in alternative k ($k = 2, \dots, K$), where k is an index for all the activity purposes. Consider the following additive, non-linear, functional form

to represent the utility accrued by an individual through time investment in various activity purposes (the index for the individual and the activity instance is suppressed in the following presentation)³:

$$U(t) = \frac{1}{\alpha_1} \exp(\varepsilon_1) t_1^{\alpha_1} + \sum_{k=2}^K \frac{1}{\alpha_k} \exp(\beta' z_k + \varepsilon_k) \{(t_k + 1)^{\alpha_k} - 1\} \quad (2)$$

z_k is a vector of exogenous determinants (including a constant and indicator variables for different levels of internet usage) specific to alternative k . The term $\exp(\beta' z_k + \varepsilon_k)$ represents the baseline preference for alternate k and controls the discrete choice participation decision in this alternative. α_k is a satiation parameter whose role is to reduce the marginal utility with increasing consumption of alternative k . $\alpha_k = 1$ for all k , represents the case of absence of satiation effects. Values of α_k closer to zero imply higher satiation (or lower time investment) for a given level of baseline preference.

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

$$\begin{aligned} V_k + \varepsilon_k &= V_1 + \varepsilon_1 \text{ if } t_k^* > 0 \text{ } (k = 2, 3, \dots, K) \\ V_k + \varepsilon_k &< V_1 + \varepsilon_1 \text{ if } t_k^* = 0 \text{ } (k = 2, 3, \dots, K), \text{ where} \\ V_1 &= (\alpha_1 - 1) \ln(t_1^*) \text{ and } V_k = \beta' z_k + (\alpha_k - 1) \ln(t_k^* + 1) \text{ } (k = 2, 3, \dots, K) \end{aligned} \quad (3)$$

³ Among different utility forms proposed by Bhat (2008), the one used below gave the best fit in the empirical analysis of the current study.

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

$$P(t_1^*, t_2^*, t_3^*, \dots, t_M^*, 0, 0, \dots, 0) = \left[\prod_{i=1}^M c_i \right] \left[\sum_{i=1}^M \frac{1}{c_i} \right] \left[\frac{\prod_{i=1}^M e^{V_i}}{\left(\sum_{k=1}^K e^{V_k} \right)^M} \right] (M-1)! \quad (4)$$

where $c_1 = \left(\frac{1-\alpha_1}{t_1^*} \right)$ and $c_i = \left(\frac{1-\alpha_i}{t_i^* + 1} \right)$ for $i = 2, 3, \dots, K$.

Chapter 5: Results

This chapter discusses the results of the ordered response mode for internet usage and the MDCEV model for activity participation explained in Chapter 4. Both models were analyzed separately.

5.1 VARIABLES CONSIDERED

The variables used to estimate the internet response included individual characteristics (age, race, worker status, individuals that have more than one job, self-employed, full time worker, medical condition, number of years in the US if immigrant), as well as, household characteristics (level of education in the household, if the household is owned or rented, household income, number of workers in the household, presence of immigrants as well as non-immigrants in the household, number of adults, number of children, household location (urban or not urban)).

In addition, several types of variables were considered for the MDCEV model analysis. These include individuals' characteristics, household characteristics, and other demographics characteristics.

Individuals' characteristics included teenager demographics like age, gender, race, medical condition, worker status, self-employed, full time worker, individuals that have more than one job, immigrant status, and number of years in the US if immigrant. Household demographics characteristics included level of education in the household, if the household is owned or rented, household income, number of adults in the household, number of children, number of workers in the household, number of workers with the option to work from home, number of self-employed workers in the household, number of fulltime worker in the household, number of people with more than one job in the household, and number of vehicles. The other demographics characteristics comprise the

presence of seniors (age > 65 years) in the household, the presence of children between 0 to 5 years in the household, the presence of children between 6 to 10 years in the household, the presence of children between 11 to 15 years in the household, presence of immigrants as well as non-immigrants in the household, household with all members immigrant, household location (urban or not urban), and the use of internet (almost every day, several times a week, once a week, once a month, and never) among teenagers.

5.2 ESTIMATION RESULTS

5.2.1 Internet Response

The final estimation results for the internet response are detailed in Table 5.1. The coefficients in the table provide the effect of the variable on internet use. The following discussion highlights some of the most interesting results from the estimation.

5.2.1.1 Individual Characteristics

Teenagers aged 17 and 18 years are more likely to use the internet almost every day to several times a week during weekdays. This result is consistent with the research of Hjorthol (2002), Athuru (2004), and Wang *et al.* (2005) who found that the use of the internet is very common among younger individuals. However, there was no significant relationship on internet use between females and males, which it is consistent with the research of Gross (2002) where no major differences were observe. On the other hand, this point differs from Athuru (2004) and Hjorthol's (2004) study, and the Centers for Disease Control and Prevention's (2009) report which found that male individuals were more attracted to this tool than females. Regarding race, African Americans and Hispanics are less likely to use the internet than Caucasian and Asian teenagers.

Teenagers who work are inclined to use the internet more on weekdays, however, teenagers who work full-time are less likely to use the internet than part-time workers.

On the other hand, an interesting finding was that teenagers who can work from home and/or are self-employed do not spent much time on the internet (around once a week). We may think that individuals who are allowed to work from home or are self-employed could be using the internet more; however, that is not the case for teenagers. In addition, teenagers that present any type of medical condition are less likely to use the internet than teenagers without any medical condition.

5.2.1.2 Household Characteristics

It is well-known that in households where the members are more educated tend to be more familiarized with the use of the internet and know how to manage the tool. Thus, we found that households that have individuals with bachelor degrees and post graduate degrees are more likely to use the internet than those individuals with a high school education or some college education.

Families that own their household have a higher likelihood for using the internet than those who rent their household. We may imply that households with higher annual income are more likely to use and have access to the internet. However, households with an annual income of US \$20,000 dollars and greater show significant interest in internet use (between several times a week to almost every day). This finding supports the research of Anderson (2001), Wang *et al.* (2005), and Contrino and McGuckin (2006), where they explained how quickly this tool has been diffused in the American society and more families from all social levels are starting to acquire the tool. Additionally, those households located in urban areas are more likely to have and use the internet than those households not located in urban areas. Probably the access to this tool could be easier in urban areas.

The number of adults in the household did not show any significant value on internet usage. On the other hand, households that have individuals who can work from home or are self-employed are more likely to use the internet. This case is completely different to the teenagers situation describe above. Nowadays, it is common to see adult individuals who work from home using the internet as a key tool for their daily job activities. In addition, children between 11 to 15 years (the age when children start middle school and the use of the internet becomes more popular in their daily activities) are more likely to use the internet than children between 0 to 10 years. In addition, households that have immigrants as well as non-immigrants are more likely to use the internet, for example, college students sharing a house or an apartment.

Table 5.1: Internet Usage Response

Variable	Internet Use Response	
	Parameter	t-stat
Threshold parameters		
Threshold 1	-0.5734	-5.471
Threshold 2	0.0658	0.628
Threshold 3	0.4526	4.310
Threshold 4	0.7017	6.607
Individual Characteristics		
Age		
Individuals 17 years old	-0.1002	-2.563
Individuals 18 years old	-0.1203	-2.576
Race		
African American	0.0992	1.676
Hispanic	0.1073	1.863

Table 5.1 (continued): Internet Usage Response

Variable	Internet Use Response	
	Parameter	t-stat
Worker status		
Individual is a worker	-0.0249	-0.660
Work from home		
Individual has an option to work from home	0.3959	2.333
Self-Employ		
Individual is self-employ	0.2651	2.646
Full time worker		
Individual is a full time worker	0.3254	4.835
Medical condition		
Individual has a medical condition	1.0719	15.445
Years in the US		
Amount of time the individual has spent in the US	0.0009	1.286
Household Characteristics		
Education		
High School Education	-0.4180	-4.734
Some College Education	-0.6701	-7.623
Bachelor Degree	-0.8589	-9.346
Post Graduate Degree	-0.9710	-10.221
Home is own or rent		
Own	-0.1455	-3.012
Household Income		
\$20,000 - \$44,999	-0.2371	-4.219
\$45,000 - \$59,999	-0.3716	-5.797
\$60,000 - \$74,999	-0.4911	-6.966
>= \$75,000	-0.5457	-9.187
Household Worker Status		
Number of workers with option to work from home	-0.0897	-2.091
Number of self employed workers	-0.1499	-4.332
Number of people with more than one job	0.0721	2.127
Immigrant status in the household		
Household has immigrants as well as non-immigrants	-0.0931	-1.994

Table 5.1 (continued): Internet Usage Response

Variable	Internet Use Response	
	Parameter	t-stat
Adults		
Number of adults in the household	0.0415	2.345
Children		
Presence of children between 0 to 5 years	0.2495	2.285
Presence of children between 6 to 10 years	0.1259	2.755
Presence of children between 11 to 15 years	0.0586	1.760
Urban Area		
Household is locate in an urban area	-0.1979	-5.703

5.2.2 MDCEV Model

The final specification results of the MDCEV model are presented in Table 5.2. The “At home” activity was taken as the base category in the MDCEV model for all variables analyzed.

5.2.2.1 Teenager Demographics

The effect of individual demographics indicates that teenagers aged 18 and 19 are more likely to perform shopping activities than teenagers between 16 to 17 years old, and as the age increases the likelihood for physical activities decreases. This last result is consistent with Dunton *et al.* (2010). Male teenagers show a higher participation in physical and less participation in shopping and personal business activities than females. This is consistent with several studies (see Gibbons *et al.*, 1997; Kohl and Hobbs, 1998; Hilbretch *et al.*, 2007; McCray and Mora, 2011). The teenager demographics effects also reveal that race influences activity participation. Caucasians, African-Americans, and Asians show less preference for meal activities than Hispanics. Consistent with the

expectation, Hispanics and African-Americans have a higher preference for non-fixed activities than other ethnic races and as we mentioned above, in the Sub-section 5.2.1.1, the same ethnic group, Hispanics and African-Americans, have a lower preference for internet usage. This result is consistent with Athuru (2004). As we expected, teenagers that work show preference activities such as shopping and getting out for meals. One possible explanation of this is that once an individual has a regular income, they are more likely to be involved in activities that require some type of expenditure. Teenagers that have a full-time job are less likely to perform non-fixed activities than those who have a part-time job or are self-employed. This result is consistent with Athuru (2004). Final observations for teenagers that have an immigration status are more likely to perform physical activities and less shopping and meals activities than teenagers with non-immigrant status. However, as the years living in the US increase, immigrant teenagers tend to practice less physical activities and more shopping activities. One possible explanation is that after several years in the US, immigrant teenagers have adopted a new culture which could be different from their origin countries.

5.2.2.2 Household Demographics

Teenagers living in households with higher levels of education (bachelor degrees or post graduate studies) are inclined to perform more non-fixed activities than those households with lower levels of education (high school or some college education). Those families that own their households are more likely to perform personal business activities than individuals who rent their households.

The effect of income shows that teenagers living in households that earn more than US \$60,000 dollars are more likely to go out for meals. Households in which members work from home or are self-employed participate in more non-fixed activities

than those individuals that have to commute for work. Not surprisingly, households that have one or more vehicles perform more non-fixed activities during the weekday.

5.2.2.3 Other Demographics

Teenagers living in households that are located in urban areas show preference for physical, recreational and social activities. The location of households could have a high impact in activity choice participation, because it could bring more options and possibly more access to different activities. Households that have senior members usually make more personal business activities. Teenagers in households with children aged 5 years and under are less likely to make recreational and social activities. On the other hand, teenagers in households that have children between 6 to 15 years are more likely to make religious activities.

5.2.2.4 Internet Usage

Consistent with the expectation, internet usage is found to have a significant impact on activity participation behavior of teenagers. To be specific, teenagers living in households that use the internet every day or several times a week are more likely to perform physical, recreational and social activities. One possible explanation for this is that internet usage helps teenagers find information about many activity opportunities. This last assumption is consistent with the study of Mokhtarian *et al.* (2004 and 2006). Thus, given the significant impact of internet usage on activity participation, accurate modeling of internet usage as a function of different individual and household demographics becomes important. In the prediction mode, we can use the models developed in this study to first predict internet usage of teenagers and then use that information to predict activity travel behavior. This would not only improve the overall

accuracy of the predictions but also allows us to separate out the direct and indirect effect of all the explanatory variables on activity behavior.

5.2.2.5 Baseline Preference Constants

The baseline preference constants are located in the second to last row of Table 5.2. The baseline preference constants do not have any substantive interpretations. They are used to accommodate the range of individuals' age in the model.

5.2.2.6 Satiation Parameters

The satiation parameters are located in the last row of Table 5.2. The values farther away from one and closer to zero indicates a higher satisfaction with the given baseline preference. In general, the satiation parameters show that teenagers that perform non-fixed activities are more likely to stay performing those activities. Additionally, the t-statistics indicate that satiation parameters are significantly different from one for all non-fixed activities.

The satiation is high for “at home” activity, showing a value of zero (0). This indicates that those individuals that are staying at home are highly satisfied with this activity. It is important to mention that all teenagers participate in the “at home” activity, making the baseline preference very high compared to all other activities where participation rates vary.

The satiation effect is closer to one for religious activity, which means that once teenagers engage in this activity, they would prefer to participate in others activities. This result is consistent with the descriptive statistics in Table 3.2, where the mean duration for religious activity is 3.22 minutes.

5.2.2.7 Log-Likelihood Based Measures of Fit

The log-likelihood value of the MDCEV model is -8.4465. The log-likelihood value for the model, that has only the baseline preference constants, is -8.4926. With 100 degrees of freedom, the t-statistic has a value of 690.31, which is substantially larger than the critical χ^2 value of 124.34 at a 0.05 level of confidence. This means that the estimated model is better than the constants only model.

Table 5.2: Activity Participation Type MDCEV Model

Individual Demographics	Activity Participation							
	At Home	Shopping	Personal Business	Physical	Recreational and Social	Meals	Religious	Other
Male	--	-0.305 (-5.64)	-0.397 (-5.64)	0.287 (4.02)	--	-0.123 (-2.04)	-0.244 (-1.64)	-0.246 (-3.44)
Age 18	--	0.266 (4.14)	--	--	--	--	--	--
Age 19	--	0.301 (4.05)	--	-0.448 (-4.05)	--	--	--	--
Caucasian	--	-0.246 (-3.18)	--	--	--	-0.287 (-2.06)	--	-0.199 (-1.91)
African - American	--	--	-0.334 (-1.71)	--	--	-0.421 (-2.19)	--	--
Asian	--	-0.379 (-2.00)	--	-0.446 (-1.90)	-0.269 (-1.49)	-0.755 (-3.00)	-1.654 (-1.64)	-0.302 (-1.26)
Hispanic	--	--	--	--	--	-0.207 (-1.56)	--	--

Table 5.2 (continued): Activity Participation Type MDCEV Model

Individual Demographics	Activity Participation							
	At Home	Shopping	Personal Business	Physical	Recreational and Social	Meals	Religious	Other
Medical Condition	--	--	0.478 (2.30)	-0.395 (-1.41)	-0.432 (-2.30)	-0.563 (-2.37)	-0.909 (-1.28)	-0.503 (-1.80)
Worker Status	--	0.292 (3.97)	--	--	0.171 (2.58)	0.225 (2.94)	--	0.309 (4.05)
Self-Employ	--	0.341 (2.53)	--	--	--	--	0.886 (3.16)	--
Full Time Worker	--	--	-0.256 (-1.20)	--	--	--	-0.559 (-1.29)	-0.401 (-2.31)
More than one job	--	0.302 (2.48)	--	0.247 (1.51)	0.186 (1.43)	--	--	--
Immigrant Status	--	-0.366 (-2.72)	-0.709 (-2.96)	0.591 (2.02)	--	-0.355 (-2.25)	--	--
Years in the US	--	0.001 (1.29)	--	-0.034 (-1.38)	--	--	--	--

Table 5.2 (continued): Activity Participation Type MDCEV Model

Household Demographics	Activity Participation							
	At Home	Shopping	Personal Business	Physical	Recreational and Social	Meals	Religious	Other
High School Education at home	--	--	--	--	--	0.141 (1.40)	--	--
Some College Education at home	--	-0.101 (-1.64)	--	--	--	--	--	--
Bachelor Degree at home	--	--	--	--	0.175 (2.90)	0.258 (3.26)	--	--
Post Graduate Education at home	--	-0.138 (-1.95)	0.158 (1.60)	0.321 (4.10)	0.099 (1.47)	0.162 (1.85)	--	--
Own the house	--	--	0.571 (3.47)	--	--	--	--	0.334 (2.63)
Income between \$45,000 - \$59,999	--	--	--	--	--	--	0.487 (2.61)	--
Income between \$60,000 - \$74,999	--	--	--	--	--	0.164 (1.52)	--	--

Table 5.2 (continued): Activity Participation Type MDCEV Model

Household Demographics	Activity Participation							
	At Home	Shopping	Personal Business	Physical	Recreational and Social	Meals	Religious	Other
Income >= \$75,000	--	--	-0.208 (-2.29)	--	--	0.206 (2.69)	--	--
Number of Workers	--	-0.121 (-3.49)			-0.050 (-1.48)	-0.053 (-1.32)	0.307 (3.49)	--
Number of workers with option to work from home	--	--	--	--	0.104 (1.86)	0.140 (2.14)	--	--
Number of self-employed workers	--	--	0.122 (1.65)	--	--	0.117 (2.13)	--	--
Number of full time workers	--	--	-0.152 (-2.54)	--	--	--	-0.343 (-2.73)	--
Number of people with more than one job	--	--	--	--	0.109 (2.00)	--	--	--
Number of vehicles	--	0.085 (3.92)	0.044 (1.31)	0.112 (4.35)	0.028 (1.36)	0.140 (5.72)	--	--

Table 5.2 (continued): Activity Participation Type MDCEV Model

Other Demographics	Activity Participation							
	At Home	Shopping	Personal Business	Physical	Recreational and Social	Meals	Religious	Other
Presence of senior adults (> 65 years) at home	--	--	0.254 (1.79)	-0.312 (-2.00)	--	--	--	--
Presence of children 0 to 5 years at home	--	--	--	--	-0.410 (0.2338)	--	--	0.459 (1.90)
Presence of children 6-10 years at home	--	-0.171 (-2.02)	-0.347 (-2.52)	--	--	-0.320 (-3.22)	0.398 (2.05)	--
Presence of children 11 to 15 years at home	--	--	--	--	--	--	0.262 (1.72)	0.367 (5.15)
Household has immigrants as well as non-immigrants	--	--	--	--	-0.214 (-2.90)	--	--	--
Household has all immigrants	--	--	--	--	-0.397 (-1.66)	--	--	--
Urban Area	--	--	0.123 (1.35)	0.119 (1.51)		0.210 (3.08)	--	--

Table 5.2 (continued): Activity Participation Type MDCEV Model

Internet Usage	Activity Participation							
	At Home	Shopping	Personal Business	Physical	Recreational and Social	Meals	Religious	Other
Internet Use - Almost Everyday	--	--	--	0.600 (4.07)	0.330 (2.10)	--	--	--
Internet Use - Several times a week	--	--	--	0.372 (2.17)	0.432 (2.60)	--	--	0.226 (2.41)
Internet Use - Once a week	--	--	--	--	0.409 (2.17)	--	--	--
Internet Use - Once a month	--	--	0.509 (2.07)	--	0.653 (2.97)	--	0.866 (2.35)	--
Baseline Preference Constants	--	-7.856 (33.80)	-9.448 (33.21)	-9.968 (36.38)	-8.428 (31.38)	-8.837 (32.16)	-10.817 (37.08)	-9.134 (35.78)
Satiation Parameters	0 (0)	0.659 (79.59)	0.682 (70.44)	0.696 (103.33)	0.702 (66.54)	0.665 (77.25)	0.708 (57.80)	0.650 (46.55)

Chapter 6: Conclusion

Teenagers can have unpredictable behavior, especially when deciding to participate in non-fixed activities. A better understanding of teenager activity choice could help the transportation planning process, as well as lead to developing safety policies that improve transportation problems such as congestion, forecasting, environmental issues, and others. Activity participation is definitely attached to travel, because, in order to perform a determined activity, it is necessary to make a trip to pursue it.

In addition, the introduction of the internet has influenced and impacted human travel behavior in different ways, by substituting, modifying, or complementing travel and activities. Teenagers are considered part of the main user group of the internet, which indicates that they are also influenced by internet usage. That is why several concerns exist among parents, teachers, planners, policy makers, and other professionals, of the effect of internet usage among teenagers' daily activities. Especially, in a world where the internet and new technologies are growing tremendously and accessibility is increasing quickly. Thus, the need to understand the link between internet usage and activity participation on teenagers, and how this linkage affects teenagers' activity choice have become important in the research field.

The data used to analyze activity choice participation and internet response of teenagers aged 16 to 19 was the 2009 National Household Travel Survey (2009 NHTS). The methodology used to develop this analysis takes the form of two models: the ordered response model (to study the teenagers' internet usage), and the Multiple Discrete Continuous Extreme Value (MDCEV) model (to study the propensity of teenagers to participate in several non-fixed activities during the week).

There are several important results from this analysis. First, over 70% of the teenagers (from this sample) have access to the internet and use it almost every day during weekdays. This result confirms that American families are using the internet at their household, giving all members of the household easy access to all the information available through this tool. Second, individual and household demographic characteristics variables have an impact on the internet usage. However, these results corroborate the importance of having (aside from age, race, worker status, medical condition, level of education, household income, number of workers, number of adults, number of children, household location, *etc.*) other variables to assess the model. Those variables must include teenagers' perception and approach towards the tool, as well as, the expectation of individuals directly related (*i.e.* family) to teenagers about the tool. Third, when the age among teenagers increases, their willingness to participate in some activities varies. We can imply from this result that when teenagers are closer to become adults their expectations start to change, setting by themselves new goals for the near future. Fourth, the effect of education and income shows an interesting result for teenager's activity choice participation. The more educated the members of the household are, the more likely teenagers are to perform non-fixed activities. We can assume that educated parents tend to be more aware of the healthy benefits of several non-fixed activities for their children. Parents play an important role in teenager development and the more informed and educated the parents are about teenagers' activities, the more guidance they could bring to their children. Regarding household income, the results show that the ability to perform activities during the week is not only for high-income households (as we tend to assume) but also for middle-income households. We may imply that more accessible and affordable activities are being offered to those middle-income households. Fifth, internet usage is found to have a significant impact on activity participation behavior of teenagers.

The effect of internet use positively affects teenagers' activity participation, showing that teenagers who use the internet generally tend to perform more recreational and social activities. Aside from recreational and social activities, those teenagers who use the internet almost every day or several times a week also show that they are more likely to perform physical activities. Additionally, teenagers who use the internet less, tend to perform more personal business and religious activities. We could imply from these results that the use of the internet among teenagers could influence their activity choice participation in different activities. The internet could be used by teenagers as a window to explore different activity options, giving the chance to select different options that can lead to increased or reduced number of travel trips depending on the activity selected.

There were some limitations of the research. One of the limitations was that several values were missing for some of the variables that should be important to teenagers' daily life such as education status, safety issues when they are out-of-home, or their perspective about how often they would like to go out. The second limitation is the lack of information about specific internet usage among individuals, such as the time spent using the internet, and the place and time-of-day in which this technology was used. By knowing the time and place where teenagers are using the internet, more research can be done to have a better understanding of the interaction between teenagers' internet usage and its impact on activity participation.

Finally, the research represents an empirical analysis of internet usage among teenagers and its effect in their activity travel behavior when several factors (individual demographics, household demographics, and other demographics) are involved. Future research needs to focus on modeling the interaction of internet usage, including time and place, jointly with teenagers' activity participation.

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