# Generational Travel Patterns in the United States: New Insights from Eight National Travel Surveys

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16. Abstract
Millennials' automobility preferences and choices have attracted widespread attention from academia, policy makers, and business industries. Existing studies, however, have reported mixed findings on whether Millennials differ from their predecessor generations, leading to contradictory conclusions drawn for transportation planning and policy recommendations. This study utilized eight U.S. national travel surveys to construct a panel data that covers a continuous range of ages for persons five years and older for Baby Boomers, Generation X, and Millennials. The study's findings on the direction and size of VMT influences associated with the five planning or policy variables did not support the speculation that Millennials would match or surpass Baby Boomers and Generation X in their future daily VMT trajectory. Public policies should be designed to nurture the shifting trend of reduced automobility from the older to the younger generations.

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# Table of Contents

# Executive Summary

Millennials have become the largest population group in the United States. They have claimed to differ much from their predecessor generations in lifestyle preference and consumption choices. If this is the case, understanding the mobility preference and travel behavior of Millennials relative to other generations is critical to transportation planning and policy enactment. This project conducted a thorough review of works on understanding generational travel characteristics and travel preferences. In order to overcome the data limitations, this project constructed a panel dataset by integrating eight national travel surveys. The daily VMT trends of Baby Boomers, Generation X, and Millennials were investigated. Specific findings and conclusions were drawn to help provide insights for transportation planning and policymaking.

Key findings of this research include:

(1) During adulthood, Millennials have kept their daily VMT consistently lower than that of Generation X by about 8%, whereas the younger group of Baby Boomers outdrove the older Millennials at age 28 and after by about 9% daily.

(2) When each generation is considered over its life course, peak-level daily VMT tends to occur at earlier ages for each successive generation.

(3) From the multi-level modeling of daily VMT, the study identified generation-related group effects and estimated VMT elasticities with respect to person age, driving licensure, vehicle ownership, household size, and gasoline price-adjusted income.

(4) The study's findings on the direction and size of VMT influences associated with the five planning or policy variables did not support the speculation that Millennials would match or surpass Baby Boomers and Generation X in their future daily VMT trajectory. The study shows that Millennials may follow the general automobility path as the older generations did when the socioeconomic and policy environments change, but likely at a reduced pace. Public policies should be designed to nurture the shifting trend of reduced automobility from the older to the younger generations.

# Chapter 1. Introduction

Whether Millennials (also called Generation Y, referring to those born in the last two decades of the 20th century) differ from their predecessor generations in lifestyle preferences and choices has attracted widespread attention, initially from news media and increasingly from academia and industries as well as policy makers. Millennials have become the largest population group in the United States (Myers, 2016). Their consumption choices and activity participation (virtual and in-person) have profound implications for both public services and private businesses. Frequently-cited anecdotes suggest that Millennials, compared with earlier generations, prefer living in urban areas; choose lower automobility (less likely to become licensed drivers, owning fewer cars, and driving less); and delay lifestyle decisions (employment, homebuying, marriage, and parenting) (Fry et al., 2018; The Council of Economic Advisers, 2014). If this is indeed the case, housing real estate, business practices, transit investments, as well as transportation and land use planning should adjust accordingly to accommodate the demographic trend (Logan, 2014; Moos et al., 2017). Understanding the mobility preferences and travel behavior of Millennials relative to other generations (hereafter referred as generational cohort effects) is essential to transportation planners and policy makers for forecasting future travel demand and for formulating mobility plans and policies.

The Age-period-cohort framework has been widely used across epidemiology and the social sciences to study the effects of the time-varying elements on the outcome of interest (Bell 2020; Yang and Land, 2013). Analyzing generational cohort effects on travel should consider age effects and period effects. Cohort effects refer to the variations across groups of individuals who share a defining characteristic, for instance, born in the same year or years. Age effects are the changes in people's preferences, needs, and values associated with chronological ages. Period effects are variations across time periods that affect all age cohorts simultaneously. At any given point of time, people from different generations have different ages. To make Millennials comparable with other generations for analyses, one may utilize data from different time points and pair up Millennials with other generations in the same age cohorts. Performing age cohort comparisons, however, should also consider period effects . Different generations of the same age cohorts live in different times. Macro factors and conditions relating to economies, technologies, and natural and political environments differ between different time periods while they affect people of all ages in any given time point. Furthermore, there also exists intra-generation variations (Ralph, 2017). The interplay of the cohort, age, and period effects makes it a challenging task to study generational mobility preferences and behavioral decisions. Existing studies on the generational cohort effects on travel have so far reported mixed findings, mainly due to their varying levels of accounting for the age, cohort, and period effects as well as the effects of other confounding factors (e.g., McDonald, 2015; Garikapati et al., 2016; O'Brien, 2017; da Silva et al., 2019; Wang, 2019; Knittel and Murphy, 2019; Wang and Akar, 2020). These mixed findings led to different or even contradictory conclusions drawn for transportation planning and policy recommendations.

Much remains to be learned on the similarities and differences between the generational cohorts concerning their travel preferences and choices. Accounting fully for the age, cohort, and period effects as well as other confounding factors' effects would need longitudinal data. With longitudinal information on individuals' travel preferences and behavioral outcome over the life course, the researcher could make generational comparisons over a continuous spectrum of ages while controlling for the influence of age effects and other factors. Nevertheless, the kind of longitudinal data is not readily available.

This study aims to contribute to improving understanding of cross-generation travel characteristics by constructing a synthetic longitudinal dataset using eight national travel surveys in the United States. With this unique dataset, the study examined the trending patterns of daily VMT associated with Baby Boomers, Generation X, and Millennials. A multi-level modeling approach was taken to identify generation-related group effects on daily VMT in addition to the effects of individual or household socioeconomic factors and geospatial context. Furthermore, the study estimated VMT elasticities with respect to five important planning/policy variables, including person age, driving licensure, vehicle ownership, household size, and gasoline price-adjusted income. Findings of the study offer new insights into the similarities and differences in automobility between- and within-generations that are informative to policy discussions and market responses.

# Chapter 2. Literature Review

Recent research on generational travel has centered mostly at the level and trend of automobility between Millennials, Generation X, and Baby Boomers. Automobility in different studies may refer to an individual's driving capacities such as vehicle ownership and driving licensure. It may also refer to travel outcomes involving automobiles, for example, driving distance on average per trip or in total measured by daily or annual vehicle miles of travel (VMT). Automobile trip rates and the driving share of modal split are also commonly used indicators of personal or aggregate automobility. These studies explored answers to one or more of the following three questions. 1) Do Millennials differ from members of Generation X (Gen Xers) and Baby Boomers in automobility? If so, in what magnitude? 2) What factors explain generational differences in automobility, personal lifestyle shifts, changes in attitudes and preferences across generations, and/or the societal and economic conditions of the time when different generations grew up and lived? 3) How will Millennials, who are just entering young adulthood, travel in the future compared with Baby Boomers and Gen Xers? While answering the third question is of essential policy and business interest, forecasting travel demand specifically for Millennials involves a great deal of uncertainty and thus is largely avoided by researchers. Existing studies have focused primarily on the first two questions while drawing cautious inferences to Millennials' future automobility from their empirical findings.

To compare automobility between Millennials and other generations, data from different times are necessary. The U.S. national travel surveys provide relatively consistent observations of personal travel in the United States over a timespan of nearly five decades. Since 1969, the U.S. Federal Highway Administration (FHWA) conducted eight national travel surveys. The first five of the surveys, under the title of Nationwide Personal Transportation Survey (NPTS), were carried out in 1969, 1977, 1983, 1990, and 1995, respectively (U.S. Department of Transportation, Federal Highway Administration, 1969-1995). The most recent three surveys, taken in 2001, 2009, and 2017, changed the title to National Household Travel Survey (NHTS) (U.S. Department of Transportation, Federal Highway Administration, 2001-2017). Researchers can extract data from different years of NPTS/NHTS for comparable age cohorts from different generations.

Many studies have utilized the NPTS/NHTS data to explore generational travel characteristics. These studies mostly focused on the individuals in specific ranges of ages (for instance, 19-42 years old) and extracted data samples from 3~5 of the eight waves of NPTS/NHTS. Some have shown that Millennials deviated from Baby Boomers (born 1946-64) and Generation X (born 1965-80) with lower levels of driving licensure, car ownership, auto trip rates, and vehicle miles traveled (VMT) (McDonald, 2015; Wang and Akar, 2020; Wang, 2019). Others, however, argued that Millennials did not differ from the earlier generations; they just delayed their life stage decisions and would catch up in automobility in the future as they age (da Silva et al., 2019). The study by Knittel and Murphy (2019) reported findings contradictory to those of most existing studies; they found that Millennials owned more cars and generated more VMT than their comparable age cohorts once confounding factors were taken into consideration. Still others observed that the reported differences between Millennials and the older generations resulted not from preference or attitude shifts, but from macroeconomic events such as the Great Recession from 2007 to 2009 (Klein and Smart, 2017; Kurz et al., 2019).

Researchers have also tapped into additional data sources to better understand Millennials' travel preferences and behavior compared to other generations. Garikapati et al. (2016) analyzed the longitudinal data from the annual American Time Use Survey series between 2003 and 2013 and found substantial differences in activity-time use patterns between the younger millennials and their older generations. These differences, however, diminished as Millennials aged: the older millennials' activity-time use patterns resembled those of Generation X. From the study findings the authors conclude that Millennials only delayed their life-course milestones (e.g., education, marriage, parenthood) compared to their predecessor generations and would catch up with higher travel demand in the future. Aside from utilizing national travel or time-use surveys, scholars have also developed customized surveys targeting Millennials. One example is a California study where findings shed light on Millennials' travel behavior and the influencing factors that are not covered adequately in the national surveys (Alemi et al., 2019; D. G. Circella et al., 2016; G. Circella et al., 2017). Findings from local studies such as the one from California are informative but may not be generalizable for Millennials in the rest of the United States.

Intergenerational characteristics of travel behavior have also attracted interests from scholars of other countries. Krueger et al. (2019) investigated the use differences in travel modes between German Millennials and Generation X. Results from the study revealed the statistically significant explanatory powers presented in all three sets of effects, i.e., age-, period-, and cohort-effects. Newbold and Scott (2017) utilized time use surveys to analyze the differences in automobility by four Canadian generational cohorts, i.e., Millennials, Generation X, Baby Boomers, and the Greatest Generation. The authors found an increasing rate of holding a driver's license and both a rising number and duration of trips by-car-as-driver for Millennials. The findings led the authors to conclude that Canadian Millennials were 'catching up' with other generations and would likely share the same automobility profiles as Generation X and Baby Boomers in the future.

Intra-generation heterogeneity in travel exists. Most studies examined intra-generation travel heterogeneity by subdividing the generational population into sub-age groups. Ralph (2017) explored the diverse travel patterns of Millennials and identified four traveler types: (1) Drivers, who traveled largely by automobiles only; (2) Long-distance Trekkers; (3) Multimodals, who used a mix of travel modes; (4) and the Car-less, those relying on transit, walking, or biking. Identifying traveler types helps develop tailored policy initiatives to address the growth of automobility while also accommodating future travel demand.

The literature on the comparative characteristics of travel preferences and behavior between generations has been accumulating rapidly. Jamal and Newbold (2020) conducted a thorough review of studies published between 2010 and 2018 on the travel behavior of Millennials and older adults. The review screened nearly 20,000 references from the initial keyword search and selected 78 studies that met the 10 criteria set by the authors for in depth review. Their thorough review led Jamal and Newbold (2020) to conclude that Millennials differed from the older adults in their travel behavior. Furthermore, the factors that influence each generation's travel characteristics differed and varied in the direction and magnitude of influence. Jamal and Newbold's review (2020) reveals the behavioral diversities and temporal variabilities of generations' travel and their associated influencing factors. Further research is needed, as the authors noted.

The majority of these studies made multiple point-to-point comparisons where a point may refer to an age cohort in specific times when the surveys were administered. Many factors may contribute to the inconsistent findings reported by these studies. For example, there exist varying definitions of generations by birth years. Some analyzed the cohorts of Baby Boomers, Generations X and Y altogether in a single study, whereas others only compared two neighboring subgroups such as the younger members of Generation X and the older Millennials. Variations in selecting time or age points (constrained to the survey years) for cohort comparisons also played a role because different generations do not follow the same lifecycle path. For example, similarities or differences between Millennials and Generation Xers observed in the cohort of ages 15 to 20 may not hold for the cohort of ages 30 to 35. Variations in survey design and implementation techniques may also affect the results of studies involving surveys conducted in different years by different agencies. Longitudinal surveys would help address many of the analytical issues mentioned above, but generally they are not available (Jamal and Newbold, 2020). In an effort to overcome the data limitations, we constructed a panel dataset by integrating eight national travel surveys from the United States. The unique dataset enabled us to investigate the daily VMT trends of Millennials along with Baby Boomers and Generation X while controlling for the age-cohort-period effects.

# Chapter 3. Study Method

## 3.1. Data sets

This study combines datasets from all of the eight national transportation surveys conducted by the U.S. federal transportation agencies. Data for all but the earliest two surveys are available from the FHWA website. The Inter-university Consortium for Political and Social Research (ICPSR) at the University of Michigan processed and made available the data and related documentations for NPTS 1969 and 1977. We created a master data file integrating the eight surveys.

Although the eight surveys did not follow exactly the same survey design and implementation methods (Venigalla, 2016), the core set of variables in the NPTS/NHTS maintains a level of consistency high enough to support analysis with the multi-year surveys combined. The 2017 NHTS underestimated VMT due to the use of a geocoding tool to derive the shortest origin-destination distance as compared to the self-reporting method used in prior surveys. The FHWA NHTS team assessed the difference between the derived and self-reported trip lengths being about 10% (FHWA 2018). We followed the NHTS team's suggestion and adjusted up the 2017 VMT by 10%. The eight NPTS/NHTS reported a wide range, from zero to more than 12,000, of daily VMT. We assessed that the very high volume of daily VMT resulted from either reporting errors or non-daily recurring travel. Accordingly, we selected the trip records with daily VMT less than 300 miles for our analysis. This threshold distance represents the 99+ percentile of the total driving distance and has been used by other studies (e.g., Wang and Akar, 2020).

Different agencies and researchers have used slightly different birth years to define generations. We follow the Pew Research Center's convention to draw the year boundaries between the Baby Boomers, Generation X, and Millennials (Dimock, 2019). Furthermore, we divide each generation into two subgroups (see Table 1 for information on the birth years used for subgrouping). The subgroups include the older Baby Boomer (GenBB1), younger Baby Boomer (GenBB2), older Generation X (GenX1), younger Generation X (GenX2), older Generation Y (GenY1), and younger Generation Y (GenY2). This subgrouping allows us to compare generational cohorts in closer age ranges and to analyze within-generation variations.

By the time the last NHTS was conducted in 2017, the oldest Millennials were 36 years old. With the eight NPTS/NHTS datasets from 1969 to 2017, we created a synthetic data file that contains multi-year travel information for Millennials in continuous ages between 5 and 36. For Baby Boomers and Generation X, the synthetic data files spread over an age range of 5 to 71 and 5 to 52, respectively.

Table 1 shows the number of sampled persons in the survey years for each of the six generation subgroups (sample distribution by age from 5 to 71 years old for the six generation cohorts is available upon request). In 1969, when the first NPTS was conducted, the youngest member of Baby Boomers (born 1946-1955) was 14 years old. Therefore, no data was available for Baby Boomers-1 aged 13 or younger. For Millennials-2 (born 1989-1996), no data was available for those aged 29 or older in the 2017 NHTS. Using the panel sample, we derived the mean daily VMT by age, along with the mean values of other socioeconomic variables associated with the "average person" of a given age (Table 2).

*Table 1. Sample Distribution by NPTS/NHTS Year and Generation Subgroups*

| Survey Year | Baby Boomer-1 | Baby Boomer-2 | Gen X1 | Gen X2 | Millennials -1 | Millennials -2 | Total |
|---|---|---|---|---|---|---|---|
| Birth Year | 1946-1955 | 1956-1964 | 1965-1972 | 1973-1980 | 1981-1988 | 1989-1996 | |
| 1969 | 3,723 | 3,395 | 0 | 0 | 0 | 0 | 7,118 |
| 1977 | 5,436 | 4,467 | 1,274 | 0 | 0 | 0 | 11,177 |
| 1983 | 2,062 | 1,875 | 1,563 | 920 | 0 | 0 | 6,420 |
| 1990 | 5,120 | 5,204 | 3,560 | 3,116 | 2,194 | 0 | 19,194 |
| 1995 | 12,562 | 12,343 | 7,864 | 6,424 | 9,555 | 2,487 | 51,235 |
| 2001 | 20,928 | 19,979 | 13,962 | 9,461 | 12,260 | 14,602 | 91,192 |
| 2009 | 48,364 | 39,164 | 24,525 | 15,128 | 9,892 | 20,277 | 157,350 |
| 2017 | 39,530 | 35,062 | 23,062 | 19,145 | 20,582 | 14,425 | 151,806 |
| Total | 137,725 | 121,489 | 75,810 | 54,194 | 54,483 | 51,791 | 495,492 |

*Table 2. Summary Statistics of the Variables for the Sample of Persons Aged 14-36*

| Variable | Definition | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| VMT | Daily vehicle miles traveled | 34.97 | 41.45 | 0 | 300 |
| Age | Years | 25.82 | 6.86 | 14 | 36 |
| Female | 1: female; 0: otherwise | 0.52 | 0.50 | 0 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| Race_White | 1: white; 0: otherwise | 0.79 | 0.40 | 0 | 1 |
| Lic_driver | 1: with driver's license; 0: otherwise | 0.84 | 0.37 | 0 | 1 |
| Employed | 1: employed; 0: otherwise | 0.70 | 0.46 | 0 | 1 |
| Edu_college | 1: with college education; 0: otherwise | 0.21 | 0.41 | 0 | 1 |
| Home_owned | 1: live in owned home; 0: otherwise | 0.58 | 0.49 | 0 | 1 |
| Hh_vehicle | Motorized vehicles in household | 2.30 | 1.18 | 0 | 6 |
| Hh_size | Number of persons in household | 3.36 | 1.20 | 1 | 5 |
| Hh_income | Household income in $1,000s | 57.27 | 40.95 | 0.50 | 225.00 |
| Gasprice | Gasoline price in $ | 1.70 | 0.62 | 0.35 | 2.33 |
| Railurban | 1: with rail transit in the urbanized area of traveler's home; 0: otherwise | 0.13 | 0.34 | 0 | 1 |
| MSA1mup | 1: traveler's home located in the MSA of population one million or more; 0: otherwise | 0.47 | 0.50 | 0 | 1 |
| In_urban | 1: traveler's home located in urbanized area; 0: otherwise | 0.73 | 0.44 | 0 | 1 |
| 1969 | 1: NPTS 1969; 0: otherwise | 0.02 | 0.15 | 0 | 1 |
| 1977 | 1: NPTS 1977; 0: otherwise | 0.06 | 0.23 | 0 | 1 |
| 1983 | 1: NPTS 1983; 0: otherwise | 0.03 | 0.17 | 0 | 1 |
| 1990 | 1: NPTS 1990; 0: otherwise | 0.07 | 0.25 | 0 | 1 |
| 1995 | 1: NPTS 1995; 0: otherwise | 0.14 | 0.35 | 0 | 1 |
| 2001 | 1: NHTS 2001; 0: otherwise | 0.21 | 0.40 | 0 | 1 |
| 2009 | 1: NHTS 2009; 0: otherwise | 0.26 | 0.44 | 0 | 1 |
| 2017 | 1: NHTS 2017; 0: otherwise | 0.21 | 0.41 | 0 | 1 |
| GenBB1 | Baby Boomer-1; born 1946-1955 | 0.06 | 0.24 | 0 | 1 |
| GenBB2 | Baby Boomer-2; born 1956-1964 | 0.13 | 0.33 | 0 | 1 |
| GenX1 | Generation Xers-1; 1965-1972 | 0.16 | 0.37 | 0 | 1 |
| GenX2 | Generation Xers-2; 1973-1980 | 0.20 | 0.40 | 0 | 1 |
| GenY1 | Millennials-1; 1981-1988 | 0.26 | 0.44 | 0 | 1 |
| GenY2 | Millennials-2; 1989-1996 | 0.19 | 0.39 | 0 | 1 |
| n= | 164,104 | | | | |
| Note: The mean value corresponding to a survey year indicates the share of that year's sample in the combined dataset. For instance, the indicator variable '1969' has a mean of 0.02, indicating that the data sample from the 1969 NPTS accounts for 2% of the total observations (164,104 ) in the combined dataset. | | | | | |

## 3.1. Analytical Approaches

The analysis includes three parts. First, we graph the sample means of daily VMT along the age spectrum for each generation and examine visually the differences or similarities exhibited in the daily VMT trends of generation groups. To complement the visual examination of VMT curves, we perform pairwise mean tests of daily VMT between generation groups by age cohorts in five-year intervals. This was the approach taken commonly by the existing studies. Applying this approach allows us to compare and cross check our study results in the context of the existing literature.

The second part of the analysis looks into the subsample containing persons aged 14 to 36. For two reasons, we chose age 14, not age 16 that most existing studies used, as the lower bound of the subsample's age range. First, we considered the legal driving age. Ten of the 50 states in the United States set the legal driving age of 14 or 14.5 years old for obtaining learner's permit (Denise et al., 2019). Second, as reported in detail in the first part of Analysis Results below, the age of 14 was a critical point that the VMT curves turned from downward to upward and then rise rapidly (for Gen X, the turning point appeared earlier at age 12).

The conventional age-cohort-period models suffer from an identification problem because of the perfect identification of the three variables (cohort = period – age). In this study we adapt the conceptual framework underlying age-cohort-period models but take a hierarchical modeling approach to avoid the identification problem (Reither et al. 2015). The modeling framework takes a two-level hierarchical structure. Level-1 measures the fixed effects associated with the variables representing travelers' individual and household socioeconomic characteristics as well as the context of their home locations. Indicator variables for NPTS/NHTS years also go to Level-1 to capture the period effects. Individuals in the sample form groups by generation subgroups that they belong to, including Baby Boomer-1 and -2, Generation X-1 and X-2, and Millennials -1 and -2. The group indicators serve as Level-2 identifies in the model for measuring the random or group effects specific to generation subgroups on VMT. The model specifies two sets of random components. One is a random intercept that captures group-level effects on the mean VMT at the individual level. The other is a set of random slopes that capture the moderating effects of group-level variations on the fixed effects at the individual level. We selected five variables that are of important practice and policy interest for the random slope modeling; they include person age, driving licensure, vehicle ownership, household size, and household income adjusted by gasoline price. This two-level model specification allows us to test (1) if there exist group level effects, or generation-specific effects, on VMT in addition to the effects of individual socioeconomic, geospatial, and macro background; and (2) in which directions that the group effects moderate the influence of the planning and policy variables on VMT outcome.

The two-level model follows the structure as shown below:

Level 1

$$Y_{ij} = \beta_{0j} + \sum \beta_{X_j} X_{ij} + \sum \beta_Z Z_i + \varepsilon_{ij} \quad (1)$$

Level 2

$$\beta_{0j} = \beta_{00} + u_{0j} \quad (2)$$

$$\beta_{X_j} = \beta_{X0} + u_{Xj} \quad (3)$$

where

$Y_{ij}$: the dependent variable taking natural log of daily VMT for person $i$ in generation subgroup $j$

$X_{ij}$: the set of explanatory variables whose effects on the dependent variable vary across generation subgroups. For a continuous variable, X takes the natural log transformation of the original value

$Z_i$: the set of explanatory variables having the fixed effects only

$\beta_{0j}$: random intercepts varying across generation subgroups

$\beta_{X_j}$: random slopes varying across generation subgroups

$\beta_Z$: fixed slopes for the set of variables $Z$.

In the third part of the analysis, we examine the direction and size of the group effects associated with generational subgroups on individual VMT outcome. We use the modeling output from the previous step to estimate the varying marginal effects of the five policy variables on VMT across generations. For continuous variables, the marginal effects denote generation-specific VMT elasticities with respect to the selected planning or policy variables.

# Chapter 4. Results and Discussions

## 4.1. Trending patterns of daily VMT by generation subgroups

Figure 1 illustrates the series of daily VMT by three generations. The graph on the top panel displays all data points for the age years where sample observations are available from eight NPTS/NHTS. Baby Boomers, Generation X, and Millennials, each have a varying length of data series in the age range of 5 to 71, 5 to 52, and 5 to 36, respectively.

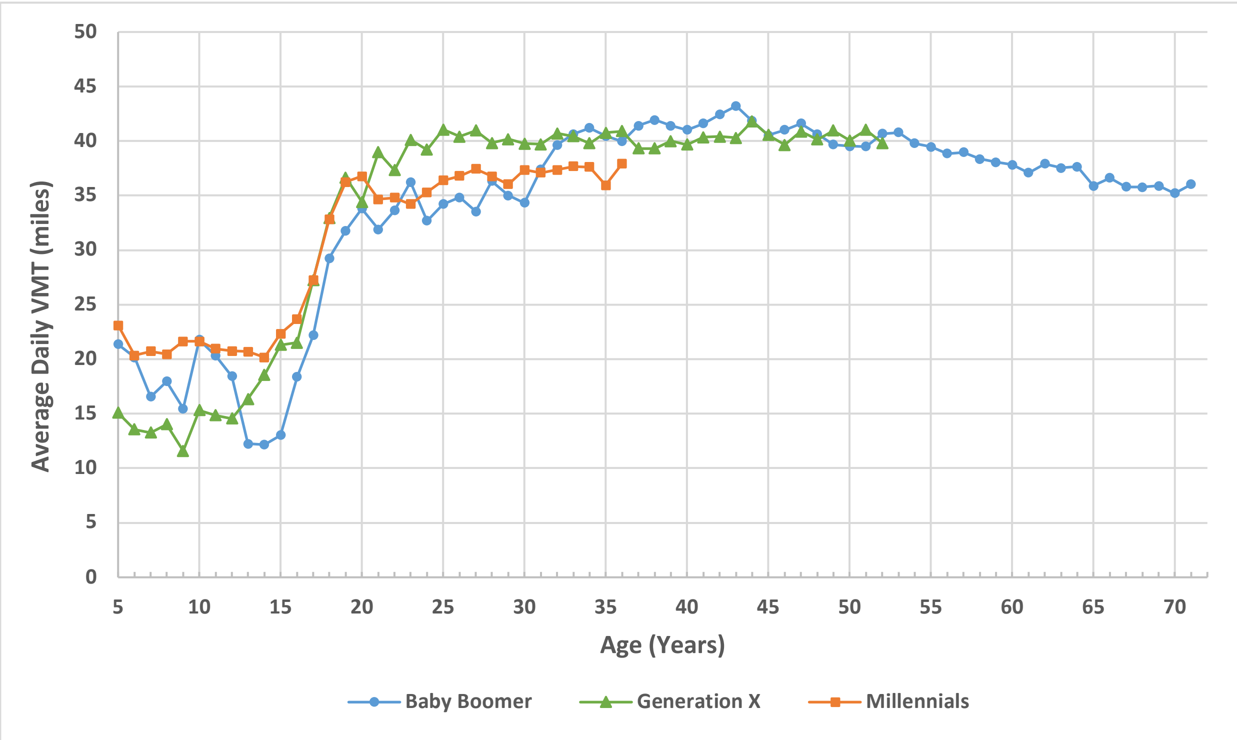


*Figure 1. Average Daily VMT by Baby Boomers (ages 5-71), Generation X (ages 5-52), and Millennials (ages 5-36)*

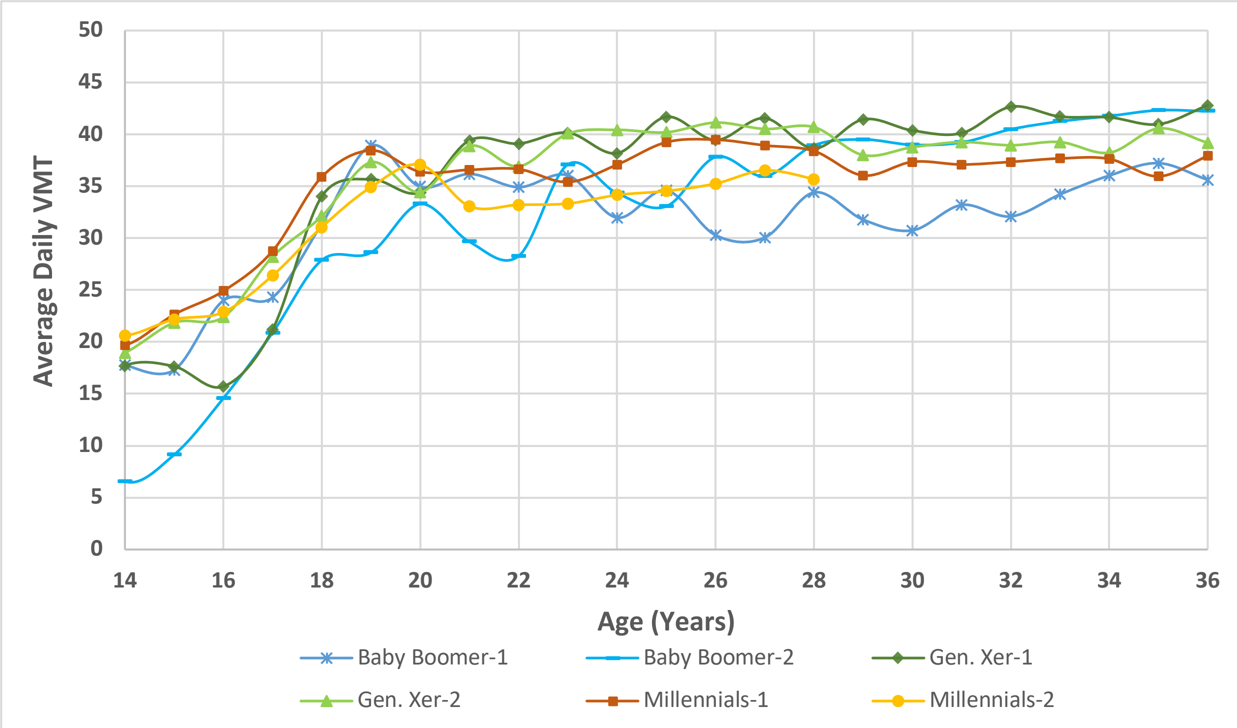


*Figure 2. Average Daily VMT by Generational Subgroups (ages 14-36)*

The three data series for Baby Boomers, Generation X, and Millennials share a number of similarities in their overall trending patterns showing in three stages by age, childhood (0-13), teenage (14-19), and adulthood (20+). Adulthood can be further divided into young adulthood (20-39), middle age (40-59), and late adulthood (60+). During childhood aged 13 or younger, individuals from all three generations exhibited relatively low daily VMT, below 24, as shown in Figure 2. People in childhood unlikely generate high VMT because they lack independent automobility and tend to have fewer out-of-home activities relative to adults. Their VMT occur mostly as passengers of adults' driving. Figure 2 shows Millennials having consistently higher VMT during their childhood than their peers from two older generations, whereas the VMT by Baby Boomers and Gen Xers in childhood fluctuated significantly. What factors account for the differences in childhood VMT between generations—socioeconomic conditions, or possibly data discrepancies among NPTS/NHTS, or maybe both? We leave the question for future studies while focusing on VMT by people in their teenage years and older.

During the teenage stage, people's average daily VMT rose dramatically and it happened to all three generations. This is the stage when most people learn how to drive, engage increasingly in school and extracurricular activities, and transition to college life or work participation. The three generations' VMT trends followed in general a rising path after entering the early stage of young adulthood but at a much slower growth rate than in their teenage time.

Despite the 3-stage pattern shared by Baby Boomers, Gen Xers, and Millennials, the three generations exhibited different VMT footprints in each of the stages. The following observations describe these footprints. It should be noted that these observations refer to specific age points (e.g., 19, 23, 32, …) for the purpose of describing the movement of VMT curves shown in Figure 2. The specific ages referred may not be interpreted literally as the exact points to expect changes in VMT by the individuals in respective generations; VMT values corresponding to the age points are statistical averages of the sample, and therefore are subject to sampling variations and errors. Teenage Millennials and Gen Xers had nearly identical VMT paths; both maintained higher levels of VMT than teenage Baby Boomers. After age 19, Baby Boomers' VMT continued to go up, with fluctuations, as they became older. Their daily VMT reached the highest level of 43.2 VMT at age 43 and then declined gradually through the older adulthood stage. For Gen Xers aged 19 or older, their VMT accelerated (also with fluctuations) faster than Baby Boomers and reached the high point of 41.04 VMT at age 25. After age 25, Gen Xers VMT plateaued, fluctuating slightly around 40 miles per day all the way through age 52. Millennials' VMT rose a bit from age 19 to 20 (with 36.77 VMT), followed by a three-years decline, and then picked up gradually until age 27. Since then Millennials' VMT curve stayed fairly flat, feathering with two low points at ages 29 and 35 (having daily VMT of 36.03 and 35.95, respectively) and one high point at 37.9 VMT in 2017 when the latest data was available.

The relative differences in daily VMT between the three generations varied depending on the age range in which the data points are selected and compared. Teenagers and young adults aged 20 to 30 from the Millennials generation appeared to drive more VMT than their counterparts of the Baby Boomer generation except for the age of 23. In age 31 and after, Baby Boomers' VMT surpassed Millennials' and continued to grow in the subsequent 12 years. Gen Xers made the highest amount of VMT among the three generations between age 21 to 32. After turning 33, Gen Xers still drove more than Millennials did; but they maintained about the same level of VMT as

Baby Boomers except for the period of age 32 to 44 when Baby Boomers recorded the highest VMT in their life course.

Figure 2 provides a close look at six daily VMT curves corresponding to six generation subgroups at ages 14 to 36 (the curve ends at age 28 for the younger Millennials due to data limitations). We divide each generation from approximately the middle point of its age range into two subgroups. Two features are evident concerning within-generation VMT variations and VMT peaking. Both Generation X and Millennials show relatively coherent VMT trends as the two curves of each generation's subgroups run side by side rather closely. For Baby Boomers, its two subgroups' VMT trends split. The older Baby Boomers maintained their VMT level higher than that of the younger Baby Boomers before age 23. Between age 23 and 25, the two curves mingle. After age 26, the younger Baby Boomers retained a consistently higher level of daily VMT than the older Baby Boomers.

Figure 2 also indicates a tendency of peak VMT points shifting from late ages for the older generation subgroups to early ages for the younger generation subgroups. For instance, Baby Boomers-1 and -2 reached the highest daily VMT of 43.75 and 43.11 at age 43 and 44, respectively (data points falling outside Figure 2, but exhibited in Figure 1). Gen X1 had their VMT peak of 42.80 at age 36. Gen X2 showed two peak points with the same VMT around 41.33 at ages 44 and 26. For Millennials, the two peak VMT points of 39.48 and 37.07 occurred at age 26 and 20 for the older and younger members, respectively. These observations are limited to the available data. It is possible that Millennials will reach new VMT peaks in the future. Whether the shifting of VMT peaking to earlier ages for younger generations underlines a generalizable trend warrants further research when combining data for additional generations such as the Silent Generation, the Greatest Generation, and Generation Z (Gen Z).

## 4.2. Pairwise mean tests of daily VMT between generation subgroups

Table 3, below, tabulates average daily VMT by four age cohorts for six generational subgroups.

*Table 3. Average Daily VMT by Generation Subgroups and Age Cohorts*

| Generation / Birth Year | | Age 14-19 | Age 20-24 | Age 25-29 | Age 30-36 |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **Baby Boomer-1 (BB1) / 1946-1955** | Mean | 26.42 | 35.65 | 32.12 | 33.42 |
| | *St. Dev.* | 39.17 | 42.53 | 38.77 | 37.03 |
| | n | 1862 | 2574 | 2929 | 3106 |
| **Baby Boomer-2 (BB2) / 1956-1964** | Mean | 19.01 | 31.84 | 37.40 | 40.88 |
| | *St. Dev.* | 29.84 | 37.37 | 42.35 | 43.17 |
| | n | 3690 | 2577 | 3101 | 11746 |
| **Generation X-1 (Gen X1) / 1965-1972** | Mean | 27.36 | 38.67 | 40.82 | 41.38 |
| | *St. Dev.* | 39.09 | 42.60 | 44.83 | 44.67 |
| | n | 1842 | 3779 | 6858 | 13909 |
| **Generation X-2 (Gen X2) / 1973-1980** | Mean | 26.20 | 38.38 | 40.08 | 39.20 |
| | *St. Dev.* | 35.66 | 43.53 | 43.55 | 41.94 |
| | n | 5971 | 6250 | 6490 | 13766 |
| **Millennials-1 (Gen Y1) / 1981-1988** | Mean | 26.25 | 36.42 | 38.10 | 37.28 |
| | *St. Dev.* | 37.13 | 40.63 | 42.09 | 42.25 |
| | n | 10416 | 5787 | 7354 | 18403 |
| **Millennials-2 (Gen Y2) / 1989-1996** | Mean | 25.28 | 34.13 | 35.53 | NA |
| | *St. Dev.* | 36.40 | 41.65 | 41.79 | NA |
| | n | 15900 | 7525 | 8269 | NA |
| **Total** | Mean | 25.24 | 36.06 | 37.83 | 39.15 |
| | *St. Dev.* | 36.25 | 41.76 | 42.68 | 42.73 |
| | n | 39681 | 28492 | 35001 | 60930 |

Table 4, below, shows results of pairwise mean tests on the average daily VMT between generational subgroups. To minimize the influence of age effects, we stratify the sample into age cohorts where cohort age ranges follow closely the five-year interval. The numbers entered in the cells under generation headers show the difference of the means between two subgroups in their daily average VMT. A negative number indicates the amount of daily VMT generated by the row-specific generation subgroup falling below that for the column-specific generation subgroup. For example, the cell of row BB-2 and column BB-1 contains the number of -7.41 for the cohort of Age 14-19, which means that, on average, the younger members of Baby Boomers (BB-2) traveled 7.41 less VMT than the older members of Baby Boomers (BB-1) when they aged 14-19. For the same pair of subgroups, the difference in mean VMT reduced to 3.81 miles when they became older in the age of 20-24. The p-value under each VMT data cell indicates whether the observed difference in means between the two subgroups is statistically significant or can be attributed to sampling error and thus neglected.

The pairwise mean VMT tests reported in Table 4 show quite complex results not generalizable regarding Millennials traveling more or less daily VMT than other generations did. For example, Millennials-1 generated daily VMT no different, statistically speaking, from the older Baby Boomers did during age 14-24. Later in ages 25-29, Millennials traveled 5.98 more VMT than the older Baby Boomers did. Millennials' daily VMT remained higher than the older Baby Boomers' in ages 30-36. Similar changing differences were evident between the older Millennials and the younger Baby Boomers. When they were at age 14-19 and 20-24, the older Millennials traveled respectively 7.23 and 4.57 more VMT than the younger Baby Boomers did. The difference continued to reduce as they grew older and became statistically insignificant. By the age of 30-36, the difference emerged in the opposite direction; the older Millennials traveled 3.6 less VMT daily than the younger Baby Boomers did.

Within-generation differences in daily VMT existed, but not for all generations in all age cohorts. For instance, the younger Baby Boomers drew less VMT when at age 14-24, but more during ages 25-36, than the older Baby Boomers. The older and younger members of Generation X showed no difference in daily VMT until ages 30-36. For Millennials, significant within-generation differences in daily VMT occurred in ages 20-29.

The complex picture of within- and between-generation VMT differences revealed the dynamics of travel behavior associated with each generation over the life stages. Comparisons between generations may produce different results depending on the generation pairs and the age ranges chosen for analysis. The diverse, sometimes conflicting, findings reported in the literature on generational travel differences can be attributed partly to their choices of different age or generation cohorts (Choi et al., 2017; McDonald, 2015).

*Table 4. Pairwise Mean Test on Average Daily VMT by Age Cohorts of Generation Subgroups*

| | **Age 14-19** | | | | | **Age 20-24** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Generation / Birth year | BB1 | BB2 | Gen X1 | Gen X2 | Gen Y1 | BB1 | BB2 | Gen X1 | Gen X2 | Gen Y1 |
| BB2/1956-1964 | -7.41 | | | | | -3.81 | | | | |
| p-value | 0.00 | | | | | 0.02 | | | | |
| Gen X1/1965-1972 | 0.94 | 8.35 | | | | 3.01 | 6.82 | | | |
| p-value | 1.00 | 0.00 | | | | 0.07 | 0.00 | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gen X2/1973-1980 | -0.23 | 7.18 | -1.17 | | | 2.73 | 6.54 | -0.29 | | |
| p-value | 1.00 | 0.00 | 1.00 | | | 0.08 | 0.00 | 1.00 | | |
| Gen Y1/1981-1988 | -0.17 | 7.23 | -1.11 | 0.05 | | 0.76 | 4.57 | -2.25 | -1.97 | |
| p-value | 1.00 | 0.00 | 1.00 | 1.00 | | 1.00 | 0.00 | 0.15 | 0.15 | |
| Gen Y2/1989-1996 | -1.14 | 6.27 | -2.08 | -0.91 | -0.97 | -1.53 | 2.28 | -4.54 | -4.26 | -2.29 |
| p-value | 1.00 | 0.00 | 0.29 | 1.00 | 0.51 | 1.00 | 0.25 | 0.00 | 0.00 | 0.03 |
| | **Age 25-29** | | | | | **Age 30-36** | | | | |
| BB2/1956-1964 | 5.28 | | | | | 7.46 | | | | |
| p-value | 0.00 | | | | | 0.00 | | | | |
| Gen X1/1965-1972 | 8.70 | 3.41 | | | | 7.97 | 0.50 | | | |
| p-value | 0.00 | 0.00 | | | | 0.00 | 1.00 | | | |
| Gen X2/1973-1980 | 7.96 | 2.68 | -0.73 | | | 5.79 | -1.68 | -2.18 | | |
| p-value | 0.00 | 0.06 | 1.00 | | | 0.00 | 0.02 | 0.00 | | |
| Gen Y1/1981-1988 | 5.98 | 0.69 | -2.72 | -1.98 | | 3.87 | -3.60 | -4.10 | -1.92 | |
| p-value | 0.00 | 1.00 | 0.00 | 0.09 | | 0.00 | 0.00 | 0.00 | 0.00 | |
| Gen Y2/1989-1996 | 3.41 | -1.87 | -5.28 | -4.55 | -2.57 | | | | | |
| p-value | 0.00 | 0.56 | 0.00 | 0.00 | 0.00 | | | | | |

## 4.3. Results of mixed-effects modeling of daily VMT by generation subgroups

While it is important to identify the differences in VMT between generations, a more interesting question is: where would Millennials' VMT curve go beyond age 36? A trend projection may suggest an approximately straight line down the road. Of course, this is uncertain. The future course could take a sharp turn upward, as some studies have suggested that GenY would travel as much as the older generations when they become older (Garikapati et al., 2016). It is also possible that the VMT trend for GenY1 would go downward due to increased adaptation of ICTs and increased use of non-driving modes for travel (Choi et al., 2017).

Instead of making uncertain forecasts for future VMT by Millennials and other generations, we examined the differentiated effects of five key variables on VMT across generation subgroups; the five variables include traveler's age, driving licensure, vehicle ownership, household size, and income adjusted by gasoline price. These five variables have proved to be strong predictors of travel demand and therefore have been widely used for planning or policy analysis (National Academies of Sciences, 2012). We first estimated conventional models with fixed-effects only (Results of the intermediate modeling are available upon request). We then tested mixed effects model specifications and compared them with the models with fixed-effects only models. The model tests and comparisons confirmed the mixed effects model outperforming the conventional models for the purposes of this study. Table 5, below, shows the results from the final, mixed effects model in which generational subgroups enter the model as level-2 group indicators.

The top section of Table 5 shows the estimated coefficients of fixed-effects for the explanatory variables. Variables representing travelers' socioeconomic characteristics entered the model statistically significant ($p < 0.01$). Their coefficients show the signs indicating the directions of VMT influence consistent with general qualitative knowledge and with those reported in the literature. Since we took log transformation for both the dependent variable and those continuous independent variables (e.g., age, vehicle ownership), the coefficients are point elasticity estimates. For example, the Ln(age) coefficient of 0.5358 suggests half a percent increase in VMT as a result of age increase by 1%. For the binary independent variables, the coefficients measure the percentage marginal changes in VMT associated with the change from 0 to 1 condition for the binary variable. A female person likely travels 4% more VMT than a male person does, all else being equal. An employed person who owns her/his home and has attained college education tends to produce daily VMT more than 45.6% of that for an unemployed person who rents a home and has not received college education.

Residential location matters as well. On average, people living in a large metropolitan region that has one million or more population likely travel 6.17% more daily VMT than those not living in a large metropolitan region. If a person lives in the urbanized area of the metropolitan region, however, her/his daily VMT could be 37.57% less than those living in the rural area of the metropolitan region. People living in the urbanized area with rail transit services may generate 19.02% less daily VMT than those in the area without rail transit, all else being equal.

*Table 5. Mixed Effects Model of Average Daily VMT*

| Dep. Var.: Average Daily VMT (in log terms) | | | | |
|---|---|---|---|---|
| ***Fixed-effects Variables*** | ***Coef.*** | | ***Std. Err.*** | ***z-test*** |
| Ln (Age) | 0.5358 | *** | 0.0662 | 8.09 |
| Female | 0.0397 | *** | 0.0063 | 6.34 |
| Race_White | 0.0646 | *** | 0.0085 | 7.59 |
| Driver's License | 0.7017 | *** | 0.0725 | 9.68 |
| Employed | 0.2379 | *** | 0.0082 | 28.98 |
| Education_College | 0.0727 | *** | 0.0080 | 9.09 |

| | | | | |
|---|---|---|---|---|
| Home_Owned | 0.1455 | *** | 0.0087 | 16.76 |
| Ln (Vehicle Ownership) | 0.2534 | *** | 0.0140 | 18.16 |
| Ln (Household Size) | -0.1485 | *** | 0.0160 | -9.31 |
| Ln (Income/Gasoline Price) | 0.0602 | *** | 0.0122 | 4.95 |
| Rail Transit in Urbanized Area | -0.1902 | *** | 0.0108 | -17.65 |
| MSA Size > 1-Million | 0.0617 | *** | 0.0073 | 8.42 |
| In_Urbanized Area | -0.3757 | *** | 0.0075 | -49.86 |
| year1969 | 0.2759 | *** | 0.0383 | 7.21 |
| year1977 | -0.0263 | | 0.0223 | -1.18 |
| year1983 | -0.0294 | | 0.0232 | -1.26 |
| year1995 | -0.0975 | *** | 0.0160 | -6.09 |
| year2001 | -0.0769 | *** | 0.0183 | -4.20 |
| year2009 | -0.1299 | *** | 0.0202 | -6.44 |
| year2017 | -0.1819 | *** | 0.0205 | -8.88 |
| Constant | 0.3702 | * | 0.2157 | 1.72 |
| ***Random-effects Parameters*** | ***Variance*** | | ***Std. Dev.*** | |
| Ln(Age) | 0.2570 | | 0.5070 | |
| Driver's License | 0.0242 | | 0.1555 | |
| Ln(Vehicle Ownership) | 0.0306 | | 0.1749 | |
| Ln(Household Size) | 0.0011 | | 0.0331 | |
| Ln(Income/Gasoline Price) | 0.0012 | | 0.0342 | |
| Constant | 0.0007 | | 0.0272 | |
| Residual | 1.5709 | | 1.2533 | |
| ***Group Variable*** | ***Gen. Subgroup*** | | | |
| Number of observations | 164,104 | | | |
| Number of groups | 6 | | | |
| Observations per group | Min.: 4,189 | | Avg.: 10,940.8 | Max.: 16,785 |
| AIC | 539982 | | BIC | 540413 |
| Prob> chi2 | 0.0000 | | | |
| Notes: | Significance level: * p<0.1; ** p < 0.05; *** p<0.01 | | | |

The year indicators capture the period effects not explicitly accounted for on personal daily VMT. Relative to VMT in the reference year of 1990, the years of 1995-2017 saw fewer VMT while the year of 1969 had more VMT when all confounding factors were controlled.

The middle section of Table 5 reports the random effects attributable to the variations at the group level, i.e., differences between generation subgroups. The statistics shown in the Estimate column denote the estimated between-group variances corresponding to the selected variables. These statistics do not tell directly the magnitude of group effects on the individual level VMT outcome.

However, they provide statistical information to derive the group effects that moderate the fixed effects by way of a postestimation tool to produce best linear unbiased predictions, or BLUPs (StataCorp, 2013). Results of BLUPs are reported and interpreted in the following section.

## 4.4. Postestimation analysis of generational group effects on daily VMT

There are two parts of VMT effects associated with the variables for person age, vehicle ownership, driving licensure, household size, and gasoline price-adjusted income. One is the fixed effects, shown in the top portion of Table 5. The other is the random effects shown in the top portion of Table 6, where there were BLUP estimates. The bottom panel of Table 6 shows the total of fixed and random effects combined. They are adjusted slopes for the variables for which the slope values shown in Table 6 are modified by the generation-specific group effects. Below, we interpret the analysis results by each of the five planning/policy variables.

*Person age:* Figures 1 and 2 above have illustrated a general trend that an individual's travel demand rises with age during the early stage of life course and declines upon entering adulthood. One question of specific interest to the study of generational travel is whether Millennials will drive more, less, or the same as other generations have done when they grow older. The elasticity estimates shown in column Ln(Age) of Table 6 indicate small variations of age effects on VMT across generation subgroups. The older Millennials have an age elasticity (0.4951) smaller than that of the younger Baby Boomers (0.7745), whereas Gen X has slightly smaller estimates than others. These observations are limited to the age range of 14-36 though. Millennials-2 has a relatively large age elasticity (0.6239), mainly because this subgroup's data is limited to those aged 14-28. Overall, age elasticities show fairly large variations in size across the subgroups with their values falling in the scale of 0.3227-0.7745.

*Driver's license:* Obtaining a driver's license provides a person with driving independence and thus often leads to a higher VMT than when she/he can make motorized travel as a passenger only. This study estimated quite a large variation between generation subgroups in the marginal effects of driving licensure on their daily VMT. Baby Boomer-2 has the largest estimate of 0.9829, suggesting that a younger member of Baby Boomer generation nearly doubled (increased by 98%) her/his daily VMT after obtaining the driver's license. For Millennials, getting the driver's license also led to VMT increases, but by just about 66% and 48% for their older and younger members, respectively.

*Table 6. Group Effects and Elasticity Estimates by Generation Subgroups*

| | Ln(Age) | Driver's License | Ln(Vehicle Owned) | Ln(Household Size) | Ln(Income / Gasoline Price) | Constant |
|---|---|---|---|---|---|---|
| | ***Group Effects*** | | | | | |
| Baby Boomer-1 | 0.0563 | **-0.1774** | **-0.0565** | -0.0095 | **0.0189** | -0.1130 |
| Std. Err. | 0.0424 | 0.0341 | 0.0064 | 0.0164 | 0.0112 | 0.1088 |
| t-value | 1.33 | -5.21 | -8.86 | -0.58 | 1.69 | -1.04 |
| Baby Boomer-2 | **0.2387** | **0.2812** | **-0.0302** | 0.0024 | **-0.0426** | **-0.9589** |
| Std. Err. | 0.0347 | 0.0292 | 0.0052 | 0.0124 | 0.0097 | 0.0905 |
| t-value | 6.88 | 9.62 | -5.78 | 0.19 | -4.38 | -10.60 |
| Gen. X-1 | **-0.2132** | **0.1078** | **0.0340** | **0.0340** | 0.0016 | **0.5757** |
| Std. Err. | 0.0361 | 0.0288 | 0.0047 | 0.0107 | 0.0085 | 0.1011 |
| t-value | -5.90 | 3.75 | 7.25 | 3.18 | 0.19 | 5.70 |
| Gen. X-2 | **-0.1293** | **0.0511** | **0.0137** | **-0.0195** | **0.0275** | **0.3281** |
| Std. Err. | 0.0260 | 0.0218 | 0.0040 | 0.0113 | 0.0069 | 0.0678 |
| t-value | -4.97 | 2.35 | 3.45 | -1.73 | 3.98 | 4.84 |
| Millennials-1 | **-0.0407** | **-0.0368** | **0.0241** | **0.0434** | **-0.0248** | **0.2121** |
| Std. Err. | 0.0209 | 0.0178 | 0.0036 | 0.0087 | 0.0061 | 0.0516 |
| t-value | -1.95 | -2.06 | 6.71 | 4.99 | -4.08 | 4.11 |
| Millennials-2 | **0.0881** | **-0.2259** | **0.0149** | **-0.0507** | **0.0193** | -0.0440 |
| Std. Err. | 0.0289 | 0.0179 | 0.0048 | 0.0110 | 0.0073 | 0.0685 |
| t-value | 3.05 | -12.61 | 3.12 | -4.62 | 2.66 | -0.64 |
| | ***Total Effects / Elasticity Estimates***[a] | | | | | |
| Baby Boomer-1 | 0.5921 | **0.5243** | **0.1969** | -0.1580 | **0.0791** | 0.2572 |
| Baby Boomer-2 | **0.7745** | **0.9829** | **0.2232** | -0.1461 | **0.0175** | **-0.5888** |
| Gen. X-1 | **0.3227** | **0.8094** | **0.2874** | **-0.1145** | 0.0618 | **0.9459** |
| Gen. X-2 | **0.4065** | **0.7527** | **0.2671** | **-0.1680** | **0.0877** | **0.6982** |
| Millennials-1 | **0.4951** | **0.6648** | **0.2776** | **-0.1051** | **0.0354** | **0.5822** |
| Millennials-2[b] | **0.6239** | **0.4758** | **0.2684** | **-0.1992** | **0.0795** | 0.3262 |
| Notes: | a. For variables in log terms, the value of the total effects denotes VMT elasticity with respect to these variables.<br>b. This study contained data points for the younger Millennials only for the ages 14-28 due to NHTS limitations. The elasticity estimate for this subgroup should be interpreted with caution.<br>Significance level: Estimates in bold face: p<0.01 | | | | | |

*Vehicle ownership*: VMT elasticities with respect to vehicle ownership are similar among the two younger generations, ranging from 0.2671 to 0.2874 for Gen Xers. Baby Boomers appear to be relatively VMT inelastic to vehicle ownership compared to the younger generations. Between the two younger generations, Generation X's VMT likely responds to increased vehicle ownership slightly greater than that of Millennials, as indicated by the larger elasticity estimates for Gen X1 and GenX2 than for Millennials-1 and -2. This result suggests that increased car ownership would translate into VMT growth more for Gen Xers but less for Baby Boomers than for Millennials.

*Household Size:* NPTS/NHTS asked questions about the respondents' life cycle status but in a varying level of detail. The information correlates with household size. Based on the testing and modeling results, we opted to keep the variable Household Size in the model. The fixed effect shows a 1.5% decrease on average in personal daily VMT associated with a 10% increase in household size. Group effects moderate the fixed effects across generational cohorts. As a result, the older Millennials show the most inelastic VMT to changes in household size (an elasticity of -0.1051). This result implies that, when household size becomes larger, for example, by having additional children, the older Millennials would drive less on the personal daily VMT basis, but not as much as -less VMT- as other generation groups would do. These interpretations follow the statistical meaning of the results. Changes in household size take place with discrete values, for example, from single to a couple and having a newborn baby joining the household.

*Income/Gasoline Price*: In this study, the coefficient of Ln(Income/Gasoline Price), which can be rewritten as Ln(Income) - Ln(Gasoline Price), measures VMT elasticity for both income and gasoline price. The average elasticity of 0.0602 from this study (Table 6) falls consistently in the range of empirical estimates reported in the literature (Goodwin et al., 2004; McMullen and Eckstein, 2013; Wenzel and Fujita, 2018). Goodwin et al., (2004) found in their meta study the income elasticities of roadway traffic ranging from 0.05 to 0.62 in the short run, and 0.12 to 1.47 in the long run. The authors also reported gasoline price elasticities of driving demand being -0.05 to -0.17 and -0.10 to -0.63 in the short and long run, respectively. Compared with other generation subgroups, the older Millennials and the younger Baby Boomers have the smallest income and price elasticities, indicating the least sensitivity of driving to changes in income or gasoline price. The income and price elasticity for the younger members of Generation X (0.0877) measures more than twice that of the older Millennials' (0.0354). This result is consistent with that of Wang and

Akar (2020) who reported household per capita income had a positive influence on driving distance, stronger for Gen X than for Millennials.

# Chapter 5. Summary and Conclusions

This study utilizes eight U.S. national travel surveys from 1969 to 2017 to create a panel dataset that covers a continuous range of ages for persons 5 years and older from Baby Boomers, Generation X, and Millennials. The unique dataset enabled us to perform analyses on the daily VMT trend for an average person from each generation and its subgroups. Most existing studies performed point-to-point comparisons between the generations grouped by discrete age cohorts. These studies provided the snapshots of travel outcome only for the chosen age groups. Much of the conflicting findings on generational travel in the literature can be attributed to their varying cohort selections. With the panel dataset of continuous age ranges, this study overcame the limitations shown in the existing studies and gained new insights into the similarities and differences between generations in their daily VMT patterns and trends.

Baby Boomers, Gen X, and Millennials shared a consistent, three-phase pattern of VMT trends over the life course but exhibited varying levels of automobility in different life stages. Phase 1 occurred during childhood, ages 13 or younger, when members of the three generations all had relatively low daily VMT. Their VMT were generated primarily as passengers of adults' driving due to their lack of independent automobility and fewer out-of-home activities relative to adults. In Phase 2, teenagers from all three generations experienced rapid VMT growth when they were expanding their daily activities within and beyond school life while most of them learned how to drive. After entering adulthood in Phase 3, members of the three generations followed a general path of rising VMT but at slower growth rates than in their teenage time. They retained higher VMT levels than in previous two phases. A fourth phase is evident for Baby Boomers who showed a gradual decline in daily VMT starting in middle age. Generation X and Millennials would likely follow the declining VMT trend in Phase 4 but data are not yet available to confirm.

Differences in the levels of personal daily VMT existed both between- and within-generations and these differences also varied across life stages. In the teenage time of Phase 2, Gen X and Millennials maintained a higher level of daily VMT than that by Baby Boomers. After age 19, the VMT levels of three generations began to diverge. Gen X deviated from others by continuing rapid VMT growth and maintaining the highest level of VMT among the three generations, whereas

Baby Boomers' VMT remained the lowest. Nevertheless, Baby Boomers displayed a second period of rapid VMT growth after age 30, most likely due to changes in lifecycle events such as purchasing homes and having babies. During the adult life (after age 20) that Millennials have had, they kept their daily VMT consistently lower than Gen X's in the magnitude of 2 to 5 miles, or about 8% on average. The younger group of Baby Boomers outdrove the older Millennials at age 28 and after by about 3.5 VMT, or 9% daily.

Another interesting observation was that, peak daily VMT seems to occur at an earlier age for each successive generation, when VMT is considered over the full life course. Baby Boomers reached their highest level of daily VMT around their mid-40's. Generation X drove the most each day in their mid- to late 30s. Millennials, however, showed their peak driving in their early to late 20's and have not driven as much since then up to the time when the latest NHTS was available and the older and younger Millennials aged 36 and 28, respectively. This generational shift in VMT peaking warrants further research. As Millennials are now entering their middle age, the younger generation, Gen Z starts entering their adult life. Gen Z soon will outnumber Millennials to become the largest portion of the U.S. population. Will Gen Z follow the shifting trend as exhibited with their preceding generations? Answering the question has enormous implications for transportation planning and related policymaking.

For transportation planning and policymaking, the essential question of interest is the future trajectory of Millennials' travel. In this study, we chose not to forecast future VMT with uncertainties. We instead looked at the influence of key planning and policy variables on the observed VMT paths. This study's findings on the direction and size of VMT influences associated with the five planning or policy variables suggest that Millennials are unlikely to match or surpass Baby Boomers and Generation X in their future daily VMT. The study confirmed the existence of group effects between Baby Boomers, Generation X, and Millennials after the period effects and the effects of confounding factors were controlled. Five planning/policy variables, including person age, driving licensure, vehicle ownership, household size, and income/gasoline price, presented differentiated influences on the VMT outcome between generation subgroups. People tend to drive more as they grow older. However, the estimated age elasticity of daily VMT appeared similar in size across the six generation subgroups. Obtaining the driver's license could lead to a significant increase in daily VMT for Millennials, but less so than for Generation X and the younger group of Baby Boomers. Similarly, increased vehicle ownership is associated with increased VMT for all, but slightly more for the two subgroups of Generation X than for Millennials' two respective subgroups. Baby Boomers' daily VMT were least responsive to vehicle ownership growth among all generations. The older Millennials have the smallest income elasticity of VMT, less than half the size of that for Gen X2.

These study findings offer a number of takeaways for transportation agencies, for example, state departments of transportation (DOTs) and metropolitan transportation organizations (MPOs). DOTs and MPOs are responsible for making and updating long-range statewide and regional transportation plans, respectively. Variables such as driving licensure, vehicle ownership, income and travel cost have long served as essential predictors for travel mode choice analysis, trip generation modeling, and other transportation planning applications. Results of this study confirmed the importance of these predictors while also revealing the differentiations between generational cohorts in travel behavioral responses to the changes of these planning and policy variables. Accounting for the differentiated variable effects can help DOTs and MPOs to improve travel demand forecasting (McDonald 2015).

The study shows that Millennials may follow the general automobility path as the older generations did when the socioeconomic and policy environments change, but likely at a reduced pace. Public policies should be designed to nurture the shifting trend of reduced automobility from the older to the younger generations. For example, transportation demand management (TDM) strategies were developed in the 1970s and 1980s when Baby Boomers and the younger Generation X were the key workforce and driving force. While TDM will continue to be an important element of transportation policies, TDM strategies should be reformed and reprogramed, catering mobility management and services to the needs and preferences of Millennials and the younger generations (Bricka et al. 2015).

There remains a great deal of untapped potential offered by multiple NPTS/NHTS for travel analysis despite changes in survey design and implementation methods across NTPS/NHTS. For example, NPTS/NHTS report travel records by day of week and month of year. The information, which is absent from nearly all metropolitan travel surveys, is essential to study seasonal and day-of-week variations. Increasing applications of information and communications technologies (ICTs) have enabled and encouraged workers and employers to adapt with flex day work schedules. Workers do not all travel every day to workplaces, but combine work-from-home and physical travel over the week. In other words, people's travel decisions are not necessarily on a 24-hour timeframe as the existing transportation planning has assumed. Instead, for many, decision timeframes are moving to a weekly or monthly basis. Transportation planning and policymaking should respond to the behavioral changes. The existing NPTS/NHTS offer some relevant information for the needed analysis. Nevertheless, they do not provide direct observations on multiple day travel, which warrant consideration in designing future NHTS.

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