Relationship between Well-Being and Daily Time Use of Elderly: Evidence from the Disabilities and Use of Time Survey

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ABSTRACT

According to US Census Bureau, the number of individuals in the age group above 65 years is expected to increase by more than 100% from the year 2000 to 2030. It is anticipated that increasing elderly population will put unforeseen demands on the transportation infrastructure due to the atypical mobility and travel needs of the elderly. Consequently, transportation professionals have attempted to understand the travel behavior of the elderly including the trip frequency, trip distance and mode choice decisions. Majority of the research on elderly travel behavior have focused on the mobility outcomes with limited research into understanding the tradeoffs made by this population segment in terms of their in-home and out-of-home activity engagement choices. The goal of the current research is to contribute to this line of inquiry by simultaneously exploring the daily activity engagement choices of the elderly Americans including their in-home and out-of-home activity participation (what activities to pursue) and time alloocation (duration of each activity) decisions while accounting for the temporal constraints. Further, the study attempts to explore the relationship between physical and subjective well-being and daily activity engagement decisions of the elderly; where subjective well-being is derived from reported needs satisfaction with life and different domains of it. To this end, data from the Disabilities and Use of Time (DUST) survey of Panel Study of Income Dynamics (PSID) was used to estimate a panel version of MDCEV model. In addition to person- and household-level demographic variables, activity participation and time use choices of elderly were found to vary across different levels of reported physical and subjective well-being measures. The model estimation results were plausible and provide interesting insights into the activity engagement choices of the elderly with implications for transportation policy development. Among other socio-demographic variables, living arrangements (living with family versus in elderly homes) were found to have significant influence on how people participate into different in-home versus out-of-home activities. For example, elderly living in the elderly home were found to participate more into out-of-home activities compared to people living with families. Elderly with disabilities were found to compensate lower participation into out-of-home activities with more participation into in-home activities. Considerable heterogeneity was observed in time engagement behavior of the elderly across reported levels of satisfaction with finance, job and cognitive needs. For example, elderly expressing high satisfaction with job was found to spend less time in in-home social activities. Elderly reporting higher satisfaction with finance were found to spend more time into OH social and shopping activities.

Keywords: Elderly Activity Engagement, Subjective Well-being, Physical Well-being, Panel MDCEV

INTRODUCTION
In the travel behavior arena, the study of the special population groups including elderly, children, individuals with disabilities, people from lower income groups, and immigrants among others is considered important owing to the additional challenges faced by these groups for their activity and travel needs Mohammadian and Bekhor (2008). Among the different special population groups, the study of elderly is gaining interest because of increase in the number of people belonging to this group due to improved life expectancy (Arentze et al. 2008, Nordbakke and Schwanen 2014). In the US, the focus on the mobility needs of the elderly is also increasing due to the unprecedented shift in population demographics expected in the next few decades due to the aging baby-boom generation. According to the US Census Bureau, 13 percent of the population was above 65 years old in the year 2010. However, this number is expected to increase by about 104 percent by 2030 (Mohammadian et al. 2013). Additionally, despite the physical and medical barriers faced by the elderly, they are more mobile today than they were in the years past with very active lifestyles (Rosenbloom 2001). The increase in the elderly population combined with the increased mobility needs is expected to exert demands on the built environments including transportation infrastructures in never before seen ways. As a result, the study of the elderly population has been of emerging interest in the transportation arena and many recent studies on the topic are a testament to this interest (Rosenbloom 2004a, Cao et al. 2010).

Among different generations of elderly population, "baby boomers" – those who were born post World War II between 1946 and 1965 have received considerable attention. A number of studies have attempted to compare the activity travel pattern of the baby boomer generation with other generations (Goulias et al. 2007, Miranda-Moreno and Lee-Gosselin 2008). Studies have shown that baby boomers tend to maintain a more active lifestyle, prefer late retirement, and tend to work full-time or part-time even after retirement compared to similar aged individuals from earlier generations (Srinivasan et al. 2006, Goulias et al. 2007). Similar trends have also been observed in European contexts. Klein-Hitpaß and Lenz (2011) found that the number of elderly people who do not make a single trip in a day has decreased over the years in Germany and during the same period the trip lengths have increased. In another study, using data from 2002 to 2005 in Quebec City, Canada, it was found that participation into out-of-home activities increased during the three years among baby boomers (Miranda-Moreno and Lee-Gosselin 2008). Alsnih and Hensher (2003) have arrived at similar conclusion while studying elderly activity-travel behaviors in the context of developing economies. Siren and Haustein (2013) also echo a number of findings from earlier studies about elderly activity-travel behaviors. However, they also note that there is considerable heterogeneity in the travel behaviors of the baby boomer generation which needs to be recognized when formulating policy. *The primary objective of this study is to add to the literature on exploring the factors that contribute to heterogeneity in mobility choices of the elderly (studied through the lens of activity participation and time allocation behaviors).* In the following subsections, existing literature on elderly time use is presented before presenting an overview of the current study. It must be noted that review of literature in this research is limited to elderly time use. For a more more comprehensive review of general time use research please refer to Jara-Diaz and Rosales-Salas (2017) and Liu et al. (2017).

Factors Contributing to Elderly Mobility
This subsection identifies the factors identified by the existing literature to be important contributor of elderly mobility. Previous studies have identified car ownership and possession of driving license as the two most important contributors to the continued mobility at the old age (Alsnih and

Hensher 2003, Cao et al. 2010, Klein-Hitpaß and Lenz 2011). Rosenbloom (2004) highlighted the gender differences in mobility needs of elderly people. The author argued that women are more dependent on the family members to meet their mobility requirements compared to the men. In addition to car ownership and possession of driving license, education status, worker status, income and household structure have been identified to be important contributors to the mobility at the old age (Miranda-Moreno and Lee-Gosselin 2008). Nordbakke and Schwanen (2015) attempt to identify the factors associated with the unmet mobility needs of elderly. According to them, in addition to the individual resources such as driving license and car availability, social support and network, general outlook on life as well as transportation infrastructure (e.g. availability of public transportation) are associated with unmet mobility needs.

One additional factor that has emerged to have close association with mobility at the old age is the quality of life. In the last decade, travel behavior researchers in general have strived to investigate the relationship between individual's perceived quality of life - often referred to as subjective well-being (SWB) and mobility as implied by activity-travel participation (Duarte et al. 2010, Ettema et al. 2010, De Vos et al. 2013, Schwanen and Wang 2014). In addition to subjective well-being, physical well-being is also believed to be closely linked to the activity-travel engagement behavior of the elderly. Recent literature has identified disability as an important consideration for mobility at the old age (Alsnih and Hensher 2003, Cao et al. 2009, Freedman et al. 2012). In the current study, the in addition to the various person- and household-level factors, different types of subjective and physical well-being measures are explored to understand the heterogeneity in activity-travel engagement behavior of the elderly individuals.

Elderly Mobility and Subjective Well-being
In understanding the association between mobility and SWB researchers have approached it from different perspectives. For example, according to Abou-Zeid and Ben-Akiva (2012) activity-travel engagement of individual is influenced by one's desire to maintain or enhance their well-being. Archer et al. (2013) and Ravulaparthy et al. (2013) argue that location of activity participation (in-home versus out-of-home), activity duration as well as activity type are correlated with individual well-being. A few studies have also tried to understand the association between well-being (both stated happiness with life and the stated happiness with regard to the transportation system) and the choice of travel mode (Duarte et al. 2010). A number of studies have also attempted to understand the association between mobility at old age and perceived quality of life (SWB). Banister and Bowling (2004) attempt to deconstruct the elements that contribute to the quality of life of elderly. In their study, the authors found that living in a neighborhood with good transport services contributed positively to the quality of life by facilitating participation into social activities. In another study, Spinney et al. (2009) found that increased transport mobility is correlated with increased life satisfaction for elderly Canadians. More recently, Nordbakke and Schwanen (2014) provide a comprehensive review of literature exploring the relationship between mobility and well-being of the elderly people from the fields of gerontology, health and transportation. From the review, the authors note that the nexus of elderly mobility and well-being research has been pursued along two lines of inquiries. One stream of research has been focused on various aspects of elderly driving cessation including coping with driving cessation and subsequent implications for travel behavior (Coughling 2001, Bauer et al. 2003, and Davey 2007). The second line of research has been focused on identifying aspects of elderly life (including mobility choices) that improve well-being of the elderly (Siren and Hakamies-Bolmqvist 2009, Musselwhite and Haddad 2010, Ziegler and Schwanen 2011). In this line of research, access to

good transportation that enables people to participate in activities of their choice was found to be an important factor for maintaining quality of life.

In the second line of research that explores the relationship between well-being and activity-travel engagement choices of elderly, mobility has often been quantified in terms of out-of-home trip frequency. Very few studies have considered the full range of time use choices of elderly (e.g. activity participation, and time allocation decisions of all types of activities that elderly pursue). Additionally, very few studies accurately account for different types of constraints and interactions they experience (e.g. physical abilities and temporal constraints as formulated by Hagerstrand 1970). It has been well established that travel is derived from individual needs to engage in activities. By understanding the time use choices one can more accurately characterize and analyze association between well-being and mobility. Spinney et al. (2009) is one of the few studies that attempted to generate contextually derived time budgets for psychological, exercise and community times. Further, they attempted to understand how they vary across different levels of life satisfaction. Nordbakke and Schwanen (2015) is another such study that attempts to explore the association between the quality of life (measured via satisfaction with life) and the unmet mobility needs of the elderly. Next section presents the subject well-being perspective adopted in the current research followed by the motivation to investigate the association between elderly time use choices and subjective well-being.

Well-being Perspectives
Subjective well-being is a broad psychological construct proposed by Kahneman et al. (1999) that represents individuals' cognitive and affective evaluation of his/her life. However, research from different disciplines such as economics, psychology, sociology, public health, geography and gerontology conceptualize well-being differently. Below different perspectives adopted by researchers while studying well-being is presented followed by a discussion of the existing conceptualization of the linkage between well-being and time allocation behavior. While some researchers have defined well-being as a subjective phenomenon arising from an individual's overall evaluation of his/her life (Veenhoven 2002), others have formulated well-being based on objective circumstances that an individual experiences (Phillips 2006). Similar to the definition of well-being, the approaches to study well-being also vary considerably across disciplines. The utility approach within economics defines well-being as the maximization of preference satisfaction. According to the basic needs approach, well-being is derived from the satisfaction of the basic needs. These research efforts draw on Maslow's need hierarchy (1943). According to Maslow, basic needs such as physiological needs, safety needs, love needs, esteem needs and needs for self-actualization follow a certain hierarchy. A need down in the hierarchy surfaces only when the preceding needs are satisfied to a certain extent. Similar to the basic needs approach, in the integral needs approach, well-being is derived from the satisfaction of needs. However, compared to the basic needs approach, integral needs approach also emphasize the non-material aspects of life for need fulfillment. For example according to Finnish Sociologist Eirk Allardt (1993), people consider needs satisfaction from three aspects: to have (refers to the material needs in life such as education, work, and money), to love (refers to the social needs such as being with other human beings), and to be (refers to the self-actualization needs). Additionally, in gerontology, health is most often considered to be the prime determinant of well-being.

In the current study, well-being is defined from the perspective of needs satisfaction. According to the adopted definition, well-being is perceived as a subjective phenomenon and is derived from the individual's own evaluation of needs. Further, well-being is characterized not

using a single measure but with a variety of measures offering their perceived satisfaction in different domains of life. The particular domains considered in the current study are the satisfaction with life, job, finance and marriage. Job and financial satisfaction are closely related to the "to have" needs highlighted by Allardt (1993). Similarly, satisfaction with marriage would relate to the "to be" and "love needs" identified by Allardt (1993) and Maslow (1943) respectively. Finally, the overall satisfaction with life would be related to the "to be" need or the self-actualization need identified by Allardt (1993) and Maslow (1943) respectively. In addition to satisfaction with life, job, finance and marriage, the research also considers health related satisfaction for characterizing well-being of the elderly.

Well-being and Time Use

Tonn in his 1984 paper talked about the socio-psychological aspect of time use. He proposed that mathematical models of individual time use behaviors should be grounded in psychological motivations and must also consider the temporal constraints that exist. According to the author, three types of needs, namely, will to live, sexual-sensual desire and need for social interaction, guide the time use behaviors of individuals. Tonn also postulated that, while allocating time to satisfy different types of needs, individuals strive to maintain a certain balance in terms of needs satisfaction rather than trying to exhaust a need before moving onto the next one. Borrowing from Tonn's hypothesis, in the current study, time use decisions of elderly are assumed to vary depending on the level of needs satisfaction (measured via the satisfaction with life and different domains of it). As identified in the last section, we adopt the definition of well-being where well-being is derived from needs satisfaction.

Arentze and Timmermans (2009) and Nijland et al. (2010) have also studied the association between needs and activity agenda formation. The authors explored the dynamic evolution of needs and it's interrelationship with activity agenda formation. However, the current study is different from these explorations. While they focus on the short-term dynamics of need formation and activity generation process, the current study focuses on the association between needs satisfaction and overall activity participation and time allocation at a particular cross-section in time (e.g. an average day in a person's life). The motivation of the current study closely resembles Dekker et al. (2014). Dekker et al. studied the influence of perceived needs satisfaction potential of different leisure activities on the choice of the leisure activity. They found that needs satisfaction potential accounts for substantial heterogeneity in the selection of leisure activity type. Despite the similarity in motivations, there are considerable differences between the current research and Dekker et al. The empirical study presented in Dekker et al. uses stated preference data. On the other hand, revealed data about time use choices is used in this current research thus offering more realistic insights into the time use behaviors. While Dekker et al. only considers the participation choice into leisure activities, in the current research, participation and time allocation decisions are considered for all types of activity types (including leisure) that elderly individuals pursue. Additionally, while Dekker et al. study the interrelationship between perceived needs satisfaction potential of leisure and the time use decision of leisure activities, the current study explores the association between expressed needs satisfaction (measured via satisfaction with life and various aspects of it) and the full range of time use choices.

While considering the needs satisfaction helps understand the socio-psychological motivations for time use decisions, one must also consider the situational constraints that individuals experience to accurately characterize time use behaviors (Hagerstrand 1970, Tonn 1984). Among the different types of constraints identified by the researchers such as time, physical,

economic, personal, scheduling and institutional constraints (Tonn 1984), time constraint is perhaps the most important and the easiest to characterize/consider in studies of time use behaviors. In particular, every individual has 24 hours at their disposal to pursue various activities. Therefore, the 24 hour duration serves as a natural constraint for the time allocated by individuals. Unlike most of the previous studies (e.g. Miranda-Moreno and Lee-Gosselin 2008, and Spinney et al. 2009) which ignore the temporal constraints when studying time use choices of elderly, the current study explicitly accounts for the temporal constraints in the empirical analysis.

Overview of the Study

The review of the literature on elderly activity-travel suggests that empirical research to date have mostly focused on the elderly mobility outcomes utilizing measures such as trip length, trip rate and mode choice (Banister and Bowling 2004, Klein-Hitpaß and Lenz 2011). Few studies have considered the participation into different out-of-home activities while also considering the tradeoff between out-of-home and in-home *activity participation* (whether to participate in an activity?) (Miranda-Morebo and Lee-Gosselin 2008). Also, to the best of the authors' knowledge, *time allocation* (how much time to spend in a chosen activity?) behavior of the elderly has not been extensively studied. *The focus of the study is in understanding the heterogeneity in elderly activity participation and time allocation behaviors.*

It should be noted that one of the fundamental aspects of the study of time allocation behavior is the explicit consideration of the temporal constraints (Becker 1965, Johnson 1966, Evans 1972). Study of different types of activities in isolation fails to capture the subsequent impacts of temporal constraints. For example, tradeoffs that people make in order to participate in and allocate time into different activities within limited time constraint is ignored. *The current study adds to this line of inquiry that is less understood by exploring the daily participation and time allocation of elderly into different in-home and out-of-activities while explicitly accounting for the temporal constraint.* Additionally, the formulation adopted in the research for the study of time use behaviors of the elderly allows variable satiation effect associated with different activity types – this is a desirable feature that captures the ability of different activity types to satisfy different types of needs and to varying degrees.

Further, in exploring the heterogeneity of activity engagement choices, particular attention is paid to their physical and subjective well-being. More specifically, the variation in participation and time allocation decisions across different levels of well-being perceived by the elderly (measured via satisfaction with life and different domains of it such as satisfaction with job, finance and health) is explored. It should be noted that while investigating the association between well-being and activity-travel engagement choices of the elderly, the current study does not postulate a causal structure; rather the well-being indicators are used to unravel the heterogeneity in the activity engagement choices of the elderly individuals. Also, it is acknowledged that the perceived overall satisfaction of life (and with different domains of life) evolve with time and with changing stages of life. Therefore, a simultaneous investigation of the association between well-being and activity engagement using longitudinal data would provide more insights into the interplay between mobility and quality of life.

To the best of the authors' knowledge*, the empirical study presented in the current paper is one of the very first explorations that attempts to explore heterogeneity in time use behaviors of elderly as a function of the well-being in addition to the individual and household characteristics.* Also, unlike previous studies, where the time allocation in different activities have been explored in isolation*, the current study explores the time use decisions into different activities simultaneously using an econometric framework that can accurately capture the temporal constraints within which a person operates.*

In this study, data from the Disabilities and Use of Time (DUST) supplement of Panel Studies of Income Dynamics (PSID) conducted in 2009 was used. The DUST dataset contains information about activity participation and time use choices for each elderly respondent for both weekdays and weekends. The Multiple Discrete Continuous Extreme Value (MDCEV) framework proposed by Bhat (2005, 2008) was used to model the activity participation and time use decision. The MDCEV framework is particularly suited for this study because the utility-theoretic formulation can simultaneously accommodate the participation and time use decisions of activity engagement while accounting for the time constraints that individuals experience when making these choices. The MDCEV framework has been applied in multiple studies to explore different aspects of activity-travel engagement decisions for different population segments (Copperman and Bhat 2007, Kapur and Bhat 2007, Sener and Bhat 2007, Sener et al. 2008). More recently, extensions of the MDCEV have been proposed to support the empirical exploration of interest at hand (Pinjari and Bhat 2010, Sobhani et al. 2013, Sobhani et al. 2014). The current study employs a panel version (Spissu et al. 2009) of the MDCEV framework to appropriately handle multiday observations (a weekday and a weekend) of the survey participants.

The rest of the paper is organized as follows. The next section introduces the DUST data set along with a description of the sample composition. An overview of the panel MDCEV model formulation is presented in the third section. The fourth section elaborates on the model specification while also presenting the specific hypothesis that informed the model development Findings from the empirical study are presented in the following section. Final section presents a summary of findings along with a discussion of the policy implications of the empirical findings. This section also presents ideas for future research regarding elderly time use studies.

DATA DESCRIPTION AND SAMPLE COMPOSITION

Data from the 2009 Disabilities and Use of Time (DUST) supplement of Panel Study of Income Dynamics (PSID) was used in the study (PSID 2014). PSID is a longitudinal household survey which began collecting information regarding employment, income, wealth, expenditures, health, marriage, childbearing, child development, and education from a nationally representative sample of individuals in the US since 1968. DUST contains information about elderly couples where both spouses were at least 50 years old by December 31, 2008 and at least one spouse was over the age of 60 at the time of the data collection. The elderly couples were interviewed on a randomly selected weekday and weekend day using time diaries. The time diary included information about all activities performed by the individual including start time, duration, location, travel mode, accompaniment type, and for whom they carried out the activities among others. Respondents were also asked to report physical well-being in a yes/no format. Additionally, respondents provided information regarding their subjective well-being by rating different aspects of life on a scale of 1 to 7 where 1 means very unsatisfied and 7 means very satisfied. The diary also included more specific well-being questions related to three randomly selected activities reported by the survey respondents. The focus of this study was on exploring the association between physical and subjective well-being, and activity engagement decisions. In addition to the above, socioeconomic information regarding individuals' employment status, education status, household type, household composition, and vehicle ownership were available from the PSID survey.

The initial survey sample comprised of 755 individuals. After eliminating individuals with missing information, the subsample used in the analysis consisted of 728 individuals with valid responses. Out of 728, 724 individuals reported data for both weekday and weekend and 4 individuals provided data only on a weekend. In terms of gender distribution, there is nearly an

equal percentage of male and female with 357 of the 728 individuals being male (49 percent) and the rest being female. 47 percent (339 individuals) of the respondents in the subsample are less than or equal to 65 years old, 42 percent (309) of the respondents belong to the 65 to 80 years' age group, and the remaining 11 percent (80) respondents are over 80 years old. A significant percentage of the elderly population is also employed; 261 of the 728 individuals (36 percent) reported that they were employed either full-time or part-time.

Activities were classified into very detailed categories in the DUST. However, in the current study the detailed categories were consolidated based on two criteria. (1) The study only focused on the discretionary activity types where the participants can exercise choice while deciding whether to participate in the activity and how much time to spend in the activity. This criterion resulted in excluding three types of activities such as sleep and relax, personal maintenance, and work for pay, (2) For the remaining activity types considered in the analysis (including meal, study and volunteer, shopping, household chores, social recreation, and leisure), the activity types were disaggregated into in-home and out-of-home activities based on location of the activity. Initial analysis indicated that some of these disaggregate activities were predominantly conducted at one location (either in-home or out-of-home). For example, shopping was mostly performed out-of-home whereas household chores and leisure were performed mostly in-home. As a result, the disaggregate categories based on location with very limited observations were combined into a single activity category that was location indifferent. The above criteria lead to following eight non-fixed activity types including in-home meal (IH meal), out-of-home meal (OH meal), in-home social recreation (IH social), out-of-home social recreation (OH social), study and volunteer, shopping, household chores (chores) and leisure.

Table 1 provides a brief description of the final activity categories considered in the analysis. The table also lists the primary activity location, participation rates as well as the mean duration of participation by weekday and weekend. In calculating the mean duration, only individuals participating in at least one episode of the particular activity type were considered. The participation rates indicate that there is a slightly higher tendency to participate in out-of-home (OH) meal and OH social activities during weekend. It is interesting to note that the activities conducted at OH location have a higher mean duration compared to activities conducted at in-home (IH) location. This is partly owing to the fact that duration for OH activities includes both the activity and the travel to engage in the activities. Leisure has the highest mean duration followed by study and volunteer. The next section presents a brief overview of the panel MDCEV model structure followed by a description of the model specification.

ECONOMETRIC MODEL STRUCTURE

The MDCEV model formulation is presented in this section. Following Bhat (2008) and Spissu et al. (2009), the functional form for the total utility derived by an individual n on a certain day t by engaging in activities K_{nt} can be given as shown in Equation 1.

$$U_{nt}(x) = \sum_{k=1}^{K_{nt}} \gamma_{nkt} \exp(\beta' Z_{ntk} + \varepsilon_{ntk} + \eta_{nk}) ln\left(\frac{x_{ntk}}{\gamma_{ntk}} + 1\right) \qquad (1)$$

In the above equation, x is the vector of the time allocated to different activities $(x_{nt1}, x_{nt2}, \ldots, x_{ntk})$. Z_{ntk} is a vector of exogenous variables (including a constant) corresponding to an alternative k and β represents the corresponding vector of unknown coefficients, ε_{ntk} and η_{nk} are the associated random error components. The term $\exp(\beta' Z_{ntk} + \varepsilon_{ntk} + \eta_{nk})$ represents

the marginal random utility[1] for allocating a unit of time to alternative k at the point of zero-time allocation and controls an individual's participation in alternative k. The term γ_{ntk} is a translation parameter which serves to allow corner solutions (representing zero allocation of time to alternative k). The parameter also serves to account for satiation effects when allocating time to different activities. Values of γ_{ntk} closer to zero imply higher satiation (or lower allocation of time) for a given level of baseline preference and vice-versa. Furthermore, the study parameterizes γ_{ntk} as $exp(\lambda' \omega_{ntk})$, where ω_{ntk} is a vector of individual specific characteristics and λ is the associated vector of unknown parameters to be estimated.

In equation (1), the first error component ε_{ntk} is assumed to be independently and identically type I extreme value distributed across alternatives, individuals and days with a scale parameter σ. The second random error component η_{nk} is assumed[2] to be normally distributed with a mean of zero and a variance-covariance matrix of Ω; Ω is a diagonal matrix with diagonal elements ω^2. A statistically significant value of ω indicates the presence of error correlations across days for the same individual (i.e. this provides evidence in support of a significant individual effect).

The MDCEV framework proceeds to model activity engagement by maximizing the utility $U_{nt}(x)$ subject to the time constraint $\sum_{k}^{K_{nt}} x_{ntk} = T_{nt}$ where T_{nt} is the total time available to participate in K_{nt} different activities. Given the assumptions about the error terms as preliminaries, the conditional probability (conditional on the error component η_{nk}) of an individual n allocating time to the first M_{nt} of the K_{nt} alternatives on a certain day t is shown in equation (2) below.

$$l_{nt} = P(x^*_{nt1}, x^*_{nt2}, \ldots, x^*_{ntM}, 0, 0, \ldots, 0 | \eta) =$$

$$\frac{1}{\sigma^{M_{nt}-1}} \left[\prod_{i=1}^{M_{nt}} f_{nti}\right] \left[\sum_{i=1}^{M_{nt}} \frac{1}{f_{nti}}\right] \left[\frac{\prod_{i=1}^{M_{nt}} e^{(V_{nti}+\eta_{ni})/\sigma}}{(\sum_{k=1}^{K_{nt}} e^{(V_{ntk}+\eta_{nk})/\sigma})^{M_{nt}}}\right] (M_{nt}-1)! \tag{2}$$

In the above equation, V_{ntk} is the utility of alternative k defined as $V_{ntk} = \beta' Z_{ntk} - \ln\left(\frac{x^*_{ntk}}{\gamma_{ntk}} + 1\right)$ where $f_{nti} = \frac{1}{x^*_{nti} + \gamma_{nti}}$. The likelihood function for the sample can finally be written as in Equation (3).

$$L = \prod_{n=1}^{N} \int_{\eta_n} \prod_{t=1}^{T_n} l_{nt} \, dF(\eta_n) \tag{3}$$

where F is a multivariate cumulative normal distribution function, T_n is the total number of choice situations for individual n (i.e. number of days), and N represents the total number of individuals in the sample. The likelihood function in equation (3) involves a multidimensional integral which can be evaluated using maximum simulated likelihood approach (Train 2009). In approximating the integral shown in Equation (3), scrambled Halton draws were used (Bhat 2003). After monitoring stability in the parameter estimates with increasing number of draws, 200 scrambled

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[1] Also referred to as baseline utility preference.
[2] Note that the second error component η_{nk} is assumed to be independently and identically distributed across alternatives and individuals but is held constant across observations from the same individual.

Halton draws were employed for the final model estimation. The panel MDCEV code developed for this study builds on the Mixed MDCEV GAUSS code distributed for public use by Bhat (2008).

MODEL SPECIFICATION
This section introduces the specification of the model while also highlighting the hypothesis that guided the model development. The primary purpose of the study was to capture the heterogeneity in the elderly activity participation and time allocation decisions. The different individual and household level characteristics along with the physical and subjective well-being variables that were used to specify the model are introduced next. It must be noted that these variables were used to explore the variability in both activity participation and time allocation decisions (i.e. they constitute the vector Z and ω introduced in the previous section).

Individual Characteristics
The different individual level characteristics used to parameterize the baseline marginal utility and the satiation parameter are gender, age, education status, worker status, living status and race. Drawing from previous literature (Alsnih and Hensher 2003, Banister and Bowling 2004), elderly individuals in the dataset were further separated into three age categories: the "young" group (those who are less than 65 years old), the "middle" group (those who are between 65 and 80 years old) and "old" group (those who are above 80 years old). It was assumed that, elderly individuals who are still working for pay would have different life styles compared to those who do not. The work status indicator was introduced to account for this effect. It was hypothesized that, the people with special living arrangements would have different mobility needs (especially in terms of social and recreational activities) compared to those individuals who stay with family. This was captured using the living status indicator. Very limited literature has considered the influence of race while examining the mobility needs of the elderly (Rosenbloom 2004b). Assuming that there are inherent differences in the way individual pursue their daily life based on their ethnic background, the present study explores differences in activity engagement using ethnicity indictors.

Household Characteristics
In the literature, the composition of the households has been identified as an important source of heterogeneity in activity participation and time allocation decisions (Kapur and Bhat 2007, Copperman and Bhat 2007). The current study assumes that presence of adults (in addition to the spouse) and kids in the household would potentially alter the way elderly individual participate in different in-home and out-of-home activities. Drawing from the previous studies on this topic (Rosenbloom 2004b), it was assumed that presence of adults in the household would allow elderly individuals to pursue different out-of-activities where they may require some assistance which might not be possible if there were no adults to assist them. Building on the previous literature, the current study also explores heterogeneity due to household income (Banister and Bowling 2004) and the vehicle availability (Klein-Hitpaß and Lenz 2011).

Physical and Subjective Well-being
Existing literature has considered influence of disabilities on mobility at old age (Freedman et al. 2012). The current study expands the source of disability to include both walking disability and disabilities related to cognitive functioning. Physical well-being information was collected on a dichotomous scale (in a yes/no format); consequently, indicator variables were constructed to indicate the presence of disability.

As highlighted previously, the study also attempts to identify the association between perceived level of satisfaction in different domains of life and the activity participation and time allocation. To this end, indicators of satisfaction with life and different domains of it including health, job and finance were explored. These variables are used to explain the heterogeneity both in the participation as well as in the time allocation decision (through their specification in vectors Z and ω respectively). The satisfaction information with life (and different domains of it) were collected on a scale ranging in values from 1 to 7. Consequently, three indicator variables were created to denote low (less than 3), medium (between 3 and 5) and high level of satisfaction (6 and 7). The next section presents the model estimation results. Additionally, where appropriate, findings from the empirical analysis are compared and contrasted with those from previous studies on the topic of elderly mobility.

EMPIRICAL RESULTS

A panel MDCEV model was estimated to understand the heterogeneity in in-home and out-of-home activity engagement decisions (including participation and time allocation) of the elderly individuals while accounting for the temporal constraints that guide the time allocation behavior. The activity types considered for the current exploration include four in-home (IH) activities: IH meal, IH social, chores, and leisure, three out-of-home (OH) activities: OH meal, OH social, shopping, plus the study and volunteer activity. The amount of time available (T_{nt}) for activity engagement is equal to 1440 minutes minus the duration of all fixed activities (including sleep and relax, personal maintenance, and work for pay) that individuals pursue over the course of a day.

As noted in the previous section in addition to the household-level demographic variables physical and subjective well-being attributes were used to explore heterogeneity in the non-fixed activity participation and time use decisions of the elderly. It must be noted that, constants were retained in the model specification even if they were not statistically significant because all the error components were assumed to have a zero mean. Model estimation results for the baseline utility (explaining the activity participation decision) are presented in Tables 2 and 3 and the estimation results for the satiation parameter (explaining the time allocation decision) are presented in Table 4. The results are discussed in further detail in the following subsections beginning with summary of model goodness of fit and findings from the panel structure exploration. In the second subsection, the estimation results for the baseline utility are presented followed by a discussion of the satiation parameter in the third subsection. It should be noted that, while presenting the observations from the empirical analysis, the study does not imply causality between the explanatory variables (including the individual characteristics, household attributes, and subjective and physical well-being measures) and the activity engagement choices. Rather, the study attempts to highlight the substantial variability that exists in the elderly in-home and out-of-home activity participation and time allocation choices as a function of different explanatory variables.

Estimation Summary

Most of the model coefficients were statistically significant at the 95 percent level of confidence. The log-likelihood of the final model at convergence (-35020.9) was higher than the log-likelihood for the constants only model (-35316.7) indicating that the final model with the explanatory variables helps explain the choices better than a model with just the constants. Further, the log-likelihood ratio test confirmed this observation at a 95 percent level of confidence (test statistic $\chi^2 = 297.8$, critical value of $\chi^2 = 124.342$ with 99 degrees of freedom). A comparison of the log-

likelihood values of the panel model (with a final log-likelihood of -35020.9) and cross-sectional model (with a final log-likelihood of -35041.3) indicates that, accounting for the individual specific error correlation (individual effect) is warranted. This is also confirmed by the log-likelihood ratio test ($\chi^2 = 40.7$, critical value of $\chi^2 = 3.841$ with 1 degrees of freedom). Further, the model estimation results show a significant ω parameter in the mixing distribution (with a value of 0.3874 and corresponding t-statistic of 11.21) of the baseline utility. The presence of individual specific error correlation was tested in the satiation parameter but was found to be insignificant.

Baseline Utility Parameters (β): Explaining the Heterogeneity in Activity Participation
The baseline utility represents preferences of the elderly to participate in different non-fixed activity types in a day. IH meal was used as the baseline for the choice of activity type. It can be seen from the estimates of constants that all other things assumed equal, elderly prefer to participate in leisurely activities the most followed by chores compared to IH meal activity. All other activity types including IH social, shopping, OH social, OH meal, and study and volunteer were less preferred than the IH meal. A discussion of the influence of the different explanatory variables is presented below.

Person- and Household-level Explanatory Variables
Table 2 presents model estimation results for the household- and person-level demographic variables. It was found that elderly females have a higher tendency to participate in chores, IH social, and OH social compared to their male counterparts and prefer less to participate in study and volunteer activities. These findings provide evidence in favor of traditional gender roles wherein women assume responsibilities for housework (part of chores), and care giving activities (part of IH and OH social).

An exploration of the relationship between age and activity participation showed that elderly who are less than 80 years old have a higher preference for participating in OH activities including OH social, shopping, and study and volunteer. Elderly in this age group were also found to be involved in more household chores than elderly who are greater than 80 years. This is reasonable considering the additional barriers one faces with such age. The notion of increased barriers with aging is also evident by observing the relative magnitude of the coefficients for elderly who are less than 65 and elderly who are between 65 and 80. It can be seen that the former group has a higher preference to participate in different activities than the latter group. This observation is also in line with the previous research by Banister and Bowling (2004). The authors conducted a bi-variate analysis to identify relationship between age and out-of-home activity participation. They also found that frequency of out-of-home activity participation decreases with the increase of age even within the elderly cohort.

Education status of elderly marginally affects activity participation. It was found that elderly with at least high school education prefer to engage in study and volunteer type of activities. The influence of working status was found to be only marginally significant. It was found that elderly workers tend to engage more in OH social and less in shopping. The tendency to participate more in OH social may be reflective of additional socializing opportunities with colleagues at work. The negative relationship with shopping may be reflective of the constraints imposed by the work activity schedules of workers.

Living arrangement of elderly is one of the factors that did not receive adequate attention in the existing literature. This factor revealed interesting observations regarding elderly mobility. It was found that individuals who live in an elderly home engage less in IH social and chores and

more in leisure, OH meal, and OH social. The tendency to participate less in chores is reflective of the nature of the elderly homes where care givers may be taking on the chores requiring elderly to engage less in these activities. Further, the additional time afforded by decreased participation in chores may be affording elderly to pursue OH activities.

Race of elderly was also found to be significantly correlated with activity participation. Elderly Black or African American individuals were more active (tend to participate more into out-of-home activities compared to the rest of the elderly cohort, while elderly Asian individuals were relatively less mobile. This finding however contradicts the observation presented by Rosenbloom (2004b) based on the bivariate analysis of trip rates by ethnicity using data from 1995. The author found that mobility of Asians is comparable, especially among male population, to the White population. The author also observed that Black population generally suffered higher losses in mobility with aging.

In addition to the different person-level explanatory variables, a host of household-level explanatory variables were found to be correlated with elderly activity participation including family income, household composition, and auto ownership. It is interesting to note that as family income increases elderly participate more in OH meal activities. This may be attributed to the additional disposable income available to higher income families compared to families with lower levels of income. This observation is also in line Miranda-Moreno and Lee-Gosselin (2008) who found that elderly individuals belonging to high income households tend to participate less in habitual (routinely performed at a fixed place and time) activities. It was also found that in the presence of household adults (in addition to the significant other), elderly individuals participate more in different out-of-home activities such as shopping and out-of-home meal compared to when they live only with their significant other. This observation is reasonable since the presence of other household members provide elderly individuals additional opportunities to pursue out-of-home activities. It is also plausible that the presence of additional adult members affords them additional opportunities for assistance, thus, allowing them to pursue more activities. This finding is in line with Rosenbloom (2004b) who found that this age cohort is generally dependent on the family members for performing out-of-home activities. It is interesting to note that vehicle ownership is positively correlated to participation in OH activities. This shows that elderly individuals without vehicle availability constraints (as reflected by the presence of more than 2 vehicles) are more active and favor participation in OH activities (OH meal, OH social and shopping). This observation is supported by the findings from a number of previous studies regarding this age cohort's dependency on car for performing out-of-home activities (Alsnih and Hensher 2003, Klein-Hitpaß and Lenz 2011). Lastly, the differences in elderly activity participation patterns between weekdays and weekends were evident from lower participation into chores and leisure and higher participation into OH social activities on weekends.

Physical and Subjective Well-being Explanatory Variables
Table 3 presents model estimation results for the physical and subjective well-being variables. It was found that there exists significant variability in elderly activity participation choices across different levels of physical and subjective well-being. Individuals who reported having difficulties with concentration, remembering and/or decision making were found to engage more in chores and less in OH social. The decreased participation may be due to their discomfort and uneasiness when being around people. This observation is in line with the finding reported by Freedman et al. (2012). In the study, the authors note that presence of disability results in less socialization. It is

however interesting to note that these same individuals tend to engage more in study and volunteer activities compared to others.

It was also found that, elderly individuals who reported having difficulties with walking tend to engage more in leisure activities compared to others. This may be reasonable because this category involves activities performed at home entailing little physical exertion such as watching television, and movies, engaging in arts and entertainment among others. Further, it was found that elderly who reported needing assistance to run their daily errands tend to be less active in general with reduced participation in both IH (social, chores) and OH (social, shopping) activities due to their limitation.

In the DUST survey, other subjective well-being measures were collected by asking the participants to report their perceived satisfaction with life, health, financial stability, memory, job and marriage. Among these measures, satisfaction related to life, health, financial condition and job were found to impact the elderly activity participation. It can be noted that, among the above types of satisfactions, satisfaction with life can be related to the self-actualization need (Maslow 1943) or the "to be" need pointed out by Allardt (1993). Whereas, the satisfaction with finance and job can be related to the "to have" needs (Allardt 1993). It was found that elderly individuals with both high (value of 6 or more) and moderate levels of life satisfaction (value of 3 through 5) tend to participate less in chores and shopping activities. However, it is interesting to note that the tendency to participate is lesser for the elderly who are more satisfied. It was observed that elderly with higher levels of health satisfaction engage less in leisure activities. This is plausible since leisure includes discretionary activities performed at home with little physical exertion such as watching television, reading book and so on. Elderly who are financially satisfied tend to engage less in IH social activities compared to others. Lastly, it was found that elderly with higher levels of job satisfaction participate more in different activity types compared to those who reported lower job satisfaction. It is interesting to note that the influence of job satisfaction on activity participation is increasing with increasing levels of satisfaction across different activity types. Elderly who are highly satisfied with their job tend to engage more in OH meal activities, and less in chores and shopping compared to those who are moderately satisfied with their job.

Satiation Parameter (λ): Explaning the Heterogeneity in Time Allocation
In the current study, the satiation (translation) parameter γ_{ntk} was parameterized using a range of explanatory variables including demographics, physical and subjective well-being to capture the influence of these different factors on the time use decisions of the elderly. Estimation results are presented in Table 4. It must be noted that a negative (positive) coefficient of a variable indicates higher (lower) satiation i.e. lower (higher) amount of time spent in an activity type. All else being equal, it can be seen that elderly tend to invest higher time in OH activities including OH social, OH meal, and shopping activities compared to IH activities such as IH meal, IH social, and leisure.

Person- and Household-level Explanatory Variables
A range of person- and household level explanatory variables including gender, worker status, income, and day of the week were found to influence the time use decisions. Elderly female individuals were found to invest more time in IH social than their male counterparts. It was also found that they tend to spend less time in IH meal, chores, and leisure activities compared to males. It is interesting to note that elderly females tend to participate more in IH social activities (see Table 2) and also engage in such activities for longer duration (see Table 3). On the other hand,

even though they participate more than elderly males, the amount of time spent in chores is less than males.

Elderly workers were found to engage less in chores compared to non-workers which is reasonable considering the additional constraints experienced by workers due to their work activity schedule. In terms of family income, it was found that with increasing income elderly individuals spend lesser time on OH social activities. Elderly individuals with income more than $50,000 were found to spend less time on chores. Individuals with family income in between $25,000 and $50,000 were found to spend more time on leisure activities. Consistent with expectation, it was observed that elderly individuals spend more time in OH (meal, social and shopping) and leisurely activities during the weekend than on weekdays.

Physical and Subjective Well-being Explanatory Variables
Subjective well-being measures (measured via satisfaction with life and different domains of it such as health, job and finance) were found to be correlated with the time allocation decisions of elderly. It was observed that elderly individuals who were highly satisfied with their life spend less time on OH meal and more time on study and volunteer activities. It was also found that elderly who were satisfied with their health tend to spend less time on at home activities including IH meal, IH social, and chores. Elderly with higher levels of cognitive satisfaction (related to concentration, memory and decision making) tend to spend more time on study and volunteer. Elderly who were financially satisfied were found to spend more time on OH social, and shopping. Finally, it was observed that elderly who are satisfied with their job tend to spend less time on IH social activities.

In the next section a summary of the findings is presented along with some concluding thoughts about the policy implications of the research presented in this paper.

CONCLUSIONS
The study of activity engagement choices of elderly Americans is of interest because of the unprecedented growth in the elderly population that is anticipated due to aging baby-boomers and increased life expectancy among others. While there is a rich body of literature related to elderly mobility, most studies to date have mainly focused on the mobility outcomes of this population segment. Much less attention has been paid to the generator of travel namely activity engagement choices (including activity participation in various in-home versus out-of-home activities and time allocation). The studies that have considered the activity engagement choices have done so in a disjointed manner by considering one activity at a time without accounting for the potential tradeoffs that exist across various activity types. The studies have also not accounted for the time constraints within which activity engagement choices are made. *The objective of the current study is to explore the heterogeneity in in-home and out-of-home activity participation and time allocation decisions of the elderly population with explicit consideration of the temporal constraints experienced by elderly individuals.* In addition to explicit consideration of the temporal constraints, *the study also explored other types of individual-specific constraints (such as physical constraint, economic constraint, personal energy constraint, and physical and cognitive constraints) for explaining heterogeneity in time allocation behavior of the elderly. An additional novelty of the current research endeavor was in exploring the association between subjective well-being (derived from perceived need satisfaction of the elderly) and the time use choices of the elderly.* Borrowing from the studies conducted in the field of sociology and psychology regarding human motivation for time allocation (Maslow 1943, and Tonn 1984), the current study postulates

that the heterogeneity in the activity engagement behavior of the elderly can be further captured via the difference in the level of perceived need satisfaction of the elderly. To this end, a panel version of the (MDCEV) model was estimated using data from the Disabilities and Use of Time (DUST) survey of Panel Study of Income Dynamics (PSID) to simultaneously study the participation and time allocation behavior while accounting for the temporal constraints. Unlike previous research on elderly mobility, the use of the MDCEV model formulation allows to study the tradeoffs across activity types by considering the various activity types simultaneously. The current study presents a more holistic picture of the daily activity engagement choices of elderly. The findings from the study provide interesting insights with implications for policy aimed at addressing the elderly activity and travel needs.

The analysis results indicate that elderly Americans are in general active. It was also found that elderly with physical and cognitive constraints are relatively less mobile (as indicated by lower participation into out-of-home activities) due to their physical limitations. While less mobile, elderly with special needs (except for those who depend on others for assistance) were found to compensate for the limited OH activity engagement with more IH activity participation. This might be a trade-off that these older populations with disabilities are forced to make, due to the lack of arrangements for pursuing out-of-home activities Affordable transportation options may address the mobility needs of people with disabilities. It can be noted that, American Disabilities Act (ADA) requires public transport operators to provide demand-responsive services to people with serious disabilities. However, the high cost associated with these services as well as the stringent definition of disabilities used by this act limit their use and ability to serve those in most need of these services. Elderly people with non-life threatening disabilities are most often precluded from availing these services on a day-to-day basis (Rosenbloom 2009). Additionally, limitations exist on the coverage of these services in terms of spatial extents and hours of operation.

The study highlights the importance of considering different types of individual-specific constraints for capturing the heterogeneity in the time allocation behavior of the elderly. One of the constraints that emerged to have significant influence on the time allocation behavior of the elderly are vehicular constraint which might be related to the physical constraint for time use behavior identified by (Hagerstrand 1973). According to the empirical results, older people who do not have vehicular constraints perform more out-of-home activities compared to others. This points to the dependency of the older people on personal vehicles for performing out-of-home activities. It is important to acknowledge that this dependency on automobile for performing out-of-home activities may adversely impact the elderly cohort at a later stage of life when their driving abilities have deteriorated or they can no longer afford driving. Demand responsive paratransit services and customized services from transportation network companies (e.g. Uber) might be an appealing substitute to private vehicle for these group of elderly individuals due to the better flexibility afforded by these services compared to fixed route and schedule based public transportation services.

Another interesting observation was noted related to the living arrangement of the elderly individual. It was found that, people living in an elderly home appear to participate less in in-home activities such as in-home social and chores. It also appears like the additional time afforded is utilized by higher participation in out-of-home meal and out-of-home social activities. An increase in the population proportions of the elderly living in elderly homes could create additional demands on the transportation infrastructure compared to increase in the population proportions of the elderly living in their own homes. Community based shared ride services might address the mobility needs of the elderly living in elderly communities. However, before employing policies

based on this finding, it is also important to study the differences in perceived quality of life between these two living arrangements so that appropriate policies that not only meet the mobility objectives but also social well-being objectives can be implemented.

It was found that elderly who are actively working seek more OH opportunities to socialize compared to those who are not currently working. Additionally, a significant positive correlation was observed between job satisfaction of workers and the participation in OH opportunities (such as OH meal, OH social, shopping, and study and volunteer). Further research is needed to identify whether the elderly individual after retirement suffer from mobility losses due to shrinking social networks and lesser disposable incomes.

In terms of household composition, it was interesting to note that activity participation decision of the elderly varies considerably depending on household composition. Elderly who live with other family/non-family members in addition to their spouses were found to engage more in in-home activities such as IH social and leisure; as well as out-of-home activities such as shopping. It indicates a two-fold impact of the presence of other household adults in the activity participation decisions of the elderly individual. Presence of household adults not only enable the elderly people to pursue additional out-of-of home activities but also provide additional opportunities of recreation at home through IH social activities. Furthermore, the significant higher participation into shopping, chores, and out-of-of social activities in the presence of other family members and kids lend evidence in support of the notion that this group of elderly cohort namely the baby boomer generation are the sandwich generation i.e. they not only take care of their parents but they also take care of their kids/grand kids. A comparative study of such influences for other generational cohorts will allow one to confirm the findings of the baby boomers being a sandwich generation.

In terms of physical and cognitive constraints, it was noted that, individual reporting cognitive difficulties participate less into OH social activities and more into chores. Less participation in OH social activities for the people with these constraints might indicate less opportunities for socialization for this group of people.

The empirical study also finds considerable heterogeneity in the participation and time allocation behavior based on the level of satisfaction with life (relates to the "self-actualization needs" according to Maslow 1943 or "to-be need" according to Allardt 1993), job and financial satisfaction (relates to the "to-have" need identified by Allardt 1993) and health satisfaction (relates to the basic need identified by Maslow 1943). In terms of "self- actualization" or "to-be" need, it was observed that, people reporting high level of satisfaction participate less into shopping and OH social activities. The observation of less participation for shopping might be attributed to the "gratification shoppers" as identified by Arnolds and Reynolds (2003). In their study of hedonic motivation for shopping, the authors identified "stress relief" as one of the motivations for participating in shopping activities (the authors identify this group of people as "gratification shoppers") – people reporting higher satisfaction with life might not be inclined to pursue shopping as a means to stress relief, which is reflected by their lower participation in the shopping activity in the current empirical study. It was also interesting to note that people reporting high level of satisfaction with job (related "to-have" needs) participate more into different types of "active" leisure types of activities such as OH meal, OH social and shopping. Higher satisfaction with finance (another indicator of "to-have" need satisfaction) was also found to be associated with higher time allocation into "active" leisure activities such as OH social and shopping. It can be noted that, satisfaction with marriage (relates to the "to love" need) was not found to be

significantly associated with the time allocation behavior of the elderly. It might be due to the marginal variability in the marriage satisfaction in the data among this age group.

Additional research is needed to understand the causal relationships between activity engagement choices and well-being of the elderly individual. Since these two dimensions may actually be evolving with time by constantly influencing each other. The study of the evolution of these dimensions using an appropriate longitudinal dataset constitutes an interesting future research endeavor. Also, it can be noted that, in the current research, different measures of subjective well-being were used directly in the model without accounting for the possibility that the different measures are indicators of some underlying latent construct of well-being. Statistical rigor of the presented exploration can be improved by considering well-being as a latent construct measured via indicators using integrated choice and latent variable model formulation (Ben-Akiva et al. 2002, Enam et al. 2016). Lastly, elderly individuals were generally found to be active, however, research conducting comparison of the participation and time allocation decisions across generations of the elderly population is needed to better inform the planners and policymakers regarding temporal stability in trends of elderly mobility.

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Table 1 Activity Description, Participation Rate and Mean Duration

Activity Category	Location	Description	Participation (%)		Mean Duration[c] (Min.)	
			Weekday[a]	Weekend[b]	Weekday	Weekend
In-home (IH) Meal	In-home	Having meal/snack/drinks at home	638 (88%)	632 (87%)	59.00	62.00
In-home (IH) Social	In-home	Socializing, caring for others, time for family, religious and spiritual activities and organizational activities conducted at in-home location	460 (64%)	443 (61%)	90.00	93.00
Chores	In-home	Food and drink preparation, laundry, clothing preparation, financial management related to household and household planning	653 (90%)	636 (87%)	172.00	159.00
Leisure	In-home	Watching television, movies, activities related to arts and entertainment such as attending to hobbies, reading, listening to music, playing video games, attending and watching sports, doing physical activities, traveling for recreating, smoking, having alcohol and so on	710 (98%)	708 (97%)	353.00	392.00
Out-of-home (OH) Meal	Out-of-home	Having meal/snack/drinks outside home	220 (30%)	234 (32%)	88.00	99.00
Out-of-Home (OH) Social	Out-of-home	Same activity types as In-home Social but conducted at out-of-home location	268 (37%)	350 (48%)	121.00	185.00
Shopping	Out-of-home	Shopping for grocery, foods as well as other durable and non-durable goods	337 (47%)	317 (44%)	89.00	106.00
Study and Volunteer	Both In-home and Out-of-home	Studying and volunteering	58 (8%)	37 (5%)	193.00	233.00

Notes:
[a] Weekday percentages are calculated across 724 individuals
[b] Weekend percentages are calculated across 728 individuals
[c] Mean taken only across the individuals who have reported to participate in at least one episode of the activity

Table 2 Model Estimation Results for the Baseline Utility: Demographic Explanatory Variables

	IH Social	Chores	Leisure	OH Meal	OH Social	Shopping	Study and Volunteer
Constants	-1.0244*	0.1160	1.8577*	-3.5445*	-2.4229*	-1.8416*	-5.6361*
	(-5.4)	(0.3)	(6.9)	(-13.9)	(-9.2)	(-3.5)	(-7.8)
Personal-level Demographics							
Female indicator	0.4659*	0.8431*			0.1116		-0.4743*
	(4.6)	(6.3)			(1.1)		(-2.1)
Age <= 65 indicator		0.3316*			0.4781*	0.4608*	0.9345*
		(2.3)			(2.6)	(2.6)	(2.2)
Age > 65 and <= 80 indicator		0.2565*			0.3911*	0.3453*	0.5556
		(1.9)			(2.2)	(2.0)	(1.3)
Education more than high school indicator							0.4191
							(1.8)
Worker indicator					0.1210	-0.5282	
					(1.0)	(-1.5)	
Living in elderly home indicator	-0.1981	-0.4763*	0.2116	0.3845	0.2383		
	(-1.1)	(-2.8)	(1.3)	(1.8)	(1.2)		
Race is Black or African American indicator	0.3756*		0.3500*	-0.9030*	0.3618*	0.3471*	
	(2.6)		(2.8)	(-3.3)	(2.2)	(2.2)	
Race is Asian indicator			-0.3956	-1.0219	-0.6749	-0.4414	
			(-1.2)	(-1.9)	(-1.4)	(-1.1)	
Household-level Demographics							
Family income > $25K and <=$50K indicator			-0.8356*	0.2851			
			(-4.0)	(1.2)			
Family income > $50K and <=$100K indicator				0.6336*			
				(2.8)			
Family income > $100K indicator				0.6478*			
				(2.7)			
Number of adults > 2 indicator	0.3947*		0.2442*			0.2472*	
	(3.5)		(2.4)			(2.0)	
Number of children		0.2567*	0.1661		0.2151		
		(2.1)	(1.4)		(1.4)		
Number of vehicle >= 2 indicator				0.6742*	0.2944*	0.2140	
				(4.3)	(2.4)	(1.8)	
Weekend indicator		-0.0961	-0.2890		0.3783*		
		(-1.4)	(-1.4)		(4.0)		

Note:
Values in the row next to a variable name represent the coefficient estimates and values in parentheses represent the corresponding t-statistics
* Indicates significant at 95 percent level of confidence

Table 3 Model Estimation Results for the Baseline Utility: Physical and Subjective Well-being Explanatory Variables

	IH Social	Chores	Leisure	OH Meal	OH Social	Shopping	Study and Volunteer
Physical Well-Being							
Cognitive issue indicator		0.0779* *(2.4)*			-0.0890* *(-2.3)*		0.2089 *(1.6)*
Walking issue indicator			0.1688 *(1.9)*				
Need assistance for daily errands indicator	-0.3496* *(-2.3)*	-0.5474* *(-3.7)*			-0.2938 *(-1.5)*	-0.4933* *(-2.5)*	
Subjective Well-Being							
Life satisfaction >=3 and <= 5 indicator		-0.8914* *(-2.2)*			-0.2116 *(-1.8)*	-0.5937 *(-1.2)*	
Life satisfaction >=6 indicator		-1.0149* *(-2.6)*				-0.5980 *(-1.2)*	
Health satisfaction >=3 and <= 5 indicator			-0.6473* *(-3.3)*				
Health satisfaction >=6 indicator			-0.7344* *(-3.7)*				
Financial satisfaction >=3 and <= 5 indicator	-0.5017* *(-2.7)*						
Financial satisfaction >=6 indicator	-0.4435* *(-2.5)*						
Job satisfaction >=3 and <= 5 indicator		0.3750* *(2.4)*		0.5833* *(3.4)*	0.3970* *(2.4)*	0.8918* *(2.6)*	0.4492 *(1.5)*
Job satisfaction >=6 indicator		0.2678* *(2.0)*		0.6187* *(4.8)*		0.8452* *(2.3)*	

Note:

Values in the row next to a variable name represent the coefficient estimates and values in parentheses represent the corresponding t-statistics

* Indicates significant at 95 percent level of confidence

Table 4 Model Estimation Result for the Satiation (Translation) Parameter

Variable Description	IH Meal	IH Social	Chores	Leisure	OH Meal	OH Social	Shopping	Study and Volunteer
Constants	3.043*	3.4824*	3.7952*	3.0799*	4.2307*	4.4636*	3.6842*	2.8641*
	(13.1)	*(29.0)*	*(14.3)*	*(15.4)*	*(21.6)*	*(17.0)*	*(30.4)*	*(2.8)*
Person-level Demographics								
Female indicator	-0.1974*	0.1736	-0.5218*	-0.3214*				
	(-2.1)	*(1.4)*	*(-3.6)*	*(-3.5)*				
Worker indicator			-0.3678*					
			(-2.6)					
Household-level Demographics								
Family income > $25K and <=$50K indicator				0.8793*		-0.3961		
				(3.8)		*(-1.4)*		
Family income > $50K and <=$100K indicator		-0.1475	-0.1477			-0.4625		
		(-1.3)	*(-1.4)*			*(-1.8)*		
Family income > $100K			-0.1790			-0.7648*		
			(-1.4)			*(-2.8)*		
Weekend indicator				0.463*	0.1599	0.6138*	0.2026	
				(2.1)	*(1.1)*	*(4.2)*	*(1.6)*	
Physical and Subjective Well-being Variables								
Life satisfaction >=6 indicator					-0.2264			0.6377
					(-1.2)			*(1.3)*
Health satisfaction >= 3 and <= 5 indicator	-0.5559*		-0.2680					
	(-2.4)		*(-1.0)*					
Health satisfaction >= 6 indicator	-0.6582*	-0.2417*	-0.2969					
	(-2.8)	*(-2.2)*	*(-1.1)*					
Memory satisfaction >= 3 and <= 5 indicator								2.2622*
								(2.0)
Memory satisfaction >= 6 indicator								1.6301
								(1.5)
Financial satisfaction >=6 indicator						0.2338	0.2152	
						(1.6)	*(1.6)*	
Job satisfaction >= 3 and <= 5 indicator		-0.1794						
		(-1.0)						

Note:
Values in the row next to a variable name represent the coefficient estimates and values in parentheses represent the corresponding t-statistics
* Indicates significant at 95 percent level of confidence