Reducing Vehicle Travel for the Next Generation: Lessons from the 2001 and 2009 National Household Travel Surveys

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Abstract: In the United States, per capita vehicle miles traveled (VMT) displayed a general declining trend in the new millennium. This paper focuses on identifying the factors that drove the recent VMT trend. Using sample data from the 2001 and 2009 National Household Travel Surveys (NHTS), this study investigated differences in travel patterns by age groups over time and explored factors associated with the recent decrease in per-capita VMT. The study results show that the daily auto mileage and number of auto trips significantly decreased in 2009, although the change was uneven across different age groups. Increased travel by public transit and walking and biking, along with urbanization efforts, partly explained the recent decrease in automobile use. The findings also suggest that population-specific strategies such as improving public transit services for younger people and upgrading walking facilities for the elderly may help reduce automobile travel demand. In addition, applications of information and communication technologies (ICTs) can offer promising alternatives to automobile travel. **DOI: 10.1061/(ASCE)UP.1943-5444.0000405.**

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Introduction

National statistics show that per-capita vehicle miles traveled (VMT) in the United States dramatically decreased after hitting its peak in 2004 (FHWA 2014). Cheap gas prices and rapid economic growth had led to the driving boom until the national VMT reached its peak. The Baby Boomer generation played a pivotal role in the VMT increase. The recent decrease, however, has been led by young Americans, the Millennials and subsequent generations. Studies using the National Household Travel Survey (NHTS) show that young people between the ages of 16 and 35 have led to the recent declines in VMT (Polzin and Chu 2014; Santos et al. 2011). According to the report *Summary of Travel Trends*, VMT per person for all ages, compared to 2001, decreased by 10.2% in 2009, and the greatest decrease was for those between the ages of 16 and 20 (−22.57%), followed by those between the ages of 21 and 35 (−17.32%) (Santos et al. 2011). Compared to other generations (e.g., the Baby Boomer generation), these groups of people drove relatively less, due in part to economic recession and higher gas prices, lower levels of licensure, and improvements in technology, as well as attitude and lifestyle changes (Davis et al. 2012; McDonald 2015).

Although the economic recession might contribute to the decrease in automobile travel among young people, there have been frequent reports showing that young Americans prefer to live in compact and mixed-use developments, which provide them with better access to walking, biking, and public transit, thereby enabling them to become less dependent on personal automobiles than their parent generations (Davis et al. 2012; Dutzik and Baxandall 2013). The technological advances in the new millennium have also enabled young Americans to become less dependent on personal automobiles. Information and communication technologies (ICTs) make transportation alternatives more convenient and reduce the necessity of travel by personal automobiles. This study examines factors that have contributed to the recent decline of per capita VMT in different age groups in the new millennium.

Literature Review

The total number of VMT in the United States reached its peak in 2007 and continued to decline until 2011 (FHWA 2014), whereas the absolute numbers of vehicles, distance driven, and fuel consumed and the corresponding rates per person, per driver, per household, and per vehicle reached their maxima in approximately 2004 (McCahill and Spahr 2013; Polzin and Chu 2014; Sivak 2014). This persistent trend can be explained by the fact that the factors that had contributed to the growth of VMT since World War II (e.g., women in the workforce, the Baby Boomer generation, household income, and automobile ownership) now play a small role in VMT increase (Jin and Wu 2011; McCahill and Spahr 2013). Among these factors, the role of the Baby Boomer generation was the most remarkable. Vehicle travel for this generation increased greatly in the 1980s and early 1990s and led to the overall VMT increase during the same period. However, vehicle travel among this generation started to decline after 1995 when they reached the age of retirement.

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In addition to the reduced role of the factors mentioned previously, the use of transportation alternatives has reduced vehicle trips and led to overall VMT decrease. The number of transit trips per person among the Baby Boomer generation increased noticeably in 2009 (McGuckin and Lynott 2012). Compared to 2001, young people took 24% more bike trips, 16% more walk trips, and 40% more transit trips in 2009 (Davis et al. 2012). Regardless of the generational difference, bike and walk trip rates have increased nationally although the increase seems fairly modest (Pucher et al. 2011). Telecommuting and online shopping have become prevalent and played an important role in the recent decline in VMT (McGuckin and Lynott 2012). Compared to the past, people have more options to work from home, and those with the option travel less for work. Online shopping has contributed to the reduction in shopping travel, and social network services (SNSs) have also played a role in reducing social trips (Davis et al. 2012).

However, one must be cautious about making any judgments on the recent trends because the Great Recession took place approximately the same time as the recent decline. Some researchers have argued that the economic depression along with the Baby Boomers retiring may in fact have caused the recent decrease. On the other hand, others have argued that the recent reduction in vehicle travel reflects noneconomic and fundamental changes in society. The increasing price of gas and economic recessions have partially contributed to this decline, but were not the primary reasons (McCahill and Spahr 2013). Rather, the adoption of new information and communication technologies, increased use of public transportation, increased urbanization of the population, and changes in the age composition of drivers played a greater role in the recent decline (Mans et al. 2012; Sivak 2014). In addition to these factors, people, particularly the young generation, have also consciously reduced driving with their willingness to protect the environment (Davis et al. 2012). They also have become more comfortable with using new technologies and integrating these technologies into their daily travel activities (Mans et al. 2012). In other words, they have begun to change their travel behavior according to the changes in society.

Just as their prior generations did, the young generation will shape the future travel demand. Several factors, including urbanization efforts, increased use of transportation alternatives, technological advances, the changes of Generation Y's values, as well as economic conditions, will contribute to their travel behavioral changes. In this sense, a comprehensive understanding of each generation's travel behavior with respect to the aforementioned factors is important to understand the future travel demand. Hence, this study will focus on the factors associated with the recent decrease in automobile use. Comparing two recent years of NHTS almost a decade apart, this study (1) explores generational differences in travel behavior changes over time, (2) examines the factors that are associated with the recent decrease in automobile use for each generation, and (3) draws policy implications from the study findings.

Methodology

National Household Travel Surveys

The primary data for this study were drawn from the 2001 and 2009 NHTSs. Similar to other travel surveys, the NHTS data set consists of four separate files, including person, household, daily trip, and vehicle files. This study mainly used the person and trip files of both survey years. The person file provides the characteristics of the surveyed individuals, such as sociodemographic characteristics, spatial characteristics, travel preference, and usage of ICTs. The trip file includes information about all trips made by the surveyed travelers on their assigned travel days. Each respondent was required to report travel distance and means of transportation for each trip he or she made. To clean the data, individuals whose age was under 16 (the minimum age to drive) and total travel mileage was above the 99th percentile (slightly less than 480 km or 300 mi/day) were excluded. In the end, 109,863 person records for 2001 and 227,154 person records for 2009 were selected for the analysis.

Daily Kilometers Traveled

The number of kilometers traveled by automobile, the primary interest of the study, was estimated based on the calculated trip distance converted into miles from the trip file in both NHTSs. If a mode of transportation used for a trip was reported as a privately operated vehicle (POV), such as car, van, sport utility vehicle (SUV), pickup truck, or other truck, those trips were considered auto trips. In order to derive daily kilometers traveled by auto for each traveler, trip distances for all auto trips were summed up to the person level. In a similar way, the number of kilometers traveled by other modes of transportation (transit, bike, and walk) were estimated.

Factors Associated with Automobile Travel

In terms of the factors associated with the recent decrease in automobile use, this study hypothesized that spatial characteristics, general travel preferences in the past, travel characteristics on the travel day, and ICT improvement, in addition to socioeconomic characteristics, could impact daily auto mileage. These factors are listed in Table 1.

Spatial Characteristics

The residential location strongly influences how the residents move around. This study hypothesized that those living in high-density areas (population or employment) tend to travel by auto less—thanks to a number of destinations within a relatively shorter distance. Similarly, urban residents are likely to travel by auto less because of having not only closer destinations but also other travel options available to them (e.g., transit, bike, or walk). These urban form variables were also expected to represent the level of accessibility of a given residential location.

General Travel Preferences

In this study, general travel preferences were determined by the number of trips by different modes of travel (walk, bike, and transit) in the last week or month as reported by the surveyed travelers. It was expected that those using sustainable transportation more frequently in the past were likely to travel by auto less on the travel day as well.

Travel Characteristics

Travel outcomes for each respondent made on travel days characterized the travel behavior (the number of kilometers traveled by walking, biking, and using transit). It was hypothesized that automobile use decreased if people used other modes of transportation more, and travel by those modes was for utilitarian purposes on the travel day.

Information and Communication Technologies

Technology improvement was determined by whether each traveler had an option to work at home in general. For the 2009 NHTS, the number of internet purchases and items delivered were used as proxies for technology improvement as well. This study hypothesized that those experiencing ICT more were likely to travel by auto less on the travel day.

Table 1. Variable Descriptions

Category	Variable name	Description
Personal characteristics	*AGE*	Traveler's age
	AGE^2	Age × age
	COLLEGE+	If a person has college degree above 1, otherwise 0
	FEMALE	If a person is female 1, otherwise 0
	WORKER	If a person is worker 1, otherwise 0
Household characteristics	*HISP*	If head of household is Hispanic 1, otherwise 0
	N_HISP_WHITE	If head of household is White 1, otherwise 0
	N_HISP_BLACK	If head of household is Black 1, otherwise 0
	*INC*1000	Total household income in 2009 dollars ($1,000)
	VEHAVAIL	Vehicles available per driver in household
	NUMCHLD	Number of children in household
Spatial characteristics	*POPDEN*	Population per square kilometer at tract level
	EMPDEN	Workers per square kilometer living in tract
	URBSTAT	Household in urban area = 1, otherwise = 0
Travel preference	*NBIKETRP*	Number of bike trips in last week
	NWALKTRP	Number of walk trips in last week
	NTRANSITTRP	Number of transit trips in last month
Travel characteristics	*AUTOTRPFREQ*	Number of vehicle trips on travel day
	WALKKM	Number of kilometers traveled by walk on travel day
	BIKEKM	Number of kilometers traveled by bike on travel day
	TRANSKM	Number of kilometers traveled by transit on travel day
Information and communication technologies	*PURCHASE*	Number of internet purchase in last month
	DELIVER	Number of internet purchases delivered to home
	TELECOM	Option to work from home

Generation Boundaries

It was hard to clearly define boundaries of age cohorts. Instead of using arbitrary age boundaries, this study used the generational boundaries (i.e., Millennials, Generation Xers, and Baby Boomers) defined in previous studies based on the year 2009 as reference (Dutzik and Baxandall 2013; McGuckin and Lynott 2012). The Baby Boomer generation has a relatively clear boundary—people born between 1946 and 1964 (McGuckin and Lynott 2012). Referring to the prior study, this study defined the Millennial generation as those born between 1983 and 2000 (Dutzik and Baxandall 2013). Then, Generation X was defined as people who were born between 1965 and 1982. Based on the definitions of boundaries for each generation, the Millennial generation falls in the cohort aged between 16 and 26, Generation X is in the cohort aged between 27 and 44, and the Baby Boomer generation is in the cohort aged between 45 and 63 in the 2009 NHTS. These three age cohorts for the 2009 NHTS were compared with the same age cohorts in the 2001 NHTS.

With the variables and generation boundaries, two specific questions were asked in this study. First, how travel behavior differed across different age groups over time, and second, how the factors affected the number of kilometers driven, and how these effect sizes varied across different age groups. For the first question, a series of weighted t-tests were conducted by age groups. For the second question, this study used a segmented regression method, also known as piecewise regression, in which age cohorts were used as breakpoints.

Findings

Kilometers Traveled and Trip Frequency by Mode

Compared to 2001, the daily auto mileage and number of auto trips for all age groups decreased in 2009. Table 2 summarizes the number of kilometers traveled and frequencies for all means of transportation by age group on their travel day in 2001 and 2009. Table 2 shows that the decrease in daily auto mileage among the 16–26 age group is remarkable. On the travel day, they traveled by auto 7.32 km (4.55 mi) less (−12.6%) and made 0.49 fewer vehicle trips in 2009 compared to the 2001 counterpart. This age group also shows increases in the number of kilometers traveled by bike and public transit. People from this age group traveled 0.07 km (0.05 mi) more by bike and 0.4 km (0.25 mi) more by transit.

Daily auto mileage and vehicle trip frequencies for other age groups also show similar trends in 2009. The 27–44 and 45–63 age groups traveled 8.42 (5.23 mi, −12.2%) and 7.62 (4.74 mi, −11.5%) kilometers less by auto in 2009, respectively, compared to their 2001 counterparts. The daily mileage by transit among these age groups increased. The 27–44 and 45–63 age groups traveled 0.3 (0.19 mi) and 0.22 (0.14 mi) more by transit in 2009, respectively, although the increases are not significant. However, daily mileage and trip frequency by nonmotorized modes of transportation (i.e., walking and biking) on the travel day increased in 2009. The findings here indicate that VMT reduction in 2009 may reflect the increases in other modes of transportation. In general, people in 2009 made more nonmotorized and public transit trips on their travel day.

Use of Sustainable Transportation Modes

On their travel days, most of the surveyed travelers used their private vehicles as the primary mode of travel in both years regardless of age group. However, general travel tendencies show that those in 2009 made more trips by other modes of transportation such as walking, biking, and public transit rather than private automobiles on typical days. Table 3 summarizes general travel tendencies among age groups and compares the use of transportation alternatives in 2001 and 2009. Both NHTSs asked the interviewees about the frequencies of walking and bike trips in the past week. In terms

Table 2. Daily Mileage and Frequency by Mode and Age Group

Age group	Mode	2001 Mean	2001 Standard error	2009 Mean	2009 Standard error	Difference (09–01)	Standard error	t	$P > \|t\|$
				Daily kilometers traveled					
16–26	Auto	57.82	1.01	50.50	1.03	−7.315[a]	1.44	−5.08	0.000
	Walk	0.44	0.03	0.48	0.03	0.035	0.04	0.96	0.335
	Bike	0.10	0.02	0.17	0.03	0.073[b]	0.04	1.86	0.063
	Transit	3.01	0.21	3.41	0.24	0.403	0.32	1.26	0.208
27–44	Auto	68.80	0.70	60.38	0.81	−8.419[a]	1.07	−7.90	0.000
	Walk	0.45	0.02	0.56	0.03	0.112[a]	0.03	3.25	0.001
	Bike	0.12	0.01	0.17	0.03	0.058[c]	0.03	2.00	0.045
	Transit	1.77	0.12	2.07	0.26	0.298	0.29	1.04	0.296
45–63	Auto	66.35	0.67	58.73	0.61	−7.622[a]	0.90	−8.44	0.000
	Walk	0.47	0.02	0.57	0.03	0.092[a]	0.03	2.92	0.003
	Bike	0.13	0.02	0.20	0.02	0.070[c]	0.03	2.42	0.015
	Transit	1.44	0.12	1.65	0.12	0.218	0.17	1.29	0.197
				Number of trips					
16–26	Auto	3.87	0.04	3.38	0.04	−0.494[a]	0.06	−8.59	0.000
	Walk	0.40	0.02	0.42	0.02	0.020	0.02	0.83	0.407
	Bike	0.03	0.00	.04	0.00	0.011[b]	0.01	1.89	0.059
	Transit	0.19	0.01	0.20	0.01	0.016	0.02	0.90	0.368
	Total	4.53	0.04	4.10	0.04	−0.427[a]	0.05	−8.03	0.000
27–44	Auto	4.42	0.03	3.95	0.03	−0.465[a]	0.04	−11.23	0.000
	Walk	0.38	0.01	0.50	0.02	0.120[a]	0.02	6.62	0.000
	Bike	0.03	0.00	0.03	0.00	0.010[c]	0.00	2.24	0.025
	Transit	0.10	0.00	0.11	0.01	0.010	0.01	1.21	0.226
	Total	4.96	0.03	4.66	0.03	−0.304[a]	0.04	−7.74	0.000
45–63	Auto	4.37	0.03	3.98	0.03	−0.390[a]	0.04	−10.66	0.000
	Walk	0.35	0.01	0.46	0.01	0.112[a]	0.01	7.96	0.000
	Bike	0.02	0.00	0.03	0.00	0.015[a]	0.00	3.85	0.000
	Transit	0.07	0.00	0.10	0.01	0.027[a]	0.01	3.75	0.000
	Total	4.86	0.03	4.65	0.03	−0.207[a]	0.04	−5.78	0.000

[a] $p < 0.01$.
[b] $p < 0.10$.
[c] $p < 0.05$.

Table 3. Use of Sustainable Modes of Transportation in the Past by Mode and Age Group

Age group	Mode	2001 Mean	2001 Standard error	2009 Mean	2009 Standard error	Difference (09–01)	Standard error	t	$P > \|t\|$
16–26	Walk trips in last week	4.13	0.10	4.35	0.11	0.219	0.14	1.51	0.131
	Bike trips in last week	0.31	0.02	0.34	0.04	0.025	0.04	0.59	0.552
	Transit trips in last month	N/A	N/A	3.44	0.19	N/A	—	—	—
27–44	Walk trips in last week	3.79	0.06	4.35	0.08	0.559[a]	0.10	5.80	0.000
	Bike trips in last week	0.25	0.01	0.31	0.02	0.060[a]	0.02	3.10	0.002
	Transit trips in last month	N/A	N/A	2.59	0.12	N/A	—	—	—
45–63	Walk trips in last week	3.87	0.06	4.57	0.07	0.693[a]	0.09	7.87	0.000
	Bike trips in last week	0.16	0.01	0.22	0.01	0.063[a]	0.01	4.72	0.000
	Transit trips in last month	N/A	N/A	2.28	0.09	N/A	—	—	—

[a] $p < 0.01$.

of transit use, interviewees in 2001 reported in the category as "about once a week," "once or twice a month," etc., whereas those in 2009 reported the frequency of transit use in the past month, which makes direct comparisons difficult.

Travelers in 2009 used more transit and nonmotorized modes in general. All age groups made more walking and bike trips than their respective age groups in 2001. The oldest age group shows a remarkable increase in walking and biking behavior. In terms of trip frequency, they made 0.7 more walk trips and 0.06 more bike trips per week in 2009 than their 2001 counterparts. Tendencies of using other modes of travel vary across age groups. The 45–63 age group made the most frequent walk trips compared to the other age groups in 2009, whereas the 16–26 age group made the most frequent bike and transit trips among other age groups in general. The prevalent use of transit and nonmotorized modes among the youngest age group can be attributed to several factors. Some studies found that today's young Americans tend not to acquire driver's licenses and tend to move to urban areas in which alternative modes of transportation are well provided for (Davis et al. 2012; McDonald 2015). Nevertheless, Table 3 demonstrates that people in 2009 tend to make more trips with alternative transportation in general. Young Americans are more likely to take public transit than any other age groups.

Table 4. Use of Information and Communication Technologies by Age Group

Age group	ICT usage	2001 Mean	2001 Standard error	2009 Mean	2009 Standard error	Difference (09–01)	Standard error	z	$P > \|z\|$
16–26	% option to work from home	0.02	0.00	0.02	0.00	0.000	0.00	−0.153	0.881
	# internet purchases in last month	N/A	N/A	1.07	0.04	N/A	—	—	—
	# purchases delivered to home	N/A	N/A	0.85	0.03	N/A	—	—	—
27–44	% option to work from home	0.07	0.00	0.11	0.00	0.036[a]	0.00	−17.691	0.000
	# internet purchases in last month	N/A	N/A	2.06	0.06	N/A	—	—	—
	# purchases delivered to home	N/A	N/A	1.61	0.05	N/A	—	—	—
45–63	% option to work from home	0.06	0.00	0.09	0.00	0.027[a]	0.00	−16.123	0.000
	# internet purchases in last month	N/A	N/A	1.52	0.03	N/A	—	—	—
	# purchases delivered to home	N/A	N/A	1.20	0.02	N/A	—	—	—

[a] $p < 0.05$.

Information and Communication Technologies

This study also explored two types of ICTs, including telecommuting and online shopping. This study defined telecommuting as whether a respondent had an option to work from home, and online shopping behavior was determined by the frequencies of purchases made via internet and actual delivery to their homes in the last month. It is, however, necessary to point out that those having an option to work from home may not actually choose to do so. Table 4 summarizes patterns of using ICTs across age groups for both years. The 2001 NHTS does not provide information about internet shopping behavior and home deliveries.

Telecommuting

Overall, the percentage of people who had an option to telecommute increased in 2009 compared to 2001, but the increases are modest. Table 4 shows the percentage of the surveyed travelers with an option to work from home for both years. The increase is most noticeable for the 27–44 age group. In 2009, approximately 11% of the surveyed travelers from this group reported that they had an option to work from home. Approximately 9% of those in the 45–63 age group reported the same response. There was a very marginal increase for the 16–26 age group. The increases in the proportion of having telecommuting options for the age groups 27–44 and 45–63 are significant. However, these results require cautious interpretation because work types can influence the feasibility of telecommuting. For instance, high-skill jobs are less place-bounded than low-skill jobs. Although Table 4 suggests that telecommuting became more prevalent in 2009, compared to 2001, it is not clear whether telecommuters actually worked at home.

Online Shopping

The 2001 NHTS does not provide information about online shopping, whereas the 2009 NHTS does. In the 2009 survey, respondents were asked to report (1) the number of purchases made via the Internet in the last month and (2) the number of these internet purchases delivered to their homes. Approximately 50% of the respondents reported that they used online shopping at least once in the last month, and approximately 90% of them reported that the items purchased over the Internet were actually delivered to them at least once in the last month. However, it is also possible that some purchases such as those with a digital format were not delivered in a physical form and thus were not reported. As expected, online shopping (both purchases and actual deliveries) was the most prevalent among those from the 27 to 44 age group in 2009. This might be because this group of people was relatively more comfortable with the ICTs than the oldest age group and had stronger consumer power than the youngest age group in 2009. On average, they made 2.06 internet purchases per month, and 1.61 of those purchases were actually delivered a month. Although the impact of online shopping on travel behavior is controversial, it is expected that online shopping behavior can reduce trips both in terms of frequency and distance only if it substitutes for traditional in-store shopping trips (Cao 2009).

Regression Analysis

Though the previous sections have described the differences in travel patterns across age groups over time, this section focuses on identifying factors that are associated with the VMT decrease and examining what can potentially reduce automobile use. Table 5 summarizes the results of the regression analysis. The coefficients of interaction terms indicate the difference in the effect sizes between the years 2001 and 2009. The model specification for the entire population is used as a reference, and the segmented model specifications for each age group are presented. In terms of model performance, the model specifications have a range of R-squared values between 0.151 and 0.207. These low R-squared values are in part because human behavior that is hard to predict is the subject of this study. The unit of analysis was the surveyed individual travelers, and daily auto mileage was regressed on the independent variables that were categorized based on the type of questions asked in both surveys (refer to Table 1 for more details about the study variables).

Overall Sample

According to Table 5, individual characteristics are associated with daily auto mileage. The education level is one of the strongest determinants of auto travel demand. The table shows that those with a college-level degree or higher are likely to travel more by auto than those with a high-school diploma or those without any degrees. This may reflect the individual's economic situation. Those with higher education levels are likely to earn more money, which leads to a higher vehicle ownership level and auto travel demand. The table also shows that females are likely to drive less than males. Being employed positively influences the level of automobile use. Race and ethnicity are also associated with daily travel by auto. Interestingly, as this analysis shows, Hispanics are likely to drive more than non-Hispanic Whites. Hispanics are likely to travel approximately 5.5 km (3.4 mi) more than the non-Hispanic White population by auto.

Other household characteristics, such as household income and vehicle availability, are significant and positively associated with individuals' automobile use. However, the effects of household income are very modest, whereas vehicle availability has a relatively strong influence on daily kilometers traveled by auto. The negative

Table 5. Regression Results

Variables	All ages			Age between 16 and 26			Age between 27 and 44			Age between 45 and 63		
	Coefficient	*t*	Significance	Coefficient	*t*	Significance	Coefficient	*t*	Significance	Coefficient	*t*	Significance
AGE	0.554[a]	11.32	0.000	1.362[a]	4.12	0.000	−0.224[b]	−1.82	0.068	0.064	0.54	0.591
AGE^2	−0.007[a]	−13.07	0.000	—	—	—	—	—	—	—	—	—
COLLEGE+	3.940[a]	5.23	0.000	9.418[a]	4.27	0.000	1.888	1.37	0.170	1.710	1.28	0.199
FEMALE	−6.814[a]	−11.11	0.000	−3.766[c]	−2.07	0.038	−12.496[a]	−9.53	0.000	−10.564[a]	−8.66	0.000
WORKER	6.585[a]	8.56	0.000	0.038	0.02	0.986	5.466[a]	2.93	0.003	7.186[a]	4.90	0.000
N_HISP_WHITE	[ref]	—	—	—	—	—	—	—	—	—	—	—
N_HIS_BLACK	0.447	0.41	0.685	0.793	0.26	0.798	4.321[b]	1.79	0.074	−2.192	−1.09	0.277
HISP	5.531[a]	4.70	0.000	0.653	0.26	0.794	9.413[a]	3.94	0.000	3.744	1.35	0.176
*INC*1000	0.050[a]	6.11	0.000	0.047[b]	1.83	0.067	0.103[a]	5.79	0.000	0.057[a]	3.55	0.000
NUMCHLD	−0.860[a]	−2.92	0.004	−1.301[b]	−1.81	0.070	−0.694	−1.27	0.205	0.193	0.26	0.797
VEHAVAIL	3.759[a]	5.24	0.000	2.589	1.20	0.229	5.458[a]	3.57	0.000	5.716[a]	3.95	0.000
POPDEN	−0.108[a]	−9.46	0.000	−0.124[a]	−4.26	0.000	−0.167[a]	−7.04	0.000	−0.146[a]	−5.93	0.000
EMPDEN	−0.322[a]	−5.14	0.000	−0.209	−1.20	0.231	−0.189	−1.51	0.132	−0.659[a]	−5.64	0.000
URBAN	−17.201[a]	−20.45	0.000	−13.654[a]	−5.59	0.000	−23.508[a]	−13.10	0.000	−16.446[a]	−9.59	0.000
AUTOTRPFREQ	9.171[a]	66.91	0.000	10.328[a]	25.02	0.000	8.509[a]	32.69	0.000	8.317[a]	34.52	0.000
WALKKM	−1.934	−1.25	0.213	−3.650	−1.05	0.291	0.293	0.11	0.912	−2.875	−0.97	0.332
BIKEKM	−1.678[b]	−1.67	0.095	−0.967	−0.79	0.431	−2.255	−1.19	0.234	−0.968	−0.34	0.732
TRANSKM	−0.692[a]	−3.61	0.000	0.030	0.04	0.971	−1.072[b]	−1.80	0.071	−0.707	−0.98	0.325
DELIVER	0.225[b]	1.92	0.055	0.150	0.43	0.667	−0.015	−0.09	0.931	0.448[c]	2.54	0.011
TELECOM	7.387[a]	3.81	0.000	−2.243	−0.45	0.653	8.080[a]	2.74	0.006	9.687[a]	3.20	0.001
Y_AGE	0.076[a]	2.80	0.005	−0.095	−0.20	0.844	0.158	0.80	0.424	−0.007	−0.04	0.965
Y_COLLEGE	−2.610[c]	−2.31	0.021	−2.752	−0.85	0.393	−2.583	−1.10	0.272	−2.195	−1.16	0.246
Y_FEMALE	0.861	0.94	0.348	1.563	0.60	0.547	4.311[c]	2.11	0.035	2.714	1.62	0.106
Y_WKSTAT	0.435	0.44	0.662	−0.176	−0.06	0.953	4.156	1.61	0.108	0.141	0.07	0.941
Y_HISP	−3.571[c]	−2.14	0.032	−1.030	−0.28	0.780	−5.182	−1.41	0.158	1.483	0.43	0.664
Y_N_HISP_BLK	1.700	1.06	0.290	−4.180	−0.94	0.349	0.548	0.15	0.879	6.202[c]	2.27	0.023
*Y_INC*1000	0.029[c]	2.17	0.030	−0.002	−0.04	0.965	0.017	0.57	0.571	0.064[a]	2.80	0.005
Y_NUMCHILD	0.694[b]	1.65	0.099	0.977	0.98	0.329	−0.042	−0.05	0.959	1.542	1.44	0.150
Y_VEHAVAIL	0.253	0.22	0.824	−0.083	−0.03	0.978	−0.870	−0.34	0.731	−.1.041	−0.53	0.595
Y_POPDEN	0.052[c]	2.53	0.011	0.223[a]	3.06	0.002	0.065	1.60	0.109	0.015	0.46	0.643
Y_EMPDEN	−0.185[c]	−2.04	0.042	−0.536[c]	−2.20	0.028	−0.296	−1.54	0.123	0.055	0.34	0.732
Y_URBAN	1.463	1.20	0.229	−6.370[b]	−1.83	0.068	7.079[a]	2.78	0.005	1.002	0.44	0.661
Y_AUTOFREQ	−1.027[a]	−4.88	0.000	−0.800	−1.18	0.236	−0.708[b]	−1.73	0.084	−1.288[a]	−3.73	0.000
Y_WALKKM	4.847[c]	2.29	0.022	6.030	1.33	0.184	1.786	0.43	0.667	3.624	1.03	0.303
Y_BIKEKM	0.319	0.29	0.773	0.487	0.34	0.736	0.588	0.25	0.799	−1.502	−0.49	0.625
Y_TRANSKM	0.536[c]	2.26	0.024	0.174	0.18	0.856	0.801	1.27	0.204	0.515	0.69	0.493
Y_TELECOM	−5.049[c]	−2.03	0.042	5.902	0.66	0.512	−7.959[c]	−2.08	0.038	−5.854	−1.58	0.114
(Constant)	15.245	7.87	0.000	1.432	0.16	0.870	20.274	5.06	0.000	27.411	3.86	0.000
N		337,017			34,070			81,443			131,531	
R^2		0.185			0.207			0.165			0.151	

[a] $p < 0.01$.
[b] $p < 0.10$.
[c] $p < 0.05$.

association between the number of children and auto mileage is different from the initial expectation. The unit of analysis of this study, which is individual, might result in this outcome. Household-level analysis would have found the significance of the number of children.

In terms of spatial characteristics, all variables considered (*POPDEN*, *EMPDEN*, *URBAN*) show expected signs and statistical significance. Population density, employment density, and urban residence are negatively associated with daily auto mileage. As demonstrated in previous studies, those living in a denser area are likely to drive less as well in this analysis. According to the model result, the discrepancy between urban and nonurban residents in terms of auto travel is noticeable. Urban residents tend to travel by auto for approximately 17 km (11 mi) less than those living in nonurban areas in this sample.

This study tested whether the travel characteristics on the travel day are associated with daily auto mileage. However, these variables were found to be endogenous with daily auto mileage. Thus, travel preference variables (i.e., the numbers of trips by sustainable transportation modes in the past; see Table 1) were used as instrumental variables. It was expected that those who frequently traveled by walking, biking, or using transit in the past would use these modes more on the travel day as well. The travel characteristic variables were, therefore, replaced by these instrumental variables.

As expected, some travel characteristics on the travel day are associated with auto travel. For instance, the frequency of auto trips is significant and positively associated with daily auto mileage, and the number of kilometers traveled by biking and public transit are significant and negatively associated with daily auto mileage. The number of kilometers traveled by walking is negatively associated with daily auto mileage, but this correlation is insignificant in the model. These findings suggest that travel using other modes might be for utilitarian purposes. In other words, travel by bike or transit is likely to replace some auto travel in both 2001 and 2009. However, the effect of transit travel to reduce auto travel is very marginal compared to bike travel.

Having an option to work from home is positively associated with individual automobile use, which is different from the initial expectation. The result shows that those with this option are likely to travel more by auto on the travel day. One possible explanation for this result is that having an option does not always mean choosing the option. It is highly likely that those with a telecommuting option still need to make work-related trips (e.g., meeting with clients or customers) or even travel more for other purposes (e.g., recreational, social trips, etc.).

2001 NHTS versus 2009 NHTS

In order to see the difference in auto travel behavior between the years 2001 and 2009, the series of interaction terms were included in the regression analysis. The variables containing "Y" represent the interaction terms, which indicate the difference in the effectiveness of the factors between these two survey years.

Individual characteristics seem to contribute to the reduction in auto travel in 2009. It is worth noting that well-educated people are likely to drive less in 2009 compared to their 2001 counterparts. The coefficient of *Y_COLLEGE+* is remarkable (−2.610) and indicates that those with a college or higher degree in 2009 tend to travel 2.6 km (1.6 mi) less by auto than their counterparts in 2001. Changes in perception may explain this outcome. It is possible that those with higher education levels may have a stronger concern about their environment and therefore may intentionally use automobiles less. This change can often be seen among more educated individuals.

Hispanics in the 2009 NHTS are likely to travel less by auto than their 2001 counterparts, but this group of the population still seems to use automobiles more than other population groups. This may be because of increased car ownership among this population group, but whether this trend continues will require further investigation.

Individuals in 2009 tend to drive less per automobile trip (*Y_AUTOFREQ*). Although it is a very short time frame for land-use changes to move national-level statistics, the negative coefficient (−1.027) of *Y_AUTOFREQ* indicates that people in 2009 tend to drive approximately 1 kilometer (0.6 mi) less per auto trip than those in 2001. The decline in the average distance per auto trip is partly the result of land-use intensification efforts, which may lead to closer destinations. In terms of telecommuting, those with telecommuting options in 2009 tend to travel 5.1 km (3.1 mi) less by auto than their 2001 counterparts. This may imply that telecommuting properly functioned as a tool for reducing automobile use in 2009 compared to 2001.

Differences among Age Groups

This study assumes that the impact of each factor on daily auto mileage is different across age groups. According to the regression analysis, the effect of transit travel on the travel day for the 27–44 age group is noticeable. The negative coefficient of *TRANSKM* shows that people aged between 27 and 44 using public transit on their travel day are likely to travel less by auto, and the impact is larger than for other age groups. This finding indicates that some portion of automobile travel was replaced with travel by public transit.

In terms of the difference between the year 2001 and the year 2009, urban residence has a very large coefficient (−6.370) for the 16–26 age group. This result shows that the urban residents for this age group in 2009 tend to travel approximately 6.4 km (4 mi) less by auto than their 2001 counterparts. Although this finding requires cautious interpretation, it is possible that urban residents in this age group are less willing to drive for several reasons (e.g., conserving the environment and using sustainable modes of transportation), or they might have moved to urban areas because of their unwillingness to drive. On the other hand, it is also possible that they may not be employed yet (because of pursuing a higher degree or being unemployed), and therefore, their travel demand decreased or they relied on less expensive modes of transportation. However, it would be expected that the use of automobile for this age group would decrease if the former explanation were true.

None of the individual and household characteristics for the age group 27–44 in 2009 are significantly different from their 2001 counterparts, except for the *FEMALE* variable. The interaction term of *Y_FEMALE* for this age group (4.311) shows that women in 2009 are likely to travel 4.3 km (2.7 mi) more by auto than their 2001 counterparts. This positive coefficient partly results from the increased travel demand by women (more women in the workforce, etc.). Noticeable differences for this age group are *Y_URBAN*, *Y_AUTOFREQ*, and *Y_TELECOM*. Unlike the age group 16–26, urban residents for this age group in 2009 tend to travel 7.1 km (4.4 mi) more by auto than their counterparts. Also, individuals in 2009 are likely to drive less per automobile trip. One possible explanation for this result is that destinations have become closer together, which made people drive less per auto trip in 2009. Having an option to work from home in 2009 seems to significantly reduce automobile use compared to the 2001 result for this age group. The finding suggests that those in the age group 27–44 with a telecommuting option in 2009 are likely to drive approximately 8 km (5 mi) less than their counterparts in 2001.

Similar to the case of the age group 27–44, those in the age group 45–63 also tend to drive less per automobile trip. This is

partly because destinations have gotten closer as a result of the efforts of compact, mixed-use developments. Some of household characteristics show significant coefficients. Interestingly, African Americans (non-Hispanic Blacks) in this age group tend to travel 6.2 km (3.9 mi) more by auto in 2009 than the 2001 counterparts, which also requires further investigation.

In sum, daily auto mileage and auto trip frequency declined in 2009 compared to 2001, but the rates of the decline vary across age groups. This can be due in part to the increased use of sustainable transportation modes (i.e., walking, biking, and public transit). It is also possible that compact and mixed-use developments have reduced distances between destinations so that people drive less per auto trip than the past. The prevalence of telecommuting also shows some possibility of reducing automobile travel. Both t-tests and regression analysis show that these factors are associated with daily auto mileage and played a significant role in reducing auto travel. The results also show that the effect sizes of these factors vary across age groups. However, there may still be other unobserved factors that explain the recent decrease in automobile use. For example, increased concern about the environment might play some role in the recent VMT decline among the 16–26 age group. If this was true, automobile use among this age group would be expected to decline. The 27–44 age group is the most responsive to the use of sustainable transportation modes. The result may imply that travel by alternative transportation seems to substitute for some travel by auto among this age group. In addition, the 45–63 age group made the most frequent walk trips. These results together point out the importance of policies that target a specific population. For instance, improving public transit service in favor of the youngest and middle age groups and conducting a campaign for reducing automobile use in the youngest age group can enhance policy effectiveness in terms of reducing automobile use. Improving the facilities for walking in favor of the oldest age group might enhance policy effectiveness in a similar sense.

Limitations

However, there exist some limitations in this study. First of all, it may be difficult to make direct comparisons of travel behavior in both years, especially for walk trips. Because of the changes in the survey methods and questionnaires, there were more walk trip observations in the 2009 NHTS than there were in 2001. Moreover, it is possible to overestimate the number of utilitarian walk and bike trips because of the insufficient information on the trip purposes in the data sets. Also, the possibility of variance in survey response rates by gender, age, and time may make direct comparison difficult. Second, trip distances are based on the self-reported miles of the surveyed individuals. Any reporting errors, which are highly likely, affected the numbers of kilometers traveled. Third, part of the 2009 NHTS was conducted in the depth of the recession, which could lead to the decrease in automobile travel. The huge VMT reduction in the 2009 NHTS might be related to the 2008 economic recession. Fourth, this study could not consider the structure of the surveyed households, which may have influenced the level of individual travel to some extent. Lastly, because of data limitations, some alternative factors that could better explain the overall travel behavior changes as the changes of each individual age group might have been missed. In addition, the 2009 data set is now 6 years old, and the travel trends have changed significantly since then. The 2016 NHTS, which is scheduled to be released to the public in the near future, will be an additional data set that will help researchers better understand long-term trends of travel behavior.

Conclusion

This study has analyzed travel behavioral changes between age groups and examined the factors associated with the recent VMT decrease. The results from both t-tests and regression analysis show that daily auto mileage declined in 2009. However, the difference in the decrease varies across age groups. Throughout the study, it was found that (1) daily auto mileage significantly decreased, and the decrease was remarkable for younger generations; (2) the increased use of public transit, along with walking and bicycling, played a role in the recent decline in automobile travel; (3) the new suburban-to-city movement as well as the increasing preference for walkable neighborhoods may explain the overall decreased auto use; (4) information and communication technologies became prevalent, although the role of technologies in VMT reduction is still unknown (but promising); and (5) there is significant potential for reducing vehicle travel for younger generations.

Several implications can be drawn from the findings. The decreasing trend may continue because of several factors, such as demographic and social changes, technological improvements, the efforts for compact and mixed-use development, etc. If this is the case, it is suggested that local or regional governments should consider their own local or regional contexts and keep a good balance between investing in new capacity projects in fast-growing areas and maintaining the existing infrastructure in steady-growing regions.

The findings also indicate that transit travel is one of multiple factors that can reduce automobile travel, and this effect may have a greater impact on younger generations. Although transit seems to play a very modest role in reducing automobile travel, it can be expected that the use of public transit may continue to reduce automobile dependency. According to the American Public Transportation Association, transit ridership has grown by nearly 3 billion trips since 1995, and Americans took 10.7 billion trips, which was the highest ridership in 57 years, in 2013 (American Public Transportation Association 2014).

There is much potential for reducing automobile travel among the youngest age group. The findings provide evidence that the youngest age group is the most frequent transit user, and they are more likely to ride it. Moreover, the youngest, Millennials, seems to prefer sustainable transportation (Davis et al. 2012). Also, they may be more exposed to ICTs and therefore feel more comfortable with using them than other age groups. These findings support the idea that improving transit service and ICTs can be effective for reducing automobile travel among younger generations and play an important role in reducing future travel demand (Davis et al. 2012; Pucher et al. 2011; Sivak and Schoettle 2011).

Though this study focuses on the 2001 and 2009 NHTSs, the authors are aware that, after 8 years of decline and staggering, the total VMT in the United States rose substantially again in 2015 and 2016. VMT per capita decreased after peaking in 2004, but climbed rapidly in 2015 and grew further in 2016. The volatile trend of VMT (both in total and per capita) results from the dynamic interplay of complex demographic, technological, and socioeconomic factors. The study presented in this paper warrants an update when the latest NHTS is released in the forthcoming year.

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