Rethinking the Future of Alternative Transportation to Work in Light of Millennial Usage

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ABSTRACT
It has been written that Millennials (born 1982-2000) use cars less often and alternative modes (bike, walk, public transit) more often than those of previous generations. Most travel mode data covers work trips. Therefore, this analysis seeks to determine—in light of current higher Millennial usage of alternative transportation to work—*whether we should plan for an increase in demand for alternative transportation to work in the future in the U.S.* To answer this question, HRTPO staff isolated the effects on usage of alt-trans-to-work of seven (7) factors (generation, age, era, income, gender, Metropolitan Statistical Area (MSA) status, Urbanized Area status) by compiling and regressing a dataset of National Household Travel Survey (NHTS) records from three different years: 1983, 1995, and 2008/2009. The analysis revealed highly significant relationships between alternative mode usage for commuting and nearly all of the independent variables selected, allowing the authors to forecast—under stated assumptions—an increase in usage of alternative transportation for commuting in the U.S., from 8.2% in 2010 to 8.8% in 2050.

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INTRODUCTION

Motivation and Purpose

The literature suggests that Millennials (considered by some to be born 1982 through 2000) are more likely to use alternative modes (walk, bike, transit) than members of previous generations. Most travel mode data covers the work trip. Therefore, the resulting research question is:

> "Given recent Millennial reports, should we plan for an increase in demand for alternative transportation to work in the future?"

To the degree that Millennials' preference for alternative modes is a function of their age and the current economy (both of which will change)—as opposed to an inherent generational trait (which will not change)—the usage of alternative modes by all generations in the future will be similar to that of today. Therefore, in order to forecast the usage of alternative transportation to work, one must consider income, age, generation, era, etc.

Understanding (and forecasting) the individual factors contributing to a phenomenon allows one to forecast that phenomenon more effectively than simply looking one-dimensionally at the changes in that phenomenon over recent years. Therefore, before forecasting the future of alternative transportation to work, Hampton Roads Transportation Planning Organization (HRTPO) staff conducted a multi-variate analysis to determine factors on which to base that forecast.

EXPLAINING ALT-TRANS-TO-WORK USING MULTI-VARIATE REGRESSION

In preparation for conducting a multi-variate regression for forecasting usage of alternative transportation to work, we reviewed the literature a) to see the forecasts of others, and b) to see their analytical methodology.

Literature Review

Mode Choice in Recent Past
From 2001 to 2009, among young workers (aged 16 to 34, therefore born between 1967 and 1993, and thus consisting of Generation Xers (Gen-Xers) and Millennials), the percentage of trips per capita by car decreased. Meanwhile, the percentage of trips by transit, walking, and biking increased. See these changes in Figure 1 below.

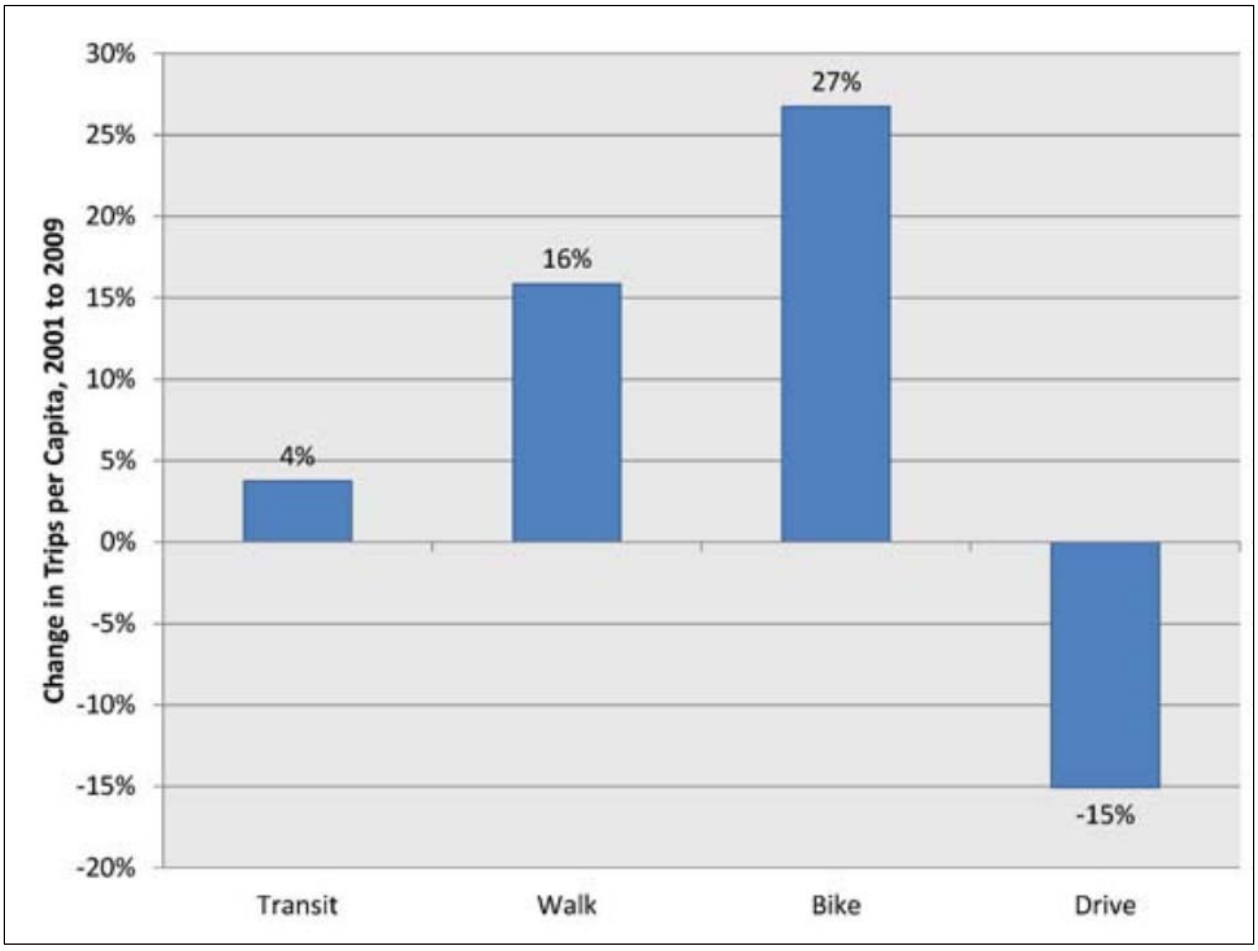

FIGURE 1 Change in # of trips per capita among 16 to 34 year-olds, 2001 to 2009, U.S.
Source: Millennials in Motion (U.S. PIRG, 2014) (*16*, p. 11)

Between 2006 and 2013, young workers (aged 16 to 24, therefore born between 1982 and 1997, and thus part of the Millennial generation) experienced the greatest decrease in commute trips made by car—with commensurate increases in other modes—as shown in Figure 2 below.

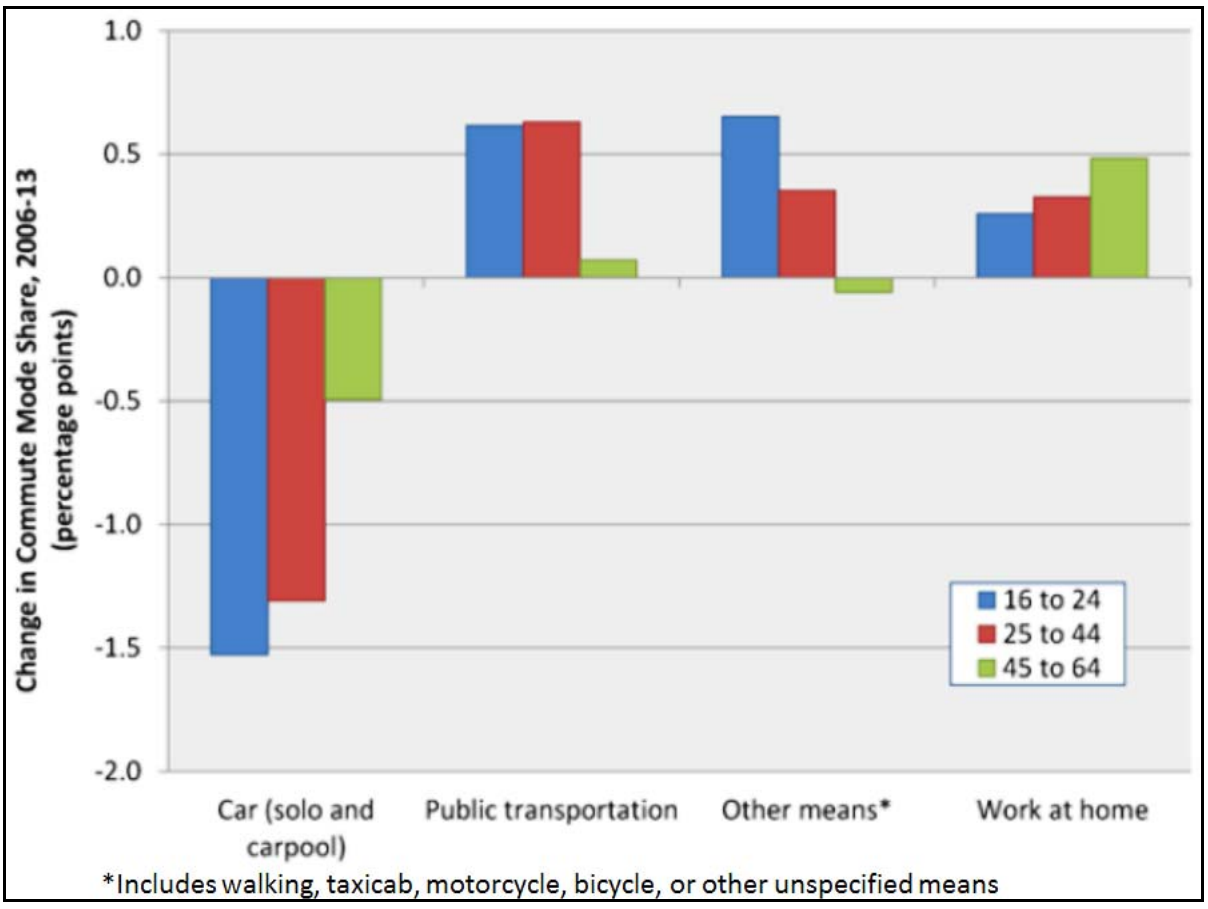

FIGURE 2 Change in commute mode share, 2006 to 2013, by age group, U.S.
Source: Millennials in Motion (U.S. PIRG, 2014) (*16*, p. 12)

Mode Choice in the Future
Vehicle-miles traveled (VMT) being theoretically related negatively to the usage of alternative transportation, we examine the future of VMT. Dutzik and Baxandall have suggested three possible scenarios for its future (*7*, pp. 29-30). The three scenarios are listed below:

1. *Back to the Future* Under this scenario, the U.S. decline in driving since 2004 is assumed to be the effect of temporary conditions: poor economic conditions and higher gas prices. As these conditions reverse, the travel preferences of Millennials will increasingly mimic those of previous generations.

2. *Enduring Shift* In this scenario, the shift in travel behavior that has occurred over the last decade is assumed to be lasting, consistent with the view that the preferences of Millennials will be embraced by future generations.

3. *Ongoing Decline* This scenario assumes that the decline in driving over the last decade is the beginning of a broader change that makes driving less necessary. The outcome of this scenario is that driving will stabilize at a much lower level per capita.

In order to determine how much of current Millennial behavior will endure as they age, Noreen McDonald measured the degree to which three factors explain their lower level of driving (*21*). She found 1) that decreased employment and other lifestyle shifts explain 10-25% of the decrease in driving, 2) that general dampening of travel demand across all age groups explains 40% of the decrease, and 3) that different attitudes and online shopping/media explain the remaining 35-50% of the decrease. This third factor is perhaps inherent to the Millennial generation, and would be expected therefore to endure.

In her dissertation "Stalled on the Road to Adulthood?" (*22*), Kelcie Ralph looked for factors to explain why people fall into four mode-based categories: 1) "Drivers", 2) "Long-distance Trekkers", 3) "Multimodals", and 4) "Car-less". Her conclusion:

> "I find that economic constraints, role deferment, and racial/ethnic compositional changes in the population primarily explain the travel trends during this period. The evidence in support of preferences and residential location explanations was substantially more limited." (*22*, p. iii)

This finding indicates that much of the decrease in automobile travel associated with Millennials is expected to reverse itself as the generation ages and economics change.

Wanting to conduct its own forecast, HRTPO staff also reviewed the literature for help in designing a multi-variate analysis on which to base that forecast.

Conceptual Framework
For generational research, the literature identifies the following types of effects on travel behavior (*3*, p. 9), (*4*, p. 3):

1. *Period (or Era) Effect* The effect of a situation that impacts an entire population for a period of time.
   - Example: rationing during World War II

2. *Age Effect* An effect associated with a particular person age.
   - Examples: being of high school age, being of working age, being of retirement age

3. *Generational Effect* The effect of events whose consequences follow a group of people, born at a specific time, throughout their lifetimes.
   - Example: the Great Depression's effect on the Silent Generation

Based on the literature, staff designed its multi-variate analysis to include each of these three effects (era, age, and generation) on mode choice.

Methodology

In her analysis of Millennial travel mentioned above, McDonald used a linear regression model to explain automobile mileage, and a negative binomial model to explain automobile trips. In order to identify to what extent differences between Millennials and Gen-Xers (at the same age) reflect preferences (as opposed to demographic—including economic—and era effects), she used the regression coefficients from her 1995 model to forecast 2009 mileage, comparing that forecast to the actual. (*21*, p. 12)

Dr. Ralph, on the other hand (in her dissertation mentioned above), used "multinomial logistic regression to identify the independent relationship between traveler type and economic resources, adult roles, residential location, and race/ethnicity." (*22*, p. iii)

As in these two papers, staff's multi-variate analysis includes demographic, economic, and location variables. Like Dr. Ralph, staff's analysis used logistic regression.

Multi-variate Regression

Source of Data
In order to conduct an original analysis that considers each of the effects on mode choice gleaned above from the literature—age, era, and generation—HRTPO staff chose the National Household Travel Survey (NHTS), a comprehensive travel survey conducted by the Federal Highway Administration (FHWA) approximately every seven years since 1969.

Variables for Regression
Dependent Variable The research question being related to mode choice, HRTPO staff chose usage of alternative transportation to work (i.e. for commuting) as the dependent variable.

Independent Variables In order to identify and measure those factors related to alt-trans-to-work, we included seven (7) groups of factors as independent variables as guided by the literature:

1) era
2) age
3) generation
4) gender
5) income
6) Metropolitan Statistical Area (MSA) status (including population)
7) Urbanized Area status.

Data Preparation
In order to measure generational effects, we used records from three NHTS surveys. The raw NHTS datasets contain 421,643 observations: 17,382 from 1983, 95,360 from 1995, and 308,901 from 2008/2009. Identifying those observations for workers with a recorded means of transportation to work resulted in a database of 170,947 usable records. Records with missing data on income (an independent variable) were given the average income of respondents reporting such data.

All variables (dependent and independent) in this analysis were entered into the regression in binary form. For the discrete variables in the NHTS dataset (era, generation, gender, MSA status (including population), and Urbanized Area status), a categorical set of binary sub-variables was created for each. For example, HRTPO staff created an "era" set containing three binary sub-variables: "Reagan Era (1983)," "Clinton Era (1995)," and "Bush/Obama Era (2008/2009)", one for each NHTS survey used. The NHTS variable for person age being an integer, HRTPO staff transformed it into a categorical set of five binary variables, one for each of five age groups. Staff adjusted the incomes from 1983 and 1995 to 2009 dollars.

The dependent variable—mode to work—was categorical in the NHTS data set, indicating which of approximately 20 modes the subject person used. Given our focus on alternative transportation, HRTPO staff converted the NHTS mode data into a binary variable: alternative (1) vs. conventional (0).

Description of Database

Descriptive statistics for the variables used in this analysis are shown in Table 1 on the following page.

As shown at the bottom of the table, in our dataset of 170,947 NHTS workers from the 1983, 1995, and 2008/2009 surveys, 6% of the (working) persons used alternative means to get to work (0.5% biked, 2.3% walked, and 3.5% used public transportation).

TABLE 1 Descriptive Statistics (unweighted), HRTPO Model

Binary Variables		Observations	Share (%)	Min	Max
Era					
Reagan Era (1983)		7,560	4	0	1
Clinton Era (1995)		46,627	27	0	1
Bush/Obama Era (2008/2009)		116,760	68	0	1
		170,947	100		
Age					
16-17		3,119	2	0	1
18-34		38,271	22	0	1
35-54		84,201	49	0	1
55-74		43,437	25	0	1
75+		1,919	1	0	1
		170,947	100		
Generation	Years born				
Lost Generation	1883-1900	5	0	0	1
G.I. Generation	1901-1924	1,111	1	0	1
Silent Generation	1925-1945	23,564	14	0	1
Baby Boomer Generation	1946-1964	90,483	53	0	1
Generation X	1965-1981	44,281	26	0	1
Millennial Generation	1982-2000	11,503	7	0	1
		170,947	100		
Gender					
Male		87,067	51	0	1
Female		83,880	49	0	1
		170,947	100		
Total Annual Household Income (2009$)					
<$20,000		9,957	6	0	1
$20,000-$39,999		26,329	15	0	1
$40,000-$59,999		30,832	18	0	1
$60,000-$99,999		61,348	36	0	1
$100,000+		42,481	25	0	1
		170,947	100		
MSA Status (including population)					
<1 million		50,641	30	0	1
1 million-3 million		35,853	21	0	1
>3 million		53,563	31	0	1
Household not in MSA		30,482	18	0	1
MSA size not identified		408	0	0	1
		170,947	100		
Urbanized Area Status					
Household in Urbanized Area		115,726	68	0	1
Household not in Urbanized Area		54,897	32	0	1
Urbanized Area status unknown		324	0	0	1
		170,947	100		
Mode to work					
Alternative modes (public transit, walk, bike)		10,712	6	0	1
Conventional modes (privately-owned vehicle, other)		160,235	94	0	1
		170,947	100		

Source: “All years-max records.xlsx”

Regression

Given the binary nature of the dependent variable (alternative mode to work), binary logistic regression was performed using SPSS. Resulting from a logistic regression, the model estimates the odds of the subject person using alternative transportation to work, as follows:

$$Odds_i = e \wedge (\beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_n X_n)$$

where $Odds_i$ is the odds of using an alternative mode, X_1 through X_n are the regressors, β_1 through β_n are the coefficients of those regressors, and β_0 is the "Constant". For ease of interpretation, "Odds Factors" have been calculated for the coefficients of the independent variables (Table 6, following page). Each "Odds Factor" indicates the impact of the subject regressor/variable being 1 (or true) on the odds of using an alternative mode, vs. the basis. For example, if the odds factor for a "male" variable (vs. basis variable "female") were 0.9 and the odds of Betty using alternative transportation is 0.50:1 (for:against, i.e. a 33% chance), then the odds of Betty's twin brother Bill using alternative transportation—all other modeled factors being equal—would be 0.45:1 (0.50*0.9=0.45), which is a 31% chance.

The regression results are summarized in Table 2 on the following page.

TABLE 2 Regression Results, HRTPO Model

Logistic regression **Number of observations** **170,947**

Dependent Variable: Alternative Mode to Work		**Significance**	**Coefficient**	**Standard Error**	**Odds Factor**	**95% Conf. Interval** Lower	Upper
Independent Variables-Regressors							
Era							
Reagan Era (1983) (basis)					1.000		
Clinton Era (1995)		0.000^{++}	-.274	.048	.760	.692	.835
Bush/Obama Era (2008/2009)		0.000^{++}	-.795	.055	.452	.406	.503
Age							
16-17 (basis)					1.000		
18-34		0.000^{++}	-.487	.063	.615	.543	.696
35-54		0.000^{++}	-.684	.071	.504	.439	.580
55-74		0.000^{++}	-.641	.082	.527	.449	.618
75+		0.000^{++}	-.710	.136	.491	.377	.641
Generation	Years born						
Lost Generation	1883-1900	0.096^{+}	1.691	1.015	5.423	.742	39.654
G.I. Generation	1901-1924	0.448	.089	.118	1.093	.868	1.377
Silent Generation	1925-1945	0.077^{+}	-.066	.038	.936	.869	1.007
Boomer (basis)	1946-1964				1.000		
Generation X	1965-1981	0.010^{++}	.082	.032	1.085	1.020	1.155
Millennial Gen.	1982-2000	0.011^{++}	.147	.058	1.158	1.034	1.297
Gender							
Male		0.000^{++}	.072	.021	1.075	1.033	1.119
Female (basis)					1.000		
Total Annual Household Income (2009$)							
<$20,000		0.000^{++}	1.218	.039	3.381	3.131	3.652
$20,000-$39,999		0.000^{++}	.454	.035	1.575	1.469	1.687
$40,000-$59,999 (basis)					1.000		
$60,000-$99,999		0.005^{++}	-.091	.032	.913	.857	.972
$100,000+		0.019^{++}	-.081	.035	.922	.862	.987
MSA Status (including population)							
<1 million		0.000^{++}	-.432	.039	.649	.601	.701
1 million-3 million		0.000^{++}	-.365	.042	.694	.640	.754
>3 million		0.000^{++}	.810	.035	2.248	2.098	2.409
Household not in MSA (basis)					1.000		
MSA size not identified		0.022^{++}	-.441	.193	.643	.441	.938
Urbanized Area Status							
Household (HH) in Urbanized Area		0.000^{++}	.869	.030	2.385	2.250	2.528
HH not in Urbanized Area (basis)					1.000		
Urbanized area status unknown		0.009^{++}	.531	.204	1.701	1.140	2.537
Constant		0.000^{++}	-2.567	.084	0.077		

$^{+}$Significant at the 0.10 level, $^{++}$Significant at the 0.05 level

Source: "all data max records results….pdf"

Statistically, the model has great explanatory power (to be interpreted carefully given the inherent causation issues of regression). The -2 Log Likelihood is 72,863, the Nagelkerke R-Square is 0.111, and 26 of the 29 independent variables are statistically significant at the 95% level.

The alt-trans-to-work odds factor results are represented in Figure 3, organized by the seven (7) independent variable sets. Each set includes the odds factor of the basis variable (1.000), to which all other variables in the set are compared.

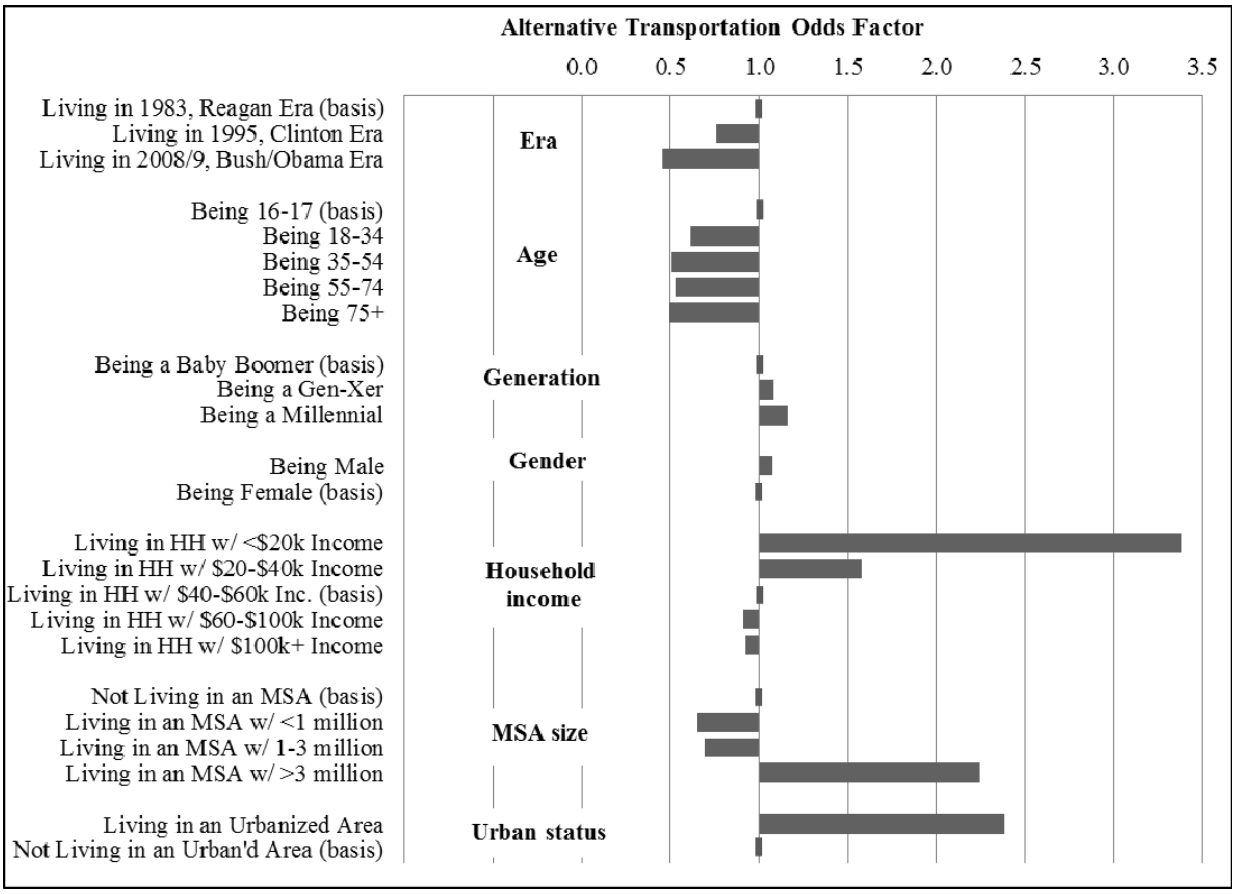

FIGURE 3 Alternative mode to work, odds factors, U.S., NHTS, HRTPO model.
Source: "Results charts- 170k records- alt trans.xlsx"

Discussion of Regression Results
The results for each of the seven (7) factor sets are discussed below.

1. Age

All of the *age* variables were significantly related to mode choice. With the youngest age group (16-17) as basis, the alt-trans-to-work odds factors of the other age groups (including ages 18 and above) all being between 0.49 and 0.62 indicates that, all other modeled factors being equal, 1) teenagers have a bent toward using alternative transportation to work, and 2) surprisingly, the bent of American workers toward such modes does not decrease significantly above age 35, even for age 75+. The regression having controlled for household income (as opposed to personal income), the teenage bent toward alternative transportation to work may be explained by being unable to afford a car, or perhaps by lack of a driver's license.

2. Gender

All other modeled things being equal, the gender odds factors show that the predisposition to use alt-trans-to-work is slightly higher for males (odds factor 1.1 vs. females) than for females.

3. Household Income

All of the *income* variables being significantly related to mode choice, the regression indicates that, all other modeled factors being equal, the bent of American workers toward alternative modes drops with increasing income, but is surprisingly flat above $40,000 (2009$). Those with the lowest income (<$20k/year) have a large bent toward alternative transportation to work (alt-trans-to-work odds factor 3.4 vs. middle income [$40-60k]). This bent is likely explained by the longer travel times and greater exposure to the elements associated with alternative transportation, and the typical proximity of transit infrastructure to the residences of low-income households.

4. MSA Status (including population)

Not surprisingly, concerning *MSA status*, all other modeled factors being equal, persons living in MSAs with more than 3m population (alt-trans-to-work odds factor 2.25 vs. not living in an MSA) are much more inclined than all others to use alternative modes to work. This can be explained by the higher densities and greater alternative mode infrastructure of large metros.

5. Urbanized Area Status

Similarly, all other modeled factors being equal, persons living in *Urbanized Areas* (alt-trans-to-work odds factor 2.4) are much more inclined than those living in non-Urbanized Areas to use alternative modes to work. This too can be explained by higher densities and greater alternative mode infrastructure.

6. Generation

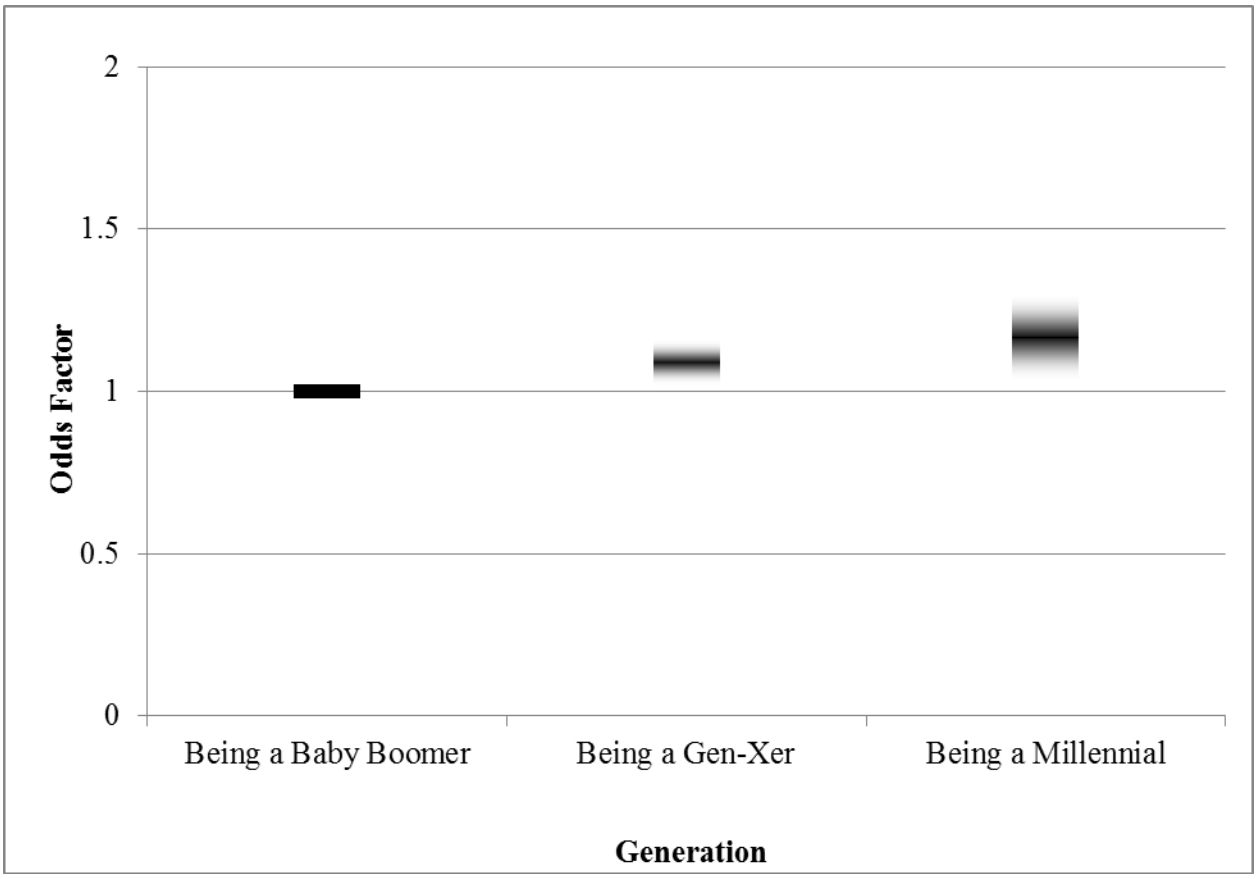

FIGURE 4 Alt. mode to work, by generation, odds factor (vs. Boomers), U.S., NHTS.
Note: Bars represent 95% confidence interval.
Source: "Results charts- 170k records- alt trans.xlsx"

Figure 4 shows the regression results for the *generation* factor set. The model coefficients for the Lost Generation, the G.I. Generation, and the Silent Generation not being statistically significant at the 95% level, odds factor estimates for those generations are not shown on the above figure.

The regression shows that, all other modeled factors being equal, Millennials (and, to a lesser extent, Gen-Xers) *may have an inherent bent toward alternative transportation to work* (vs. Baby Boomers: Millennial alt-trans-to-work odds factor 1.16, Gen-X alt-trans-to-work odds factor 1.09).

7. Era

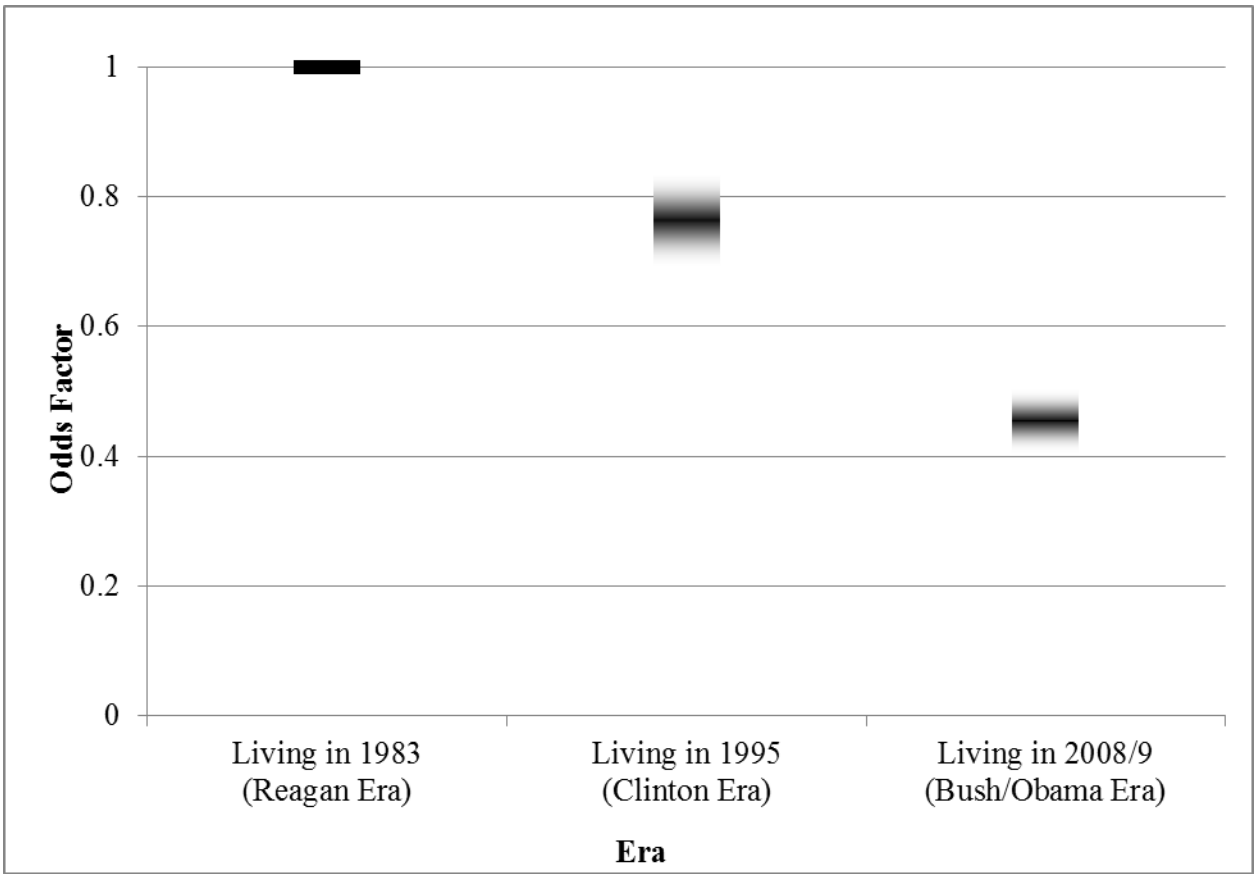

FIGURE 5 Alternative mode to work, by era, odds factor (vs. Reagan Era), U.S., NHTS.
Note: Bars represent 95% confidence interval.
Source: "Results charts- 170k records- alt trans.xlsx"

Figure 5 shows the regression results for the *era* factor set. The model revealed an era trend of increasingly lower inclination toward alt-trans-to-work over time. With the Reagan Era as basis (odds factor 1.0), the odds factors of the Clinton Era (0.76) and the Bush/Obama Era (0.45) indicate that, all other modeled factors being equal, the bent of American workers toward alternative modes for work has decreased greatly over recent decades.

This era trend not being explained by age, income, generation, or location—all of which were controlled for—theories explaining why the bent toward alternative transportation to work has declined over this 26-year period are presented below.

Our first theory explaining the era effect is that the "suburbanization of work" over that time period has made jobs harder to reach by bicycling, walking, and riding transit. This theory is based on the accommodations for bicycling (e.g. slower vehicle speeds), walking (e.g. sidewalks), and transit (e.g. bus hours) being typically more scarce in suburbs than central cities. According to HUD, the portion of jobs located in the suburbs increased from 45% in 1980 to 52% in 2000 (*23*).

Our second theory explaining the era effect, perhaps related to the above suburbanization-of-work theory, is the increase in work trip length over that time, longer trips favoring the more-rapid automobile mode. According to *Commuting in America 2013* (*20*), work trip lengths increased almost 40% over the subject time period (8.5 miles in 1983, 11.8 miles in 2009).

Our third theory explaining the era trend away from alternative transportation to work is the increasing affordability of automobiles. As shown in Figure 6, automobiles became more affordable over the study period, 1983-2009.

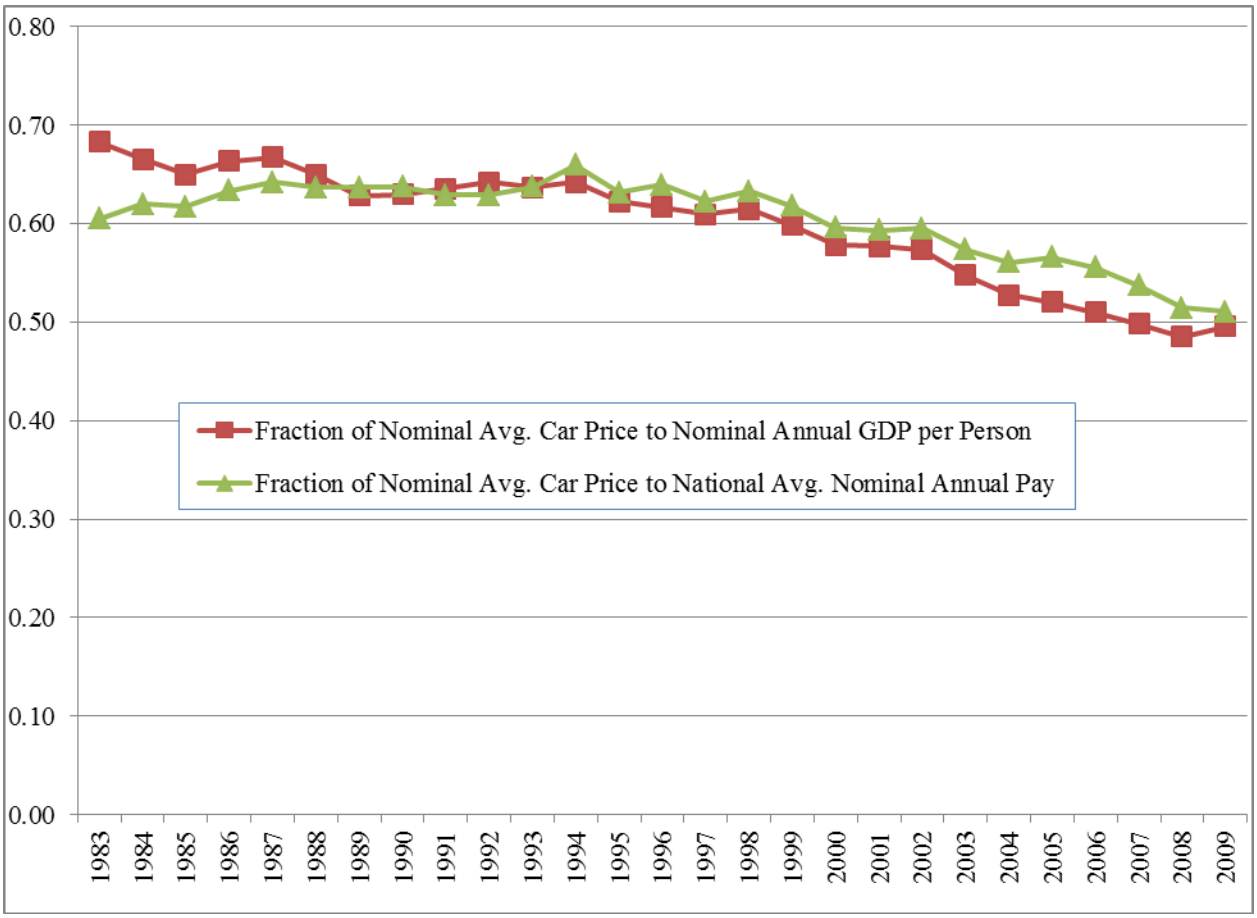

FIGURE 6 Automobile cost.
Source: HRTPO Staff analysis of ORNL (*24*), World Bank (*25*), BEA (*26*), and BLS (*27*) data ("All Car Data 1980-2010.xlsx")

Each of these three theories—1) suburbanization of work, 2) lengthening work trip distances, and 3) increasing automobile affordability—being logically sound and supported by data, it appears that the observed era effect results from some combination of the four, plus likely other unknown factors.

FORECAST OF USAGE OF ALTERNATIVE TRANSPORTATION TO WORK IN U.S.

As shown in Figure 7, usage of alternative transportation to work declined significantly over the 30-year period, from 12.3% in 1980 to 7.9% in 2000, with a 0.3% increase to 8.2% in 2010.

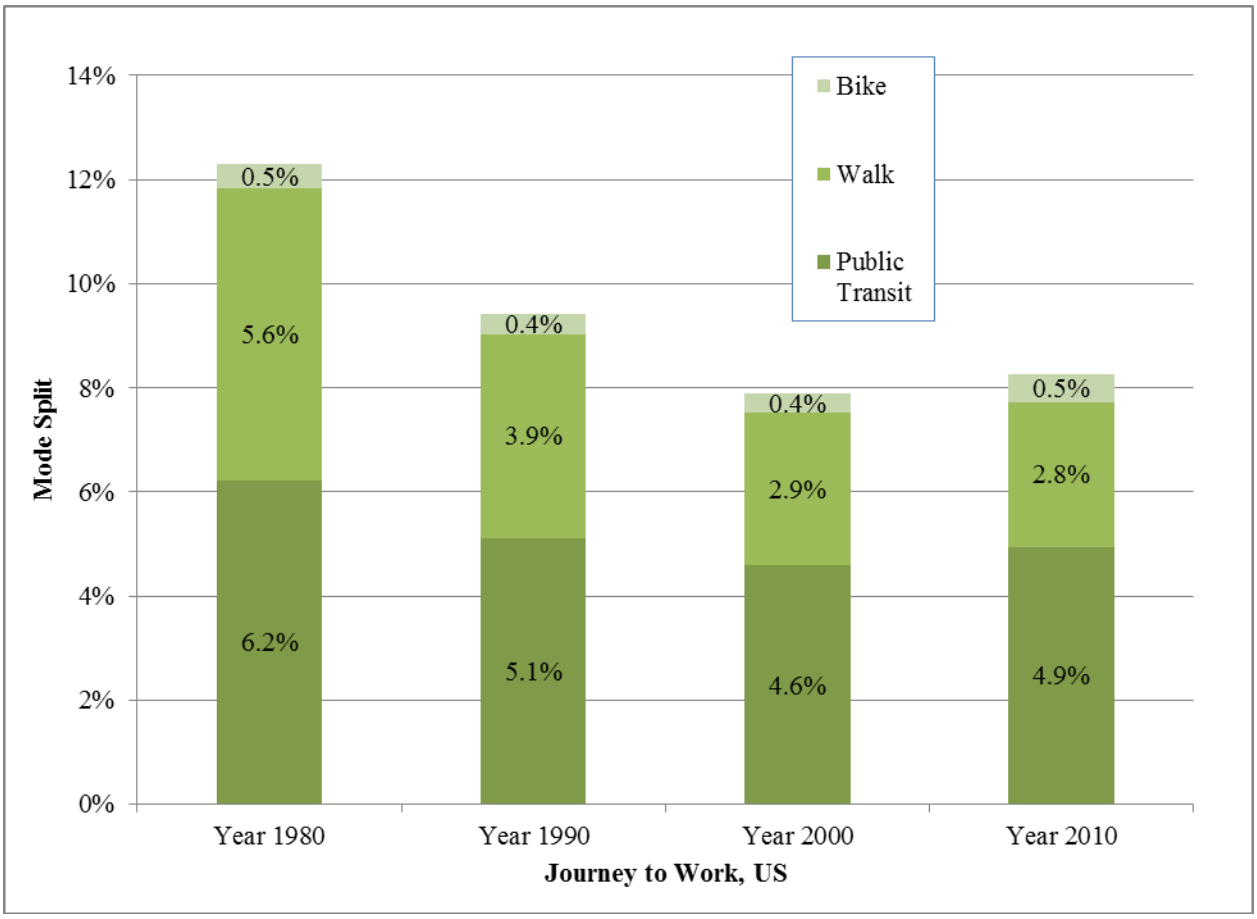

FIGURE 7 Usage of alternative modes to work, U.S.
Sources: "Commuting in America III" (*28*) and HRTPO processing of US Census ACS data (*29*) ("US Alt Trans Data Table.xlsx")

In order to determine how usage of alternative transportation for commuting in the U.S. might *change* from this 8.2% value in the future, HRTPO staff ran and *compared* two scenarios—base and future—using the model estimated above, for all 116,760 U.S. workers (with mode information) from the 2008/9 NHTS survey.

The base scenario was designed as follows:

I. "U.S. in 2008/9 Model" Scenario: 116,760 U.S. workers as surveyed using original data for all seven (7) factors:

1. Income
2. Age
3. Urbanized Area status
4. Gender
5. Era
6. MSA status/population
7. Generation (mostly Boomers, Gen-Xers, and Millennials)

The future scenario, "U.S. in 2050 Model," was designed to reflect what the U.S. might look like when Gen-Xers have largely retired (the youngest Gen-Xer will be 69 in 2050), and therefore Millennials and subsequent generations comprise the workforce.

Assuming that the "Millennial" factor found above (1.16 odds factor vs. Baby Boomers) is inherent and therefore will be retained by Millennials in 2050 (age 50-68), and assuming that subsequent generations have this same bent toward alternative transportation, HRTPO staff created the future scenario by giving each of the 116,760 U.S. workers the "Millennial" odds factor (1.16) of using alternative transportation to work. Concerning the other six factors—1. Income, 2. Age, 3. Gender, 4. Era, 5. MSA status/population, 6. Urbanized Area status—HRTPO staff assumed that U.S. workers in the future would have the same income, age, gender, etc. as U.S. workers did in 2008/9.

Therefore, the future scenario was designed as follows:

II. "U.S. in 2050" Scenario: modified data for 116,760 U.S. workers

1. Income	unchanged from 2008/9 scenario
2. Age	unchanged from 2008/9 scenario
3. Urbanized Area status	unchanged from 2008/9 scenario
4. Gender	unchanged from 2008/9 scenario
5. Era	unchanged from 2008/9 scenario
6. MSA status/pop.	unchanged from 2008/9 scenario
7. Generation	all persons given the Millennial odds factor (1.16)

Dividing the results of the base model (6.6% alternative transportation) by the results of the future model (7.1%) indicates that usage of alternative transportation in 2050 (under the above assumptions) will be 1.08 times higher (1.071/1.066 = 1.08) than in 2008/9. Therefore, as shown in Figure 8 below, usage of alternative transportation in the U.S. being 8.2% today (Census, from above), usage of alternative transportation in 2050 *would be* 1.08 times higher, or 8.8%.

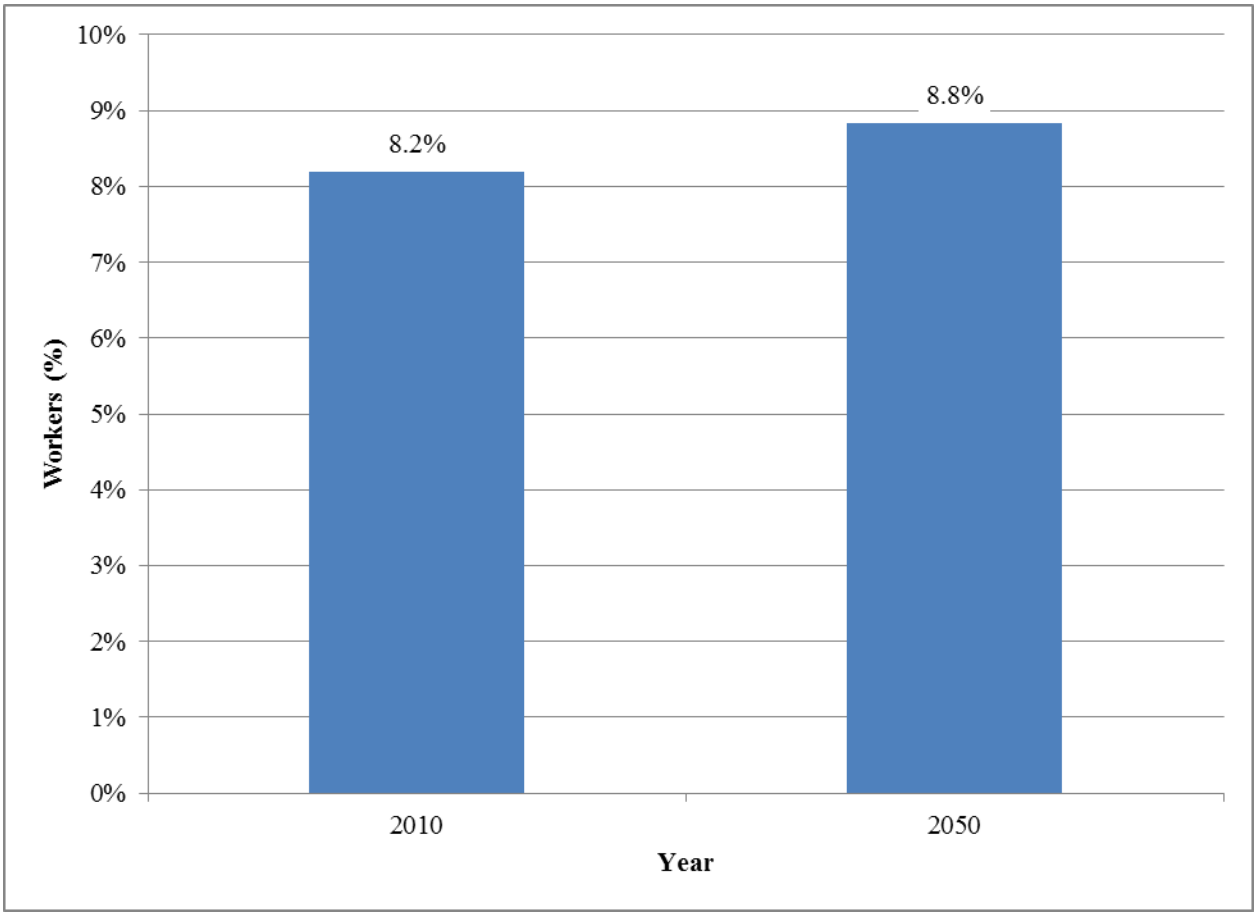

FIGURE 8 Actual and possible usage of alternative modes to work, U.S.
Sources: (2010) HRTPO processing of US Census ACS data (*29*) and (2050) HRTPO model ("PER2PUB- 100% sample- workers only- forecast.xlsx")

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