Fuels Institute

Driver Demographics

The American Population's Effect on Vehicle Travel and Fuel Demand

Fuels Institute

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The Fuels Institute hopes to set in motion a dynamic whereby people in the United States and elsewhere can have a more informed discussion. It is hoped that whether the reader is a business leader, store manager, policymaker, consumer, citizen, scientist, engineer or any other role of interest, that the analysis here can provide a common point of reference and a jumping-off point for new conversations.

Readers are welcome to write the Fuels Institute with their feedback on this report—criticism, praise, suggestions for improvement, new ideas, old ideas, data sources, analytical methods—all these forms of feedback, and more, are welcomed. The overall goal is to create a common sense of citizenship, through catalyzing creative, fact-based conversations that can elevate the level of the dialogue.

Comments should be direct to John Eichberger, executive director of the Fuels Institute, at jeichberger@fuelsinstitute.org or (703) 518-7971.

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About the Author

This report was prepared for the Fuels Institute by Hart Schwartz, who served as research coordinator for the organization from June 2013-December 2014. He is now an external research associate and continues to work on projects for the Fuels Institute as an independent contractor.

Driver Demographics

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Executive Summary

This report analyzes the historic growth and stabilization of vehicle-miles traveled (VMT), through a demographic examination of drivers and driver behavior. The demographic variables of gender, age, income, wealth and employment were examined. Figures 1 and 2 show one of the major motivations for undertaking this study.

Fuels Institute participants asked what is happening with Millennials' shifting travel patterns, but it turns out that Millennials' patterns fit into much more comprehensive patterns of the entire population. Total annual VMT has had an historic stabilization since the mid-2000s, even in the face of a continually growing population. This study examines this stabilization through the demographic lenses of drivers and how they behave.

The following equation is the bulwark of the report:

Aggregate Annual VMT = (Number of Drivers) × (Annual VMT per Driver)

This equation has been brought to bear on every demographic variable, and related back to the graphs below, to present a coherent picture of what has happened.

At certain times in this study, the equation was phrased more conceptually, as follows:

VMT = (Drivers) × (Driver Behavior)

A major purpose of this study is to systematize this knowledge in one place. Another purpose is to determine "what can be known, what cannot be known," so that the fuels and vehicles industries can understand the overall

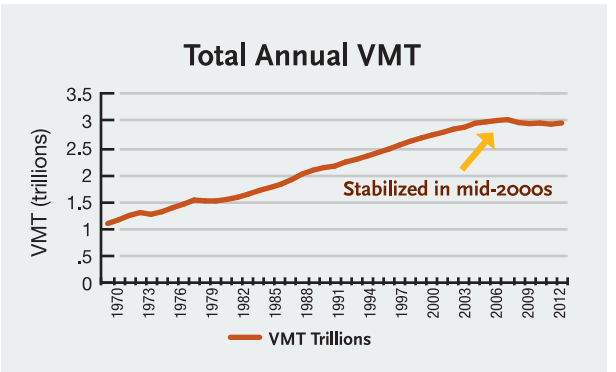

Figure 1: *Total Annual VMT*
(Source: Federal Highway Administration)

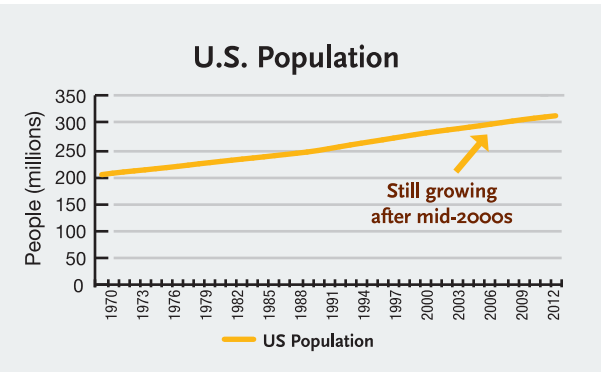

Figure 2: *U.S. Population*
(Source: U.S. Census Bureau)

scope of the data available to analyze transportation patterns. Both the data and the gaps in the data are instructive.

Summary of Findings

In short, the common thread tying together all of the impending market changes and paradigm shifts of the fuels and vehicles industries is that *transportation demand has stabilized after a century of continuous growth*. The natural capacity of almost every VMT growth factor related to drivers has been reached, with the exception of general population growth, and even population growth alone will be constrained by the natural limits that have been reached by the other growth factors.

Female drivers made historic progress before plateauing by the early 1990s, and while Millennials have fallen off from their predecessor 20-somethings, it is a mild fall-off that has been offset by the unprecedented increase in driving by older Americans. Nevertheless, all age groups stand near natural saturation limits of driver licensing and driving distance. The widening income inequality in the United States is not helping matters either, since it is encouraging saturation of travel demand amongst the affluent, and choking off travel demand amongst the majority of Americans who are middle-income or low-income. Given all of these constraints, population growth alone is not sufficient to reproduce the steep VMT growth curve that existed throughout the 20th century and lasted through 2005 or so (although it may produce a gently upward sloping VMT curve, particularly if and when the economy recovers more strongly).

As alternative fuels are introduced, the markets for individual new fuels will fragment the existing market—the transformation of the fuels industry will occur within a context of fixed transportation demand—a process that can be coined as *"transportation within a context of saturation."* Moreover, as alternative vehicles that double their fuel-efficiency to 50 mpg or greater become commonplace, the total consumption of motor fuels could be cut in half or even in quarter, thus rendering the fragmentation of the fueling market an even sharper problem. This is a disquieting situation, a strategic business quandary, which necessitates further research into vehicle travel demand and fuel-efficiency, the two major components that affect fuel consumption.

THE BALANCE SHEET

"DRIVING SOCIETY": While the amount of drivers continues to grow in aggregate, drivers as a percentage of overall population has leveled off. Historically, the amount of drivers as a percent of population grew rapidly until 1980. Since then, it has plateaued at around two-thirds of the general population, and 87%–88% of the population age 16 and over.

FEMALE DRIVERS: The growth of female drivers was an historic, non-repeatable trend between 1949 and 1980. Its evident saturation since 1980 has neutralized a major factor in overall VMT growth.

AGE: The aging of the Baby Boomers may turn out to offset the decline in Millennials' driving. The Baby Boom generation has known the highest driver licensing and vehicle travel rates in history. This may continue into advanced ages, in comparison to previous generations.

INCOME: There is an unequivocal link between personal travel and income: The higher the household income, the more household travel that occurs. The link between personal travel and national income is less clear: Sometimes aggregate VMT falls off during a recession, and other times aggregate VMT actually increases during a recession.

WEALTH: Older generations seem in general to have gotten wealthier with respect to younger generations. This is a contributing factor to the possibility that Baby Boomers may end up driving more at advanced ages than any previous generation.

LABOR MARKET TRENDS: The principal labor market variables of labor-force participation and unemployment rates, have a stronger correlation with the VMT of age-specific cohorts than with the aggregate national VMT of all drivers put together.

THE BOTTOM LINE: SATURATION
The common thread—the thread which ties all of the above together—is saturation.

A key concept to understand is the non-repeatability of saturation. Once something is saturated, it's saturated. It can never again be a significant factor of growth, unless that variable is completely destroyed and re-created. Saturation gives vivid meaning to the "creative destruction" paradigm of capitalism, famously proposed by economist Joseph Schumpeter.

Discussion and Analysis

These findings can be translated into the driving equation presented throughout the study:

Aggregate Annual VMT = (Number of Drivers) × (Annual VMT per Driver)

Applying saturation into the driving equation, the following statements are true:

- The driving pool is saturated, particularly due to the non-repeatable increase in female drivers, but also due to the massive increase in older drivers.
- Driver behavior among younger drivers is not currently saturated, but that is only because it has receded from multi-decade plateaus.

Given that both the driving pool and driving behavior are very close to their long-term natural limits, the bottom line is that U.S. driving is occurring at very close to full capacity, and this is a major overarching factor underlying the longest plateau in driving in recorded history. Nearly every growth factor for VMT seems to have reached its natural limit. The economic crisis of 2009 is only a blip, because by 2004 or 2005, driving had already started to plateau. It seems that driving was already occurring at full "natural capacity," or very close to it, and that the Great Recession created a "slip" away from this full capacity. A return to the very low unemployment rates of the early 2000s may return some of the lost VMT, but it will not cause the steep increases in VMT seen at various times throughout the 20th century.

The only real growth factor left available, in terms of the driver population, is general U.S. population growth. While general growth of the population will certainly have some effect on aggregate VMT growth during the next several decades, this will not change the fact that the driving population, as well as driving behavior, seem to have reached a long-term "natural capacity." On a per-capita basis of behavioral trends *per driver*, nearly every growth factor is saturated, particularly when one takes a longer historical view.

Strategic Context of Market Saturation

The fuels and vehicles industries are currently entering a period of massive, dynamic paradigm shifts, which may last a generation or two. Uncertainty is high. Nobody quite knows what business models will prove successful as alternate fuels and drivetrains mature.

Combining this transformative moment, with the above trends of saturation, reveals the essence of the situation: **"transformation within a context of saturation."** This means, practically speaking, that the paradigm shifts that are underway will take place within the overall context of a relatively fixed end-user market. The transformational technological changes already underway will give rise to strategic business problems of market fragmentation. How to pay for multiple, parallel infrastructures—of petroleum, electric, hydrogen, diesel, natural gas, biofuels or whatever else—will be vastly complicated by the fact that these parallel worlds will serve an end market which is not growing very rapidly, if at all. Everything will change except for the total amount of consumers. If one considers fuel-efficiency gains, it is even possible that the market could ultimately be chopped in half or further, thus prompting a slowly-unfolding crisis of sorts.

To restate: "transformation within a context of saturation" is the strategic business insight to "take away" from this report. Everything will change except the total amount of consumers and the total amount of driving that they do.

To read in-depth about the supporting details of this thesis, look at female drivers in the Gender section; older drivers in the Age section; income inequality in the Income and Wealth section; and at labor-force participation and unemployment trends within the Labor Market section.

To read more about how this defines a focus for future studies, read about Parallel Populations at the end of Labor Market Trends.

Introduction

This report analyzes the historic growth and stabilization of vehicle-miles traveled (VMT), through a demographic examination of drivers and driver behavior. The demographic variables of gender, age, income and wealth will be examined, as well as the labor market trends of labor-force participation and unemployment rates.

The pivotal importance of demographics becomes clear in framing the market development problems facing the future of fuels. This study sets up a broad, integrative new framework for objectively understanding the underpinnings of the future of transportation. In order to achieve long-term sustainability, wearing the lens of demographics and connecting it to the additional lens of mass consumer markets can be a pivotal tool.

This study mostly focuses on numbers, but there are interludes of reflective commentary sprinkled throughout. Numbers are necessary but not sufficient. Statistics must be placed within a broader context of history and future, business and policy, strategy and sustainability.

Why Use VMT as the Major Statistic?

Fuels are consumed when drivers drive vehicles. Fuels are consumed at a predictable rate, according to the following equation:

$$\text{Fuel Consumption} = \frac{\text{(Vehicle-Miles Traveled)}}{\text{(Fuel Efficiency)}}$$

A major problem facing the fuels and vehicles industry is that gasoline sales volumes have been steadily declining since 2007. While this has been related to increasingly tough fuel-efficiency standards, the above equation shows that fuel-efficiency is not the only variable at play.

The numerator—VMT—is perhaps the best-tracked variable in all of transportation. The federal government has annual VMT records dating back to 1900. It is the fundamental variable used for long-term transportation planning. VMT is central, in short, to any serious discussion of the future of transportation. It sizes market demand, expresses total vehicle and roadway usage and has direct implications for energy consumption, pollutant emissions, air quality and climate change.

To better understand the implications of declining fuel consumption, the fuels and vehicles industry need to look at VMT instead of fuel consumption, since fuel consumption is derived from VMT. Fuel consumption is a derived demand, and this begs the question: *If fuel demand derives from VMT, then what are the determinants of VMT?* That is why this study focuses specifically on VMT. It is a deceptively complex variable with all sorts of complex inputs. It is absolutely not true that variables such as unemployment, national income or labor-force participation are the sole determinants of VMT, or that these variables have always had a meaningful correlation with VMT. It turns out, rather, that there are powerful demographic inflections that historically have influenced the aggregate level of VMT, and therefore

the market demand for both motor fuels and motor vehicles.

The open question currently is what has happened to cause the historic leveling off of VMT since the mid-2000s? In the entire history of this variable, since the dawn of motor transportation in 1900, it has never known as long of a period of stagnation since 2007, not even during the Great Depression. (Figure 3)

The pattern is very striking. Even during the Great Depression of the 1930s, VMT continued to relentlessly increase. Even during the oil crises of 1973 and 1979, there was only a year or so of plateau in VMT—and then it kept rising. This raises the obvious question: *What's different recently?* For those who may look at the years 1900 to 1920 in Figure 3, and notice the flat line, this flat line actually becomes a curve of exponential growth, when properly drawn to scale.

The obvious question to ask is whether the overall market has become completely and totally saturated, and if so, why. What can a thorough, comprehensive examination of the past tell us about prospects for the future?

Broader Purposes of Study: Common, Objective Frame of Reference

This study seeks to conduct an examination of the past, but with a strategic eye towards the future. An enormous amount of alternative transportation technologies are rapidly developing, but market development in the United Sates and around the world has been very slow. One of the major obstacles to market development has been a common frame of reference for understanding the practicalities in a way that can catalyze large-scale, sustainable change.

This study aims to provide a common frame of reference, and to clearly situate the context. This ought to reduce uncertainty and enable business leaders and policymakers to more effectively link facts to strategies.

Methodology: History and Demographics

For a scientific study of this nature, it is necessary to say a few words about the methodology.

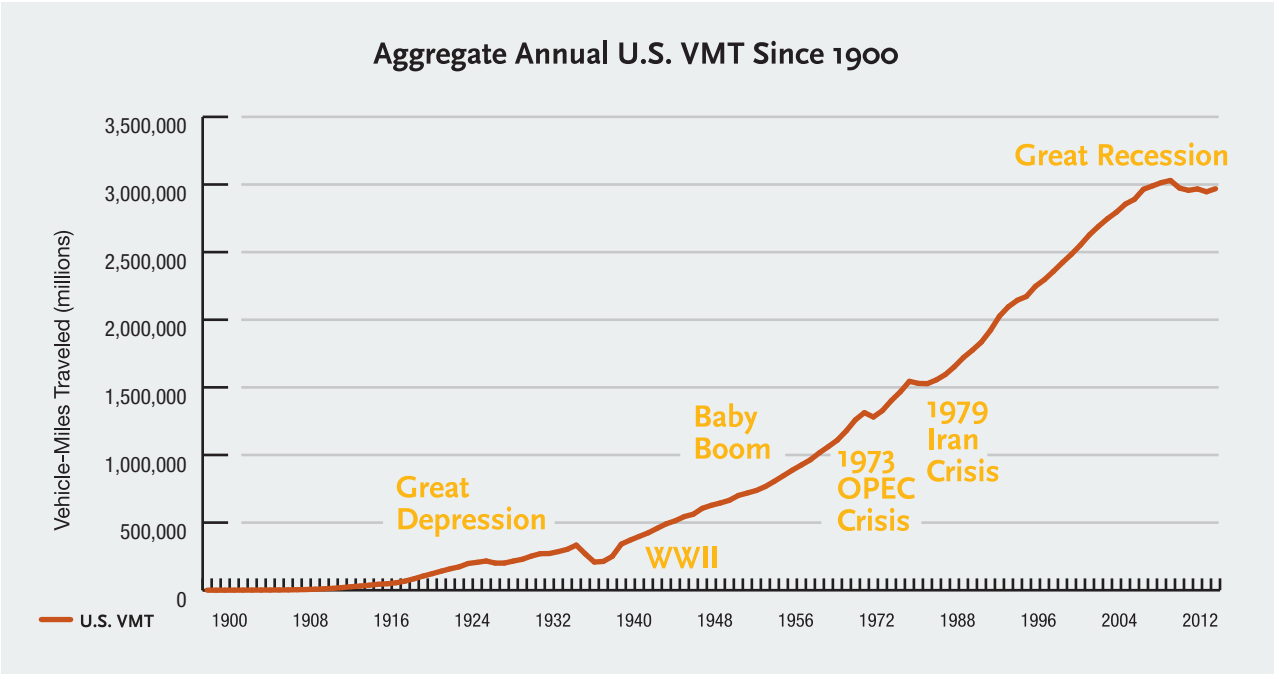

Figure 3: *Aggregate Annual U.S. VMT Since 1900 (Source: Federal Highway Administration)*

History

One primary method is an exhaustive historical examination of the available data. The analytical purpose is to take a long historical view to clearly isolate the episodes of transformative change against the backdrop of "business as usual." A long view of history enables us to distinguish "trends worth paying attention to" from "business as usual."

The metaphor of the foreground and background of a painting is useful here. If one looks only at a small section of a painting, it is possible to miss the larger significance of what is being communicated. For example, focusing attention exclusively on a tree in the foreground of a painting may miss the point of either a serene sunset or a thunderous rainstorm in the background.

So it is with data. Focusing attention on only a few years' worth of data can miss the larger trend in which those years are situated. That is why this study has gone as far back in time as possible. The time period covered is roughly the last half-century. Most data stretches back to the 1960s, and where it doesn't, this is only due to lack of availability.

Demographics

Demographics lies at the heart of the study. The discipline of demographics can be defined as the analysis of large-scale populations according to their rates of aging and the resultant growth, decay or stability. This study uses age as a central axis for understanding all of the other demographic variables, and provides age-based breakouts wherever possible. The concept of "cohorts versus generations," which is explained in-depth in the Age section, is an indispensable tool.

Another aspect of demographics involves the segmenting of sub-populations to understand behavior. This study uses the variables of gender, age, income, wealth, labor-force participation and employment to see how targeted populations correlate with vehicle-miles VMT. The goal is to see what effect the *demographic* variables have had on the behavioral variable, or *performance* variable, of vehicle-miles traveled.

Another way to say it is that the demographic variables are the independent variables, and VMT is the dependent variable. This is too simplistic, though, because often there are reciprocal feedback effects between VMT and the demographic variables. As such, it is important to keep in mind that "correlation does not mean causation," and that even if correlation is highly suggestive of causation, it may in fact be a two-way, reciprocal causation.

Relevancy

History and demography provide a sort of calibration. Taking a look at demographic trends over long periods of time can help place them in much clearer relief, and to separate out temporary uncertainty from genuine long-term transformations. This long-term perspective can help ground some of the massive uncertainty facing today's industry, as alternative fuels and drivetrains become more conventional.

An overarching goal is to reduce uncertainty, which can help channel investment into the most productive, least wasteful business activities, and aid policymakers to convert abstract data into concrete, useful regulatory frameworks. The practical application is that this can help identify how your markets are changing, and where your most sustainable market opportunities may lie in the future.

Notes on the Data

The data presented in this study are all publicly available, downloaded from various government and university websites.

The most important data source is the Federal Highway Administration (FHWA), a department of the US Department of Transportation. The FHWA's *Highway Statistics Series* has tracked VMT annually since 1900; driver licensing since 1949; accident rates since 1900; public road mileage since 1900; paved / improved roadways since 1904; and a variety of other factors.

In addition, the FHWA is responsible for conducting the National Household Travel Survey (NHTS), which is a survey of driver behavior performed every six to eight years since 1969. (Note that in 1969 the NHTS was performed by the U.S. Census Bureau and it was called the Nationwide Personal Travel Survey, or NPTS, until 2001.) The most recent iteration of the NHTS was conducted in 2009, and the next iteration is due in 2015. Due to the structure and timing of this survey, many of the behavioral charts presented in this study end in 2009 and do not have annual data points.

The reason that the NHTS is conducted so infrequently is because it is a massive undertaking, roughly similar in

scope to the U.S. Decennial Census; the cost of an annual survey would be unaffordable. A helpful consequence of conducting the NHTS only every six to eight years is that the more time that has elapsed in-between surveys, the more likely it is that significant, meaningful changes may have occurred. Nevertheless, there is some loss of sensitivity in the data enumerated. The NHTS's lack of annual frequency can sometimes raise compelling questions of what happened in the meantime and when specifically did the tracked changes actually occur. Despite these limitations, it is an extremely comprehensive, useful study which provides the bulk of data for serious transportation researchers.

Other data sources for this study include the U.S. Census Bureau, in the form of the Decennial Census and the Bureau of Labor Statistics (BLS). These sources provide extremely useful data on the general demographics of the U.S. population. The BLS focuses especially on the over-16 population, which also happens to coincide by-and-large with the legal driving population.

Special mention must be made of the National Historical Geographic Information System (www.nhgis.org). This unique repository proved indispensable for exploring the massive amounts of historical census data. The NHGIS is a free online database maintained by the University of Minnesota Population Center. It organizes enormous amounts of census data going all the way back to 1790. The NHGIS is cited in this study for graphs where it was directly utilized, but even where not cited directly, it lurks in the background as an essential contextual tool for obtaining a clear understanding of the topic matter.

The Growth in "Driving Society"

Total Number of Drivers

The first and most straightforward way to explain the historic trends in VMT is through examining the driving population—i.e. the raw number of licensed drivers.

VMT can be stated as follows:

Aggregate Annual VMT = (Number of Drivers) × (Annual VMT per Driver)

Clearly, the raw number of drivers will have a tremendous effect on scaling up to overall VMT.

The official annual source for licensed drivers is the Federal Highway Administration (FHWA), which collects annual driver license registrations from every state DMV and publishes these figures on its website. Data is available since 1949. (Figure 4)

The data shows a consistent upward trend, with perhaps some stabilization occurring since 2009 or 2010. The most obvious explanation of the long-term growth in "driving society" derives from general population growth. The U.S. population has grown at a very steady rate. (Figure 5)

But this does not tell the whole story. The graphs of raw numbers camouflage the vastly different growth rates of the driver population versus the general population. A graph of

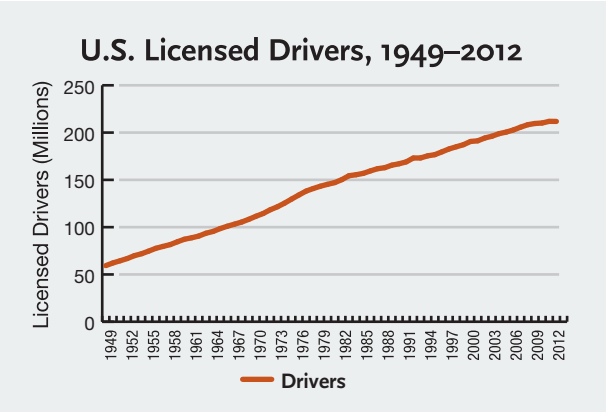

Figure 4: *U.S. Licensed Drivers, 1949–2012 (Source: Federal Highway Administration)*

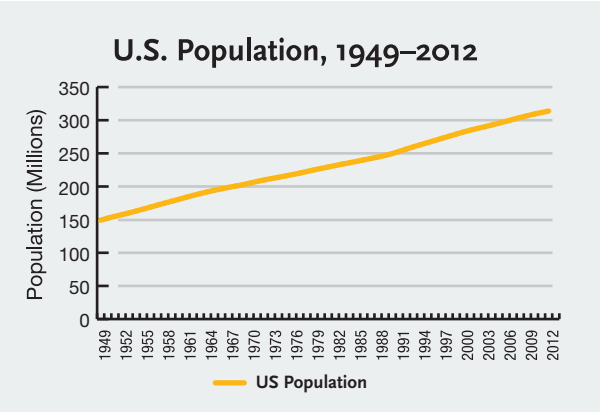

Figure 5: *U.S. Population, 1949–2012 (Source: U.S. Census Bureau)*

the indexed growth rates of each, with 1950=100, shows that the driver population has grown at a much more rapid rate than the general U.S. population. (Figure 6)

The critical question, in terms of examining potential saturation trends, is what proportion the licensed drivers comprise out of the overall population, and whether that proportion has been changing? (Figure 7)

As Figure 7 makes clear there was a dramatic increase in drivers as a percentage of the population from 1949 through approximately 1980. *However, since the early 1980s, the proportion of drivers has leveled off to about two-thirds of the U.S. population.* If we limit ourselves to strictly the proportion of drivers in the age 16 and over population, we obtain a similar pattern. (Figure 8) This graph, too, shows rapid growth followed by saturation.

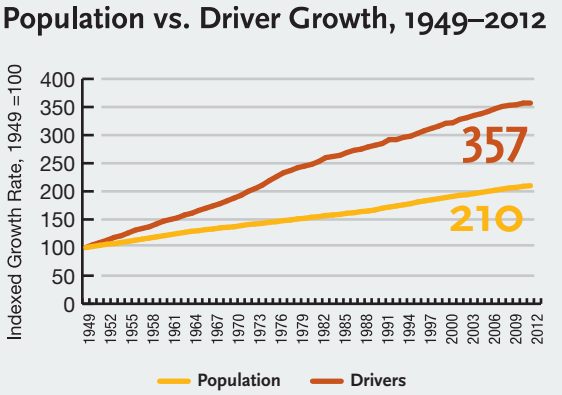

Figure 6: *Population vs. Driver Growth, 1949–2012 (Sources: Federal Highway Administration; U.S. Census Bureau)*

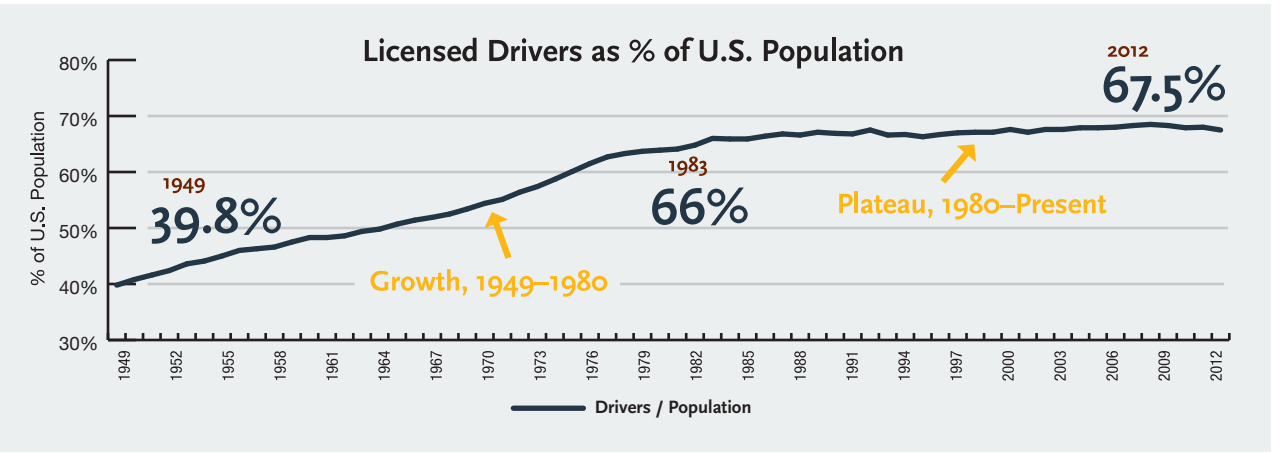

Figure 7: *Licensed Drivers as % of U.S. Population (Sources: Federal Highway Administration; U.S. Census Bureau)*

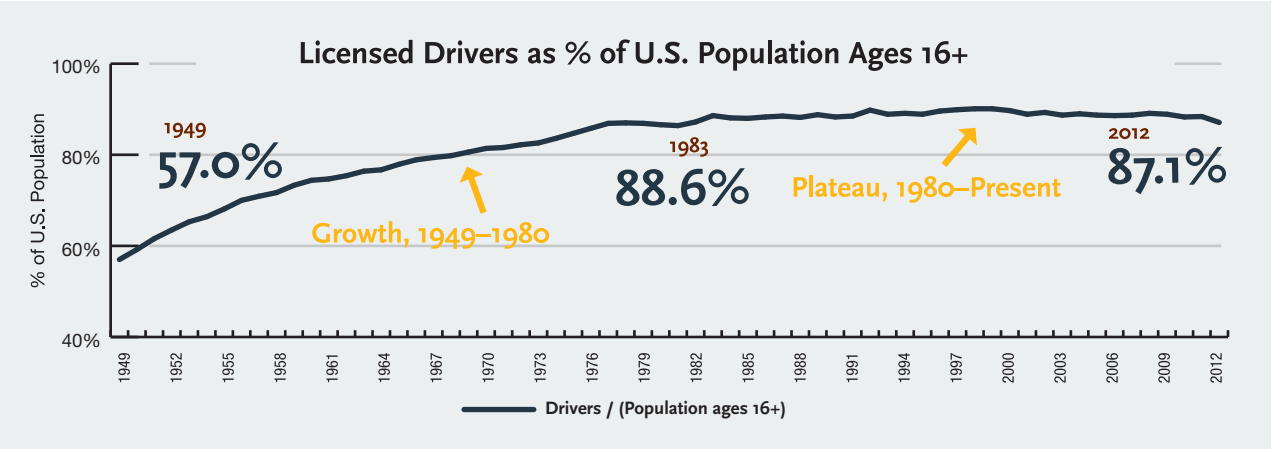

Figure 8: *Licensed Drivers as % of U.S. Population Ages 16+ (Sources: Federal Highway Administration; U.S. Census Bureau)*

Driver Behavior

The driving equation will be restated:

$$\text{Aggregate Annual VMT} = \text{(Number of Drivers)} \times \text{(Annual VMT per Driver)}$$

$$\text{VMT} = \text{(Drivers)} \times \text{(Driver Behavior)}$$

An overall view of driver behavior, in the form of annual VMT per driver, can be obtained by dividing aggregate VMT by the number of drivers:

$$\text{Driver Behavior} = \text{Annual VMT per Driver} = \frac{\text{(Aggregate Annual VMT)}}{\text{(Number of Drivers)}}$$

If one takes all of the FHWA's tabulated data and does the calculations, it reveals a significant disruption to per-driver VMT during the oil crises of the 1970s. (Figure 9) This means that the increases in VMT during the 1970s were driven more by population growth than by behavioral changes of the average driver. Nevertheless, driving picked up again in the mid-1980s, and per-driver VMT steadily rose until beginning to decline in the mid-2000s.

Overall, the long-term growth has been staggering. The average American driver travels nearly twice as far, annually, as in the middle of the 20th century.

Summary of "Driving Society": What Has Caused These Patterns?

The above section on the growth of driving society has shown long-term growth followed by historic saturation, in both the amount of drivers and the amount of driving done by the average driver.

We are thus left with the questions:

- What caused the rapid growth in the proportion of drivers to population? Why has it become saturated?
- What caused the long-term growth in mileage per driver? What then caused the behavioral saturation?

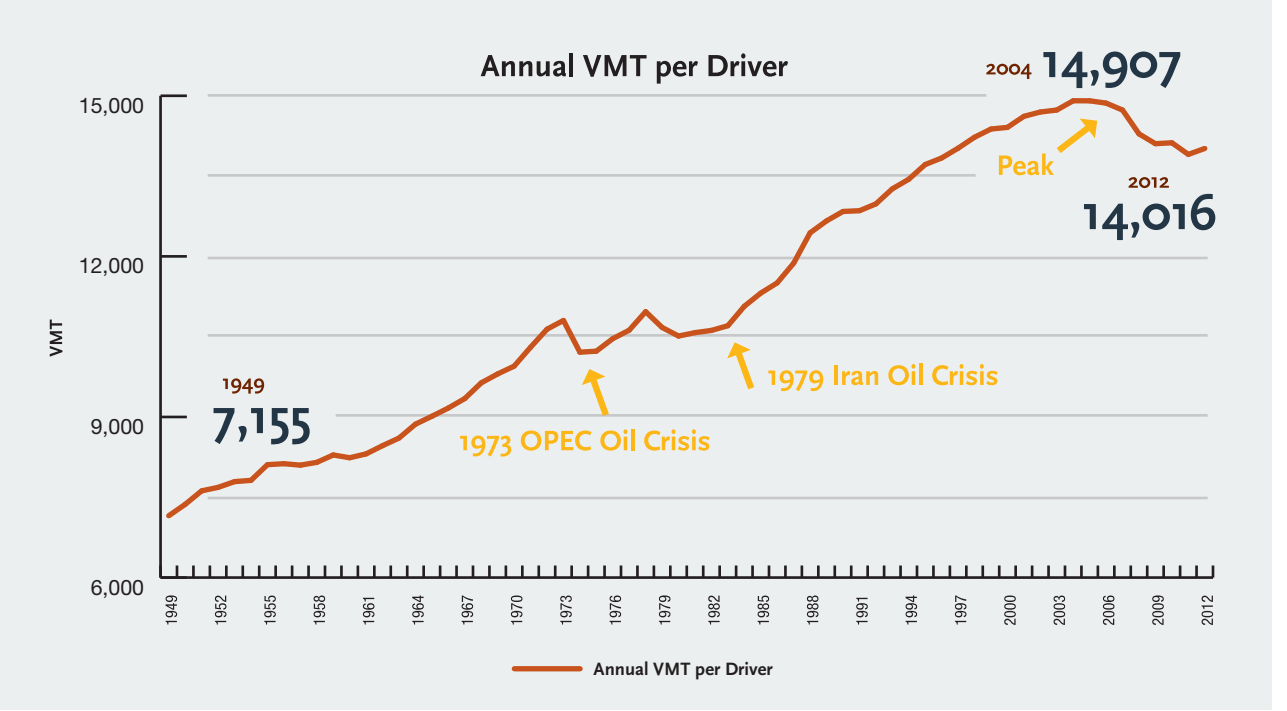

Figure 9: *Annual VMT per Driver (Source: Federal Highway Administration)*

Female Drivers Enter "Driving Society"

Total Number of Female Drivers

It turns out that the single biggest contributor to increased frequency of driver licensing, and increased VMT followed by saturation, has been the mass entry of women into the "driving society." Data on driver licensing by gender are available since 1963. (Figure 10, 11)

This saturation becomes even clearer if we look at the proportion of females who have drivers' licenses out of all females who are old enough to get one (i.e. older than 16). It seems that this has been stable since the early 1990s, and that nearly every female who wants a license has one. (Figure 12)

To summarize, we return to the equation of travel demand:

VMT = Drivers (Driver Behavior) = (Drivers) × (VMT per Driver)

We have seen that the amount of drivers as a percentage of the U.S. population, and as a percentage of the 16-and-over population, grew from 1949 until hitting saturation in 1980. Since 1980, roughly two-thirds of Americans have had a driver's license, and close to 90% of all Americans aged 16-and-over have had a driver's license. (Figure 13)

The major factor driving this trend has been women's mass entry into the driving pool. This is a non-repeatable trend; now that women have reached a longtime saturation

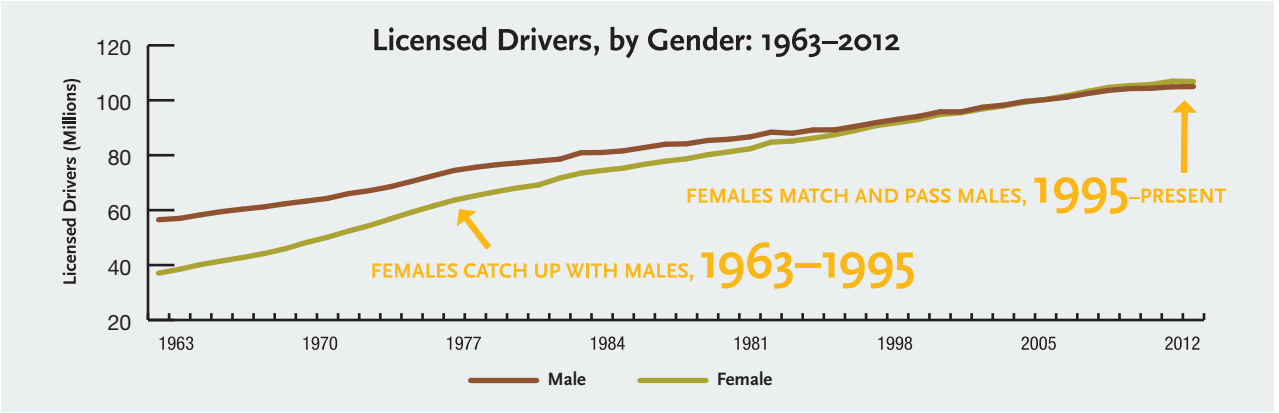

Figure 10: *Licensed Drivers, by Gender: 1963–2012 (Source: Federal Highway Administration)*

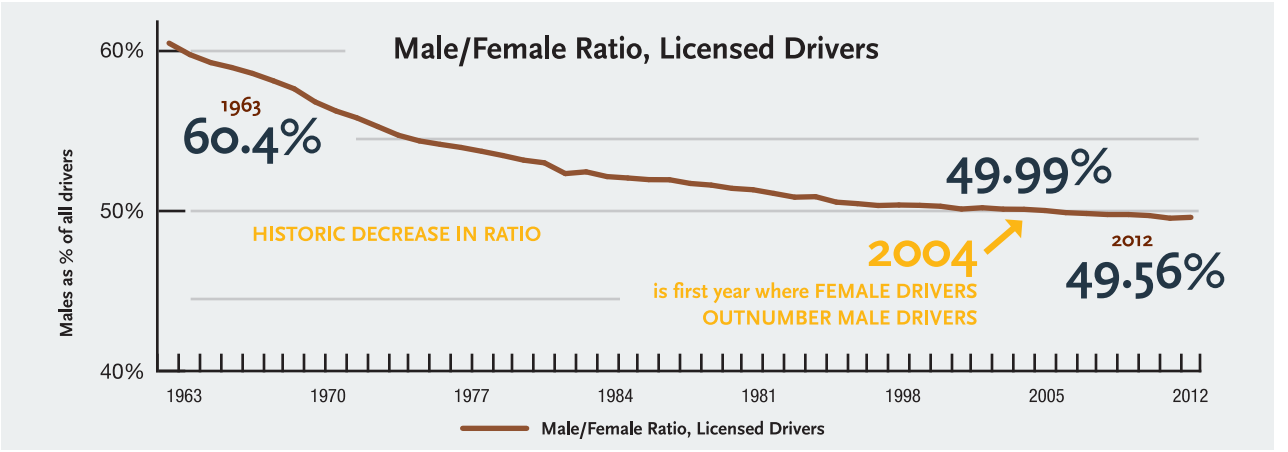

Figure 11: *Male/Female Ratio, Licensed Drivers (Source: Federal Highway Administration)*

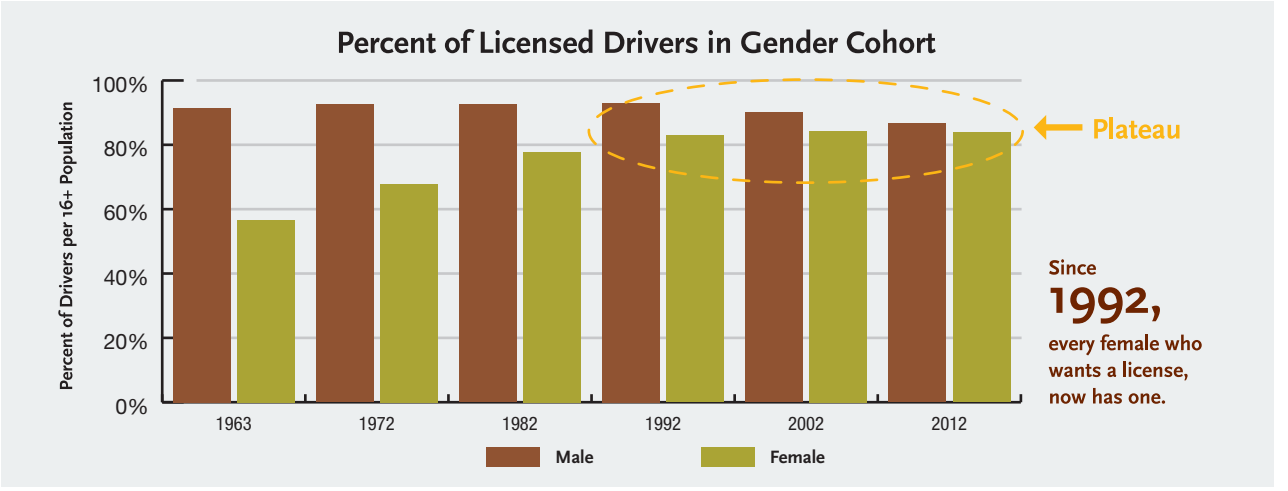

Figure 12: *Percent of Licensed Drivers in Gender Cohort (Sources: Federal Highway Administration; U.S. Census Bureau; Bureau of Labor Statistics)*

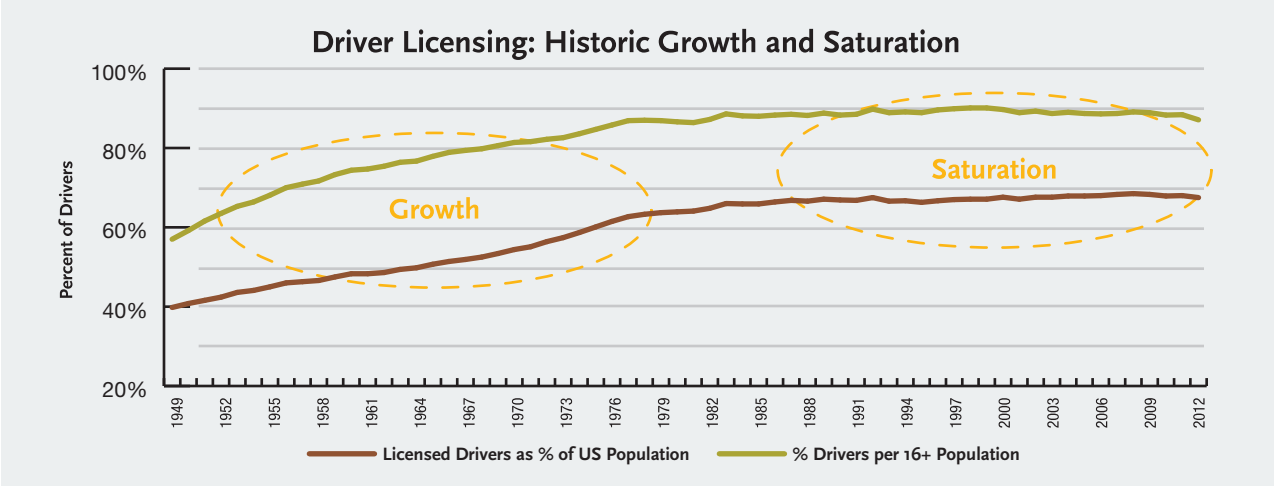

Figure 13: *Driver Licensing: Historic Growth and Saturation (Sources: Federal Highway Administration; U.S. Census Bureau)*

point, this trend is reaching its physical and arithmetic limits. It cannot happen again. For that reason, the entrance of female drivers will no longer influence VMT.

Driver Behavior for Females

The other piece of the equation is behavioral. The typical female driver has driven much further since the 1990s than previously. VMT per female shows the same pattern of dramatic growth followed by saturation. The National Household Travel Survey has studied this since 1969. (Figure 14)

A major reason for increased female driving has been that female participation in the labor force has risen dramatically since 1960. Figure 15 shows the respective percentages of males and females in the labor force, where the labor force is considered to be the percentage of age 16 and over, non-institutionalized Americans who are either working or seeking work.

Another lens is the so-called "gender ratio." This is the amount of males for every 100 females in a given population. Whereas there used to be 200 males for every female in the workforce, this has now equalized at roughly 115 males for every 100 females in the workforce, since approximately 1995. This contrasts with a sex ratio of about 90 males for every 100 females for the entire 16+ population. (Figure 16)

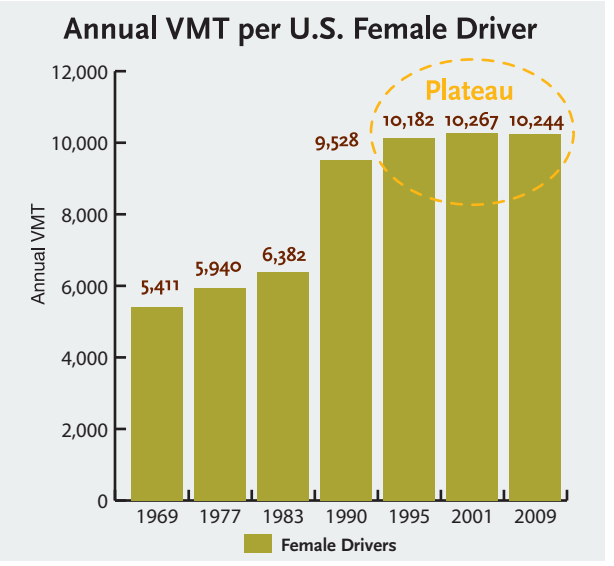

Figure 14: *Annualized VMT per U.S. Female Driver (Source: National Household Travel Survey,* 2009 Summary Trends)

Suburbanization and Growth of Female Drivers

Suburbanization is the other factor driving female entry into the driving pool and expansion of female VMT. Since the early 1950s, the vast majority of Americans have moved to suburbs, where an automobile is required in order to attend to the necessities of life, such as shopping, medical visits, dropping children at school, and so on. As a result non-working women have needed to get driver's licenses in order to manage daily family life.

It is extremely difficult to measure suburbs over time, primarily due to shifting urban boundaries. Figure 17 is the best effort that can be made at defining a historically comparable benchmark. "Suburb" here consists of all counties in a metropolitan area that are not considered to be within the core "central city." The figure of 158 million Americans in suburbs in 2010 is likely understated, since many so-called "central cities," such as Denver or Phoenix, are exceptionally auto-dependent with a very sprawling layout that most people would colloquially refer to as "suburban."

For the analysis of female drivers, the point is that there has been massive growth in suburbs. Consequently, more and more women have felt the need to obtain a driver's license, and those women who have a driver's license have felt more reason to drive on a day-to-day basis.

Summary of Female Drivers: Non-Repeatable Trend

The behavioral pattern of female driving is unmistakable: Growth followed by saturation. This is true both for the total number of female drivers, as well as the distance traveled by the average female driver.

The implication for further aggregate VMT growth is that a major growth factor has exhausted itself. The massive increase in female driving is a non-repeatable trend. If VMT is to continue growing, other sources of growth will need to contribute.

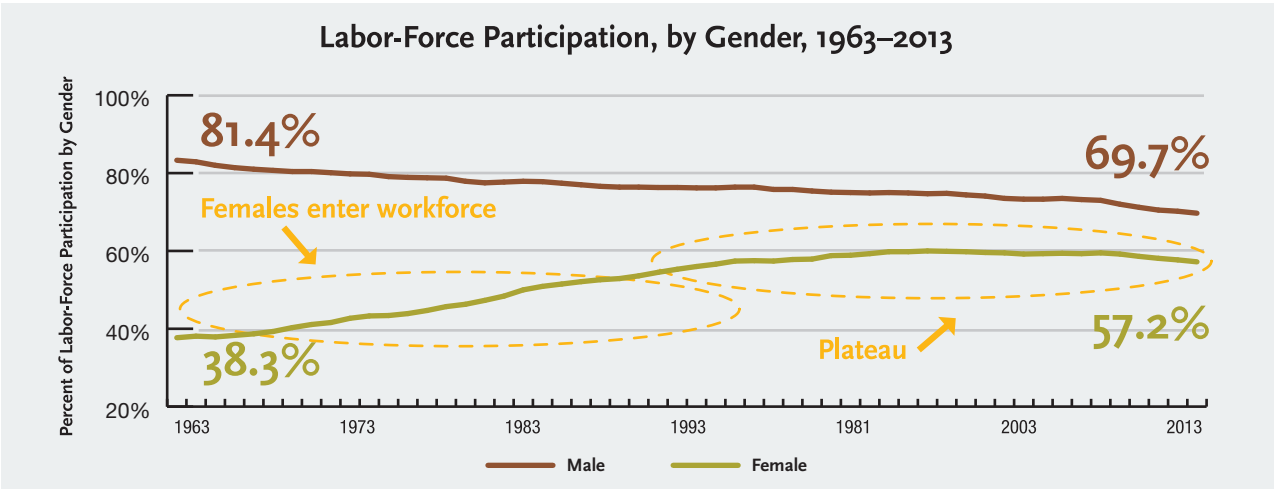

Figure 15: *Labor Force Participation, 1960–2012 (Source: Bureau of Labor Statistics)*

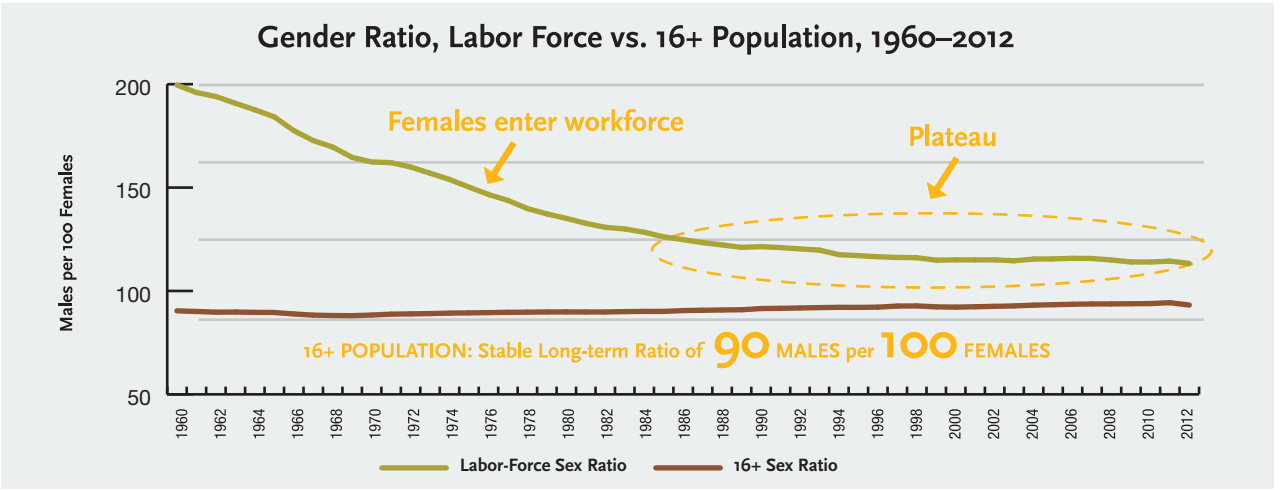

Figure 16: *Gender Ratio, Labor Force vs. 16+ Population, 1960–2012 (Sources: Bureau of Labor Statistics; U.S. Census Bureau)*

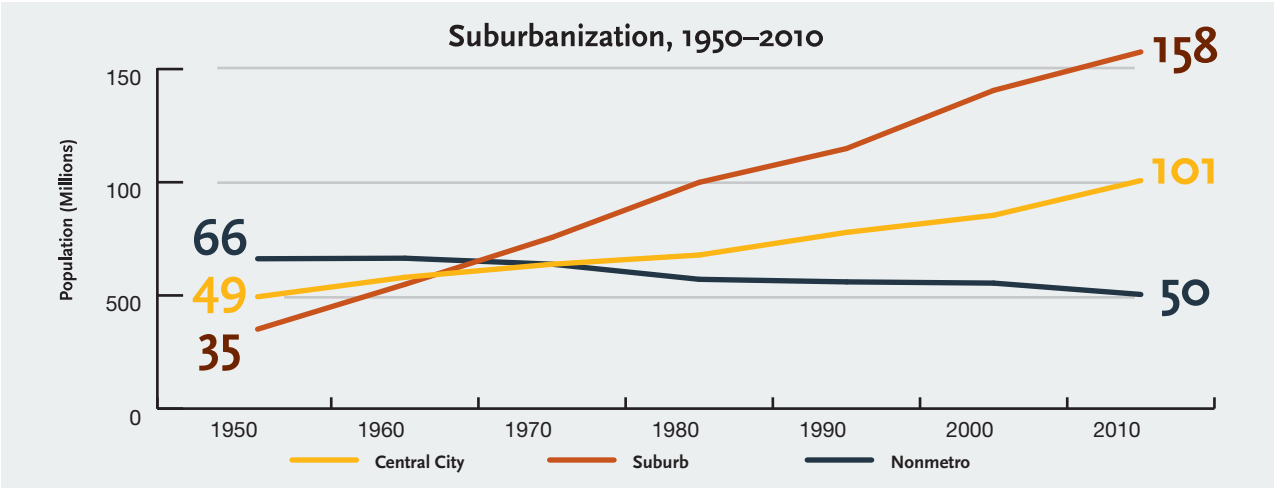

Figure 17: *Suburbanization: 1950–2010 (Sources: U.S. Census Bureau; National Historical Geographical Information System, University of Minnesota Population Center, www.nhgis.org)*

Age

The main finding of this section is that growth in driving by Baby Boomers may offset a decline in driving by Millennials.

This finding applies to the short-term, which in demographic terms refers to the next 20 years or so. In the long-term, over the next 40-60 years, it is unclear how the patterns of today's Millennial generation will cycle through the age structure of the driving population. If Millennials' patterns follow the traditional age-cohort patterns presented in this section, then Millennials will likely drive more as they get older, since out of all the ages of working adults age 20-64, the 20-29 cohort has the lowest rate of VMT per driver.

But the further we look into the future, the more it's possible for unforseen paradigm shifts to cloud the crystal ball. Who could have possibly predicted the advent of smart-phones? Who can know the effect that self-driving cars may have? America has long been a leader in aggressive development of innovative technologies, and it is likely that by the time that the Millennials retire, that many more groundbreaking technologies, unheard of today, will have been taken up in daily American life.

It is impossible to truly know. But to the extent that things remain the same—and in this regard, it is true that people will always be the ultimate components of markets—this section on age can aid in developing a consistent method of interpretation. The charts presented here establish long-term historical benchmarks that can structure future-looking analyses.

Cohorts Versus Generations

The main conceptual theme to watch running throughout this section is the tension between cohorts and generations.

A *cohort* is a snapshot of an age-grouping at any given period of time. For instance, 20-29 year olds in 1980, 1990, 2000 and 2010. The population within a cohort is always changing and will never repeat.

A *generation* is a group of people born in a set period of years that advances through every stage of life at the same time. For instance, the Baby Boom, consisting of everybody born between 1946-1964, is a generation. The individuals who comprise a generation are constant over time, even as the generation itself proceeds through different age stages of life.

The link between cohorts and generations is that a generation will "fill up" and then "empty" the age cohorts, as its members age. The upshot for driver demographics is the question of whether behavior is more constant across an age cohort or more constant across generations.

Practical Implications of Cohorts Versus Generations

In terms of generations: If Baby Boomers exhibited very high driver-licensing rates when they were young, will this continue into old age? If Millennials have exhibited very low driver-licensing rates when they are young, will this continue throughout adulthood and into old age?

In terms of cohorts: Will all drivers at the same age tend

Defining the Generations

	Born	Age in 2014
Millennials (Gen Y)	After 1980	33 and younger
Generation X	1965–1979	34–49
Baby Boomers	1946–1964	50–68
Silent Generation	1928–1945	69–86
Greatest Generation	Before 1928	87 and older

Figure 18: *Defining the Generations (Source: Pew Research Center, "Millennials: A Portrait of Generation Next")*

to behave in the same way, regardless of which generation they belong to? Do 20-somethings, 30-somethings, and so on, exhibit the same behaviors no matter which generation they belong to? Are there historic norms to which every generation seems to revert? Or are there norms which have been changing over time?

The Pew Research Center has made authoritative studies of Millennials and defines the generations as as shown above in Figure 18.

Linking to Transportation

The VMT equation is:

VMT = (Amount of Drivers) × (VMT per Driver)

This section will examine historical changes in the number of drivers and the VMT per driver for age cohorts in order to examine the effect of driver ages on aggregate VMT. In some cases, the Pew Center's generations will fit neatly into available data. Other times, it will not, and the best available approximations will be made.

Total Number of Drivers, by Age

Figure 19 examines age cohorts in the general population. It shows the overall pool from which the drivers come.

The chart shows the dramatic growth in the size of the 50-59 and 60-69 cohorts. It cannot be emphasized enough, that this growth is historic and unprecedented. The rolling of the Baby Boomers through the age structure of the U.S. population is having a profound effect on all manner of industries, and will have this effect for decades to come. Driving is no exception.

The chart also shows a steady upward trend in the raw number of 70 and 80 year olds. It seems that these groups are poised to swell even further as the Baby Boomers age.

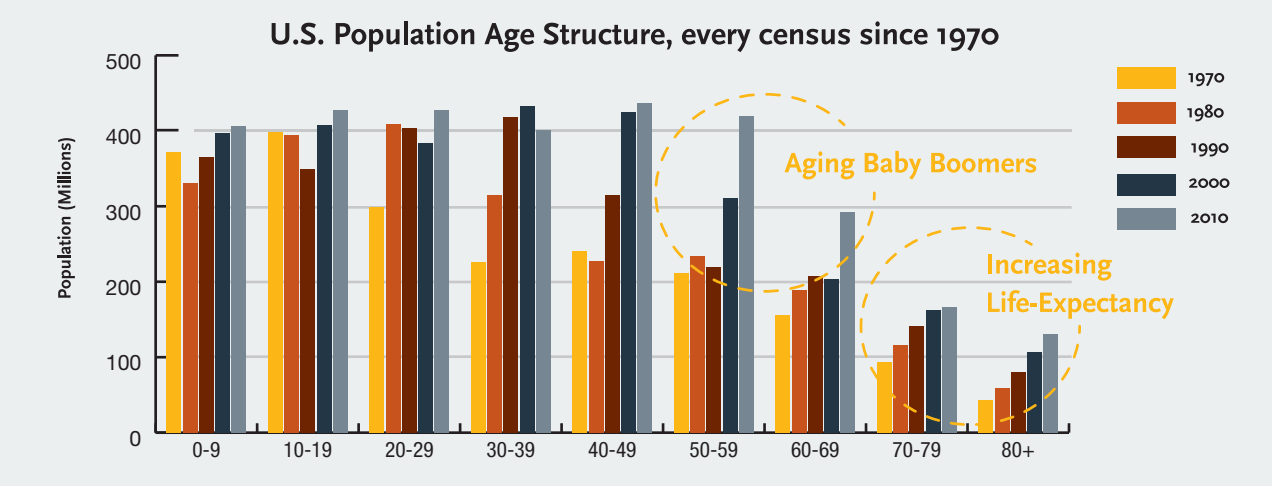

Figure 19: *U.S. Population Age Structure, every census since 1970 (Sources: U.S. Decennial Census; U.S. Census Bureau; National Historical Geographical Information System, University of Minnesota Population Center, www.nhgis.org)*

At the younger end, the chart shows the highest numbers ever of 10-19 and 20-29 cohorts in 2010, but this is only a marginal increase over the numbers of these cohorts in 2000. The 10-19 and 20-29 year olds of the 2010 Census are the first waves of the Millennials, born since 1980. These persons will cycle through and become the 30-39 year olds and 40-49 year olds of the 2020 and 2030 censuses.

There is an organic linkage between the Millennials and the Baby Boomers. Simply put, the Millennials are most frequently the children of the Baby Boomers (and to a lesser extent Generation X). This is why they have been referred to as the "echo boom." Together, these two generations—Baby Boomers and Millennials—rival one another in size, at roughly 80 million persons each.

What is unusual, though, and highly relevant to driving, is that the ballooning older cohorts, in the general population, are unprecedented. This should be kept in mind while reading this section.

U.S. Licensed Drivers by Age

The number of individuals with driver's licenses by age groups is presented in Figure 20, which shows the same dramatic, unprecedented growth in 50-year-old and 60-year-old drivers as does the Census data on the general population. In addition, the steady increase in 70+ drivers matches the steady increase in the over-70 population from the Census data.

At the younger end of the chart, the raw numbers of teenage drivers have actually been steady since 1970. The raw number of 20-something drivers actually increased between 2000 and 2010, while the raw number of 30-something drivers saw a substantial decrease of 5 million drivers. This is likely due to the smaller aggregate size of Generation X.

The overall trend of greatest importance, however, is the unprecedented growth in numbers of older drivers.

Per-Capita Driver Licensing: Propensity of Each Cohort to Have a License

The next step is to assess whether a person in a given age cohort has become more or less likely to obtain a driver's license. Figure 21A shows the proportion of people of any given age, sixteen and over, who have a driver's license.

Figure 21A shows a very striking pattern whereby licensing rates for ages 60-69 have gone from being second lowest of any age group in 1963, to the highest in 2012. This is a very noticeable inversion!

The other noticeable pattern is that of saturation. The highest plateau level for driver licensing seems to hover around 92%. The highest-ever level was 96% for drivers aged 40-49 in 1992. These are the very same drivers who comprise the 60-69 cohort in 2012. Clearly there has been a generational consistency, as the Baby Boomers have moved through the age structure.

Switching the axes for further clarity, the previous graph is restated in Figure 21B.

Whereas the age structure of drivers used to be heavily weighted towards younger drivers, older drivers have clearly caught up. People over the age of 70 have become just as

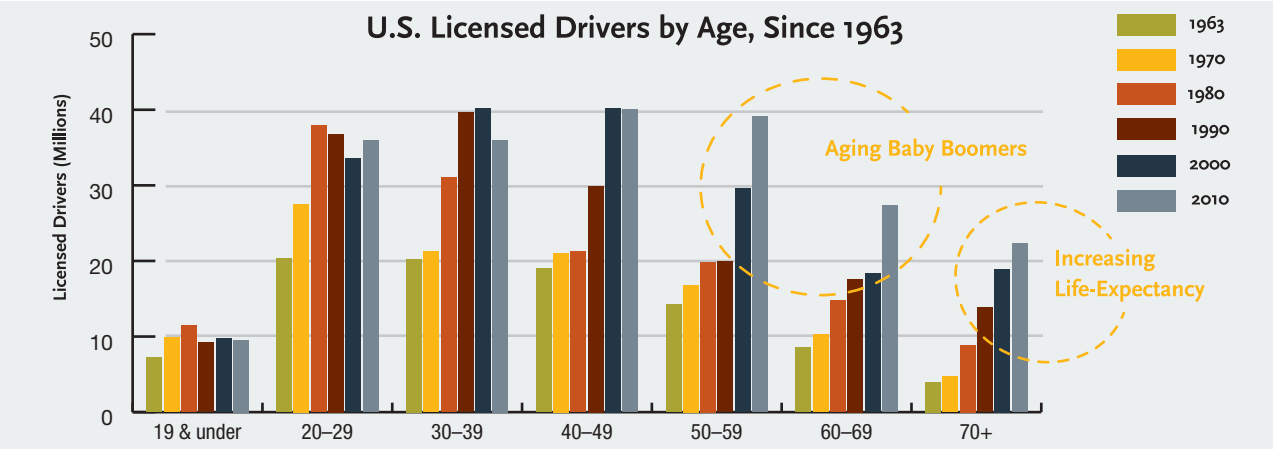

Figure 20: *U.S. Licensed Drivers by Age, Since 1963 (Source: Federal Highway Administration, Highway Statistics Series)*

likely to have a driver's license as people between age 20-29.

It should be noted that today's over-70 drivers, who had a 79.3% licensing rate in 2012, are the same individuals as the 20-somethings who had an 85.6% licensing rate in 1963. Today's 70-year-olds are the "Silent Generation," defined by Pew Center as born between 1928 and 1945. The historic increase in driver-licensing rates actually precedes the Baby Boom generation.

At the same time, the Baby Boom generation's advancement throughout the age structure has had a major impact on driver licensing rates. The record-high licensing rates of 20-something Boomers in 1972 and 1982 have cycled through and become the record-high rates of 40-somethings and 50-somethings in 2002, and of 50-somethings and 60-somethings in 2012.

In other words, there appears to have been some consistency in terms of a generation's advancement throughout the age structure. Nevertheless, there has also been some consistency in terms of the amount of driving done by any given cohort in any given year. The following section will break out trends in specific age cohorts.

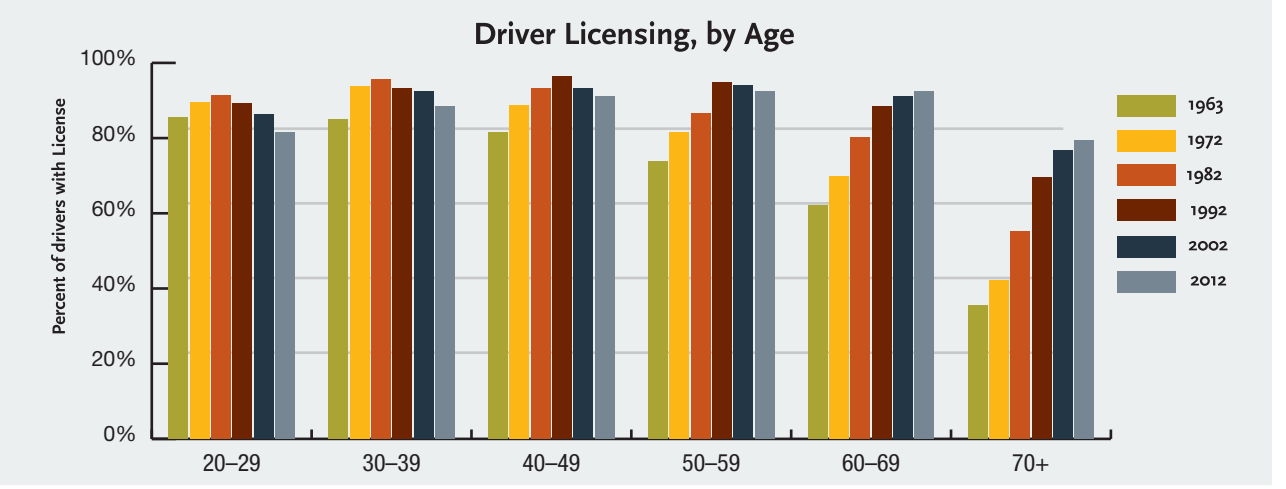

Figure 21A: *Driver Licensing, by Age (Sources: Federal Highway Administration; U.S. Census Bureau)*

Note: Drivers aged 16-19 could not be included in the graph because of missing FHWA data for 2000 and 2010.

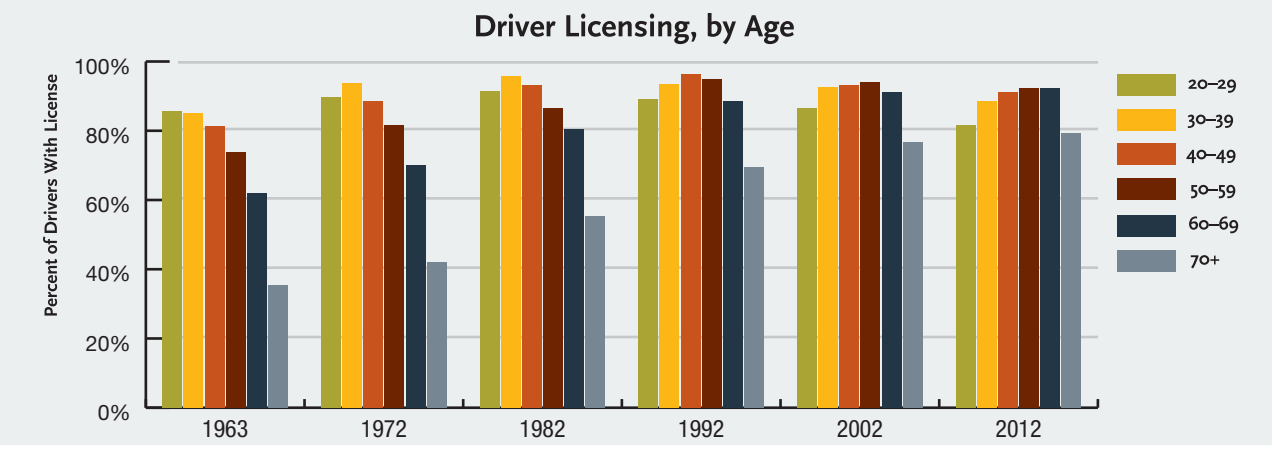

Figure 21B: *Driver Licensing by Age (Sources: Federal Highway Administration; U.S. Census Bureau)*

Specific Age-Group Breakouts

The report will now break out age groups more specifically. This will help to tease out the licensing patterns of age cohorts, as opposed to generations, and will add further texture to the question of whether it is the generation or the age cohort that matters most.

Teenagers

Every teenaged year, age sixteen and above, shows a steady decline in licensing rates since 1982. (Figure 22)

The year 2012 is particularly remarkable, in that licensing rates for 16 year olds sank to new lows of under 30%. It is likely that a combination of graduated licensing laws and cultural changes such as smart-phone use and "helicopter parents" have come together to have this influence. These factors may interact most acutely at age 17, the age which has shown the most precipitous, steadiest decline in driver licensing over time.

The overall licensing for age 16-19 is shown in Figure 23.

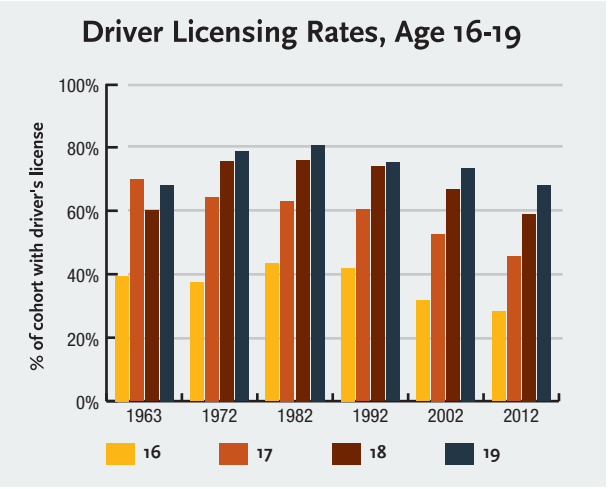

Figure 22: *Driver Licensing Rates, Age 16-19 (Sources: Federal Highway Administration; U.S. Census Bureau)*

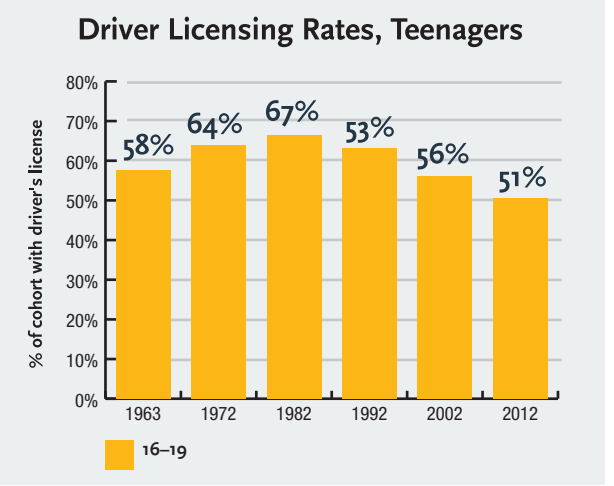

Figure 23: *Driver Licensing Rates, Teenagers (Sources: Federal Highway Administration; U.S. Census Bureau)*

Millennials / Young Adults

A key question asked by many relates to Millennials, that generation of people which was born between 1981 and 2000. This begs the question of how today's licensing rates for 20-somethings will change as these individuals mature into their 30s. Figure 24 gives historical insight.

The data show that if today's Millennials follow historic patterns, they will have higher driver licensing rates when they reach their 30s.

Since the early 1970s young adults in their 30s have consistently had higher rates of driver licensing than young adults in their 20s. Life milestones such as moving out on their own, getting married, having children, and simply a developing desire for more independence and convenience, probably have a systematic effect on increasing driver's licensing rates between age 20-29 and age 30-39.

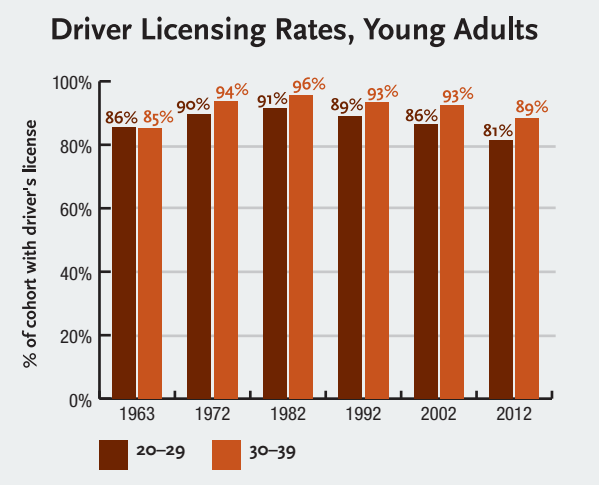

Figure 24: *Driver Licensing Rates, Young Adults (Sources: Federal Highway Administration; U.S. Census Bureau)*

Notwithstanding the difference between 20-29 and 30-39 cohorts, there is no doubt whatsoever that driver licensing rates have been declining for people in both their 20s and their 30s since all-time highs in 1982. The predecessors to today's Millennial generation were indeed more likely to have a driver's license, and same with the predecessors to today's "Generation X" (born between 1965 and 1979) who in 2012 were the primary occupants of the 30-39 cohort.

Middle Adults

The cohort of 40-year-olds was composed in 2012 mostly of Generation X, born between 1965 and 1979. The cohort of 50 year olds was composed entirely of Baby Boomers in 2012. (Figure 25)

The driver-licensing rates of these two groups have shown a long-term plateau at very high, total saturation levels since the early 1990s. Nevertheless, there has been a slight decline in 2012 from 2002, and a very slight decline in 2002 from 1992, respectively.

Older Adults

Figure 26 shows perhaps the most definitive pattern of all. Older drivers are undoubtedly increasing their driver licensing rate. It will be interesting to see if the 70+ cohort of 2022 approaches today's very high, saturation-level licensing rates for 60-69 year olds.

Summary of Driver Licensing by Age

Older adults have been getting and/or keeping their driver's licenses at very high, historically unprecedented rates. This may well offset the lower driver licensing rates of Millennials, particularly if the current crop of young adults follow the historic pattern of higher driver licensing rates in middle adulthood, and if today's adults in their 50s and 60s stick to their high, saturation-level driver licensing rates as they enter old age. If the catch-phrases "90 is the new 70" and "70 is the new 50" apply to the age structure of the driving population, then the emergence of older drivers may have a significant offsetting effect on the declining licensing rates of younger adults.

However, this covers a relatively short-term horizon, over the next 10 or 20 years. The graphs presented in this section are suggestive of longer-term trends as well. Both the Silent Generation (born 1928–1945) and the Baby Boom Generation (born 1946–64) have shown consistent driver-licensing patterns over time. Does this mean that Millennials will show consistent patterns as well? Does this mean that today's lower rates of Millennial licensing will lead to lower rates of driver-licensing by the 40-somethings of 2032 or the 50-somethings of 2042?

The truth is that any prediction several decades into the future is hazardous at best. Any number of paradigm shifts may occur to derail the predictions. Nevertheless, the fact that demographic patterns have already been tracked for

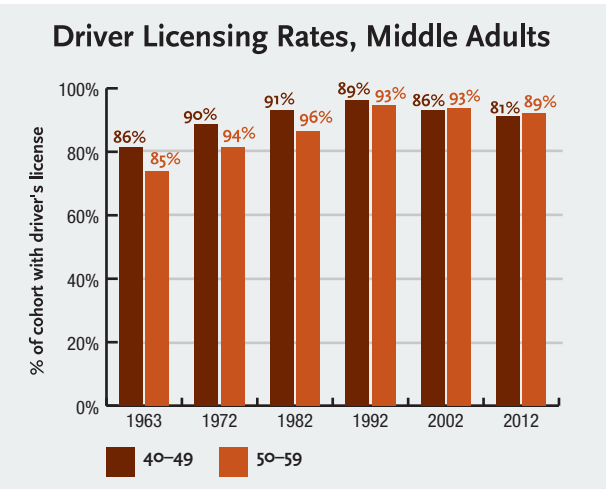

Figure 25: *Driver Licensing Rates, Middle Adults (Sources: Federal Highway Administration; U.S. Census Bureau)*

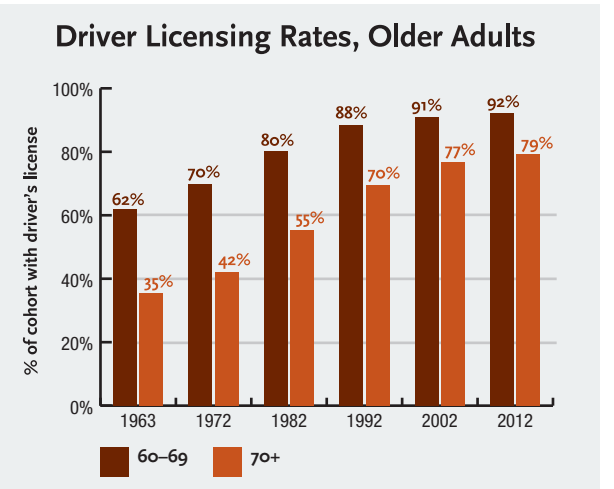

Figure 26: *Driver Licensing Rates, Older Adults (Sources: Federal Highway Administration; U.S. Census Bureau)*

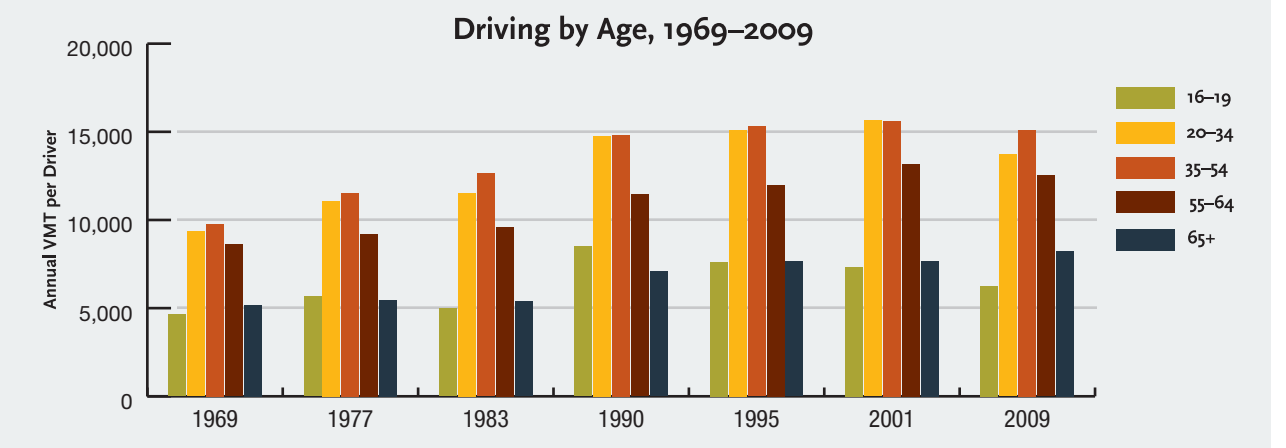

Figure 27: *Driving by Age, 1969–2009*
(Source: National Household Travel Survey, 2009 Summary Trends)

50 years means that at least a basic framework exists for interpreting the possibilities in the next 50 years. The following trends have been very clearly established in the age cohort breakouts:

- 30-somethings have higher licensing rates than 20-somethings
- 40-somethings and 50-somethings have the highest driver licensing rates
- Older drivers (60 and above) have higher licensing rates than ever before

What this implies for the Millennials is that their lower driver licensing rates are nevertheless likely to see some increases, and to remain relatively high in older age.

That is all well and good; but so far the discussion has only centered around the total number of drivers. There is a behavioral factor that is crucial: How far does each age cohort drive in a given year? The challenge of the next section is to look at driving behavior by age cohort, in order to determine how to properly weight the effect of driver licensing rates.

Driver Behavior by Age

Restating the driving equation,

$$\text{VMT} = (\text{Drivers})\,(\text{VMT per Driver}),$$

we've established that while the proportion of older drivers has been increasing, the proportion of younger drivers has been decreasing.

The next step is to look at each group's actual travel behavior. How has the proportion of each age group's vehicle travel changed over time?

Unfortunately, data on VMT per driver is unavailable in decade-on-decade age cohorts. Figure 27 is the best that can be presented. Overall, this chart shows 2001 seems to have been the peak travel year for adults age 20-64.

Every age cohort, with the exception of people age 65 and over, dropped in VMT per driver in 2009. The drop was most noticeable amongst the young adult or Millennial cohort, age 20-34. The other working-age adults, age 35-54 and 55-64, seemed to remain relatively stable, with a very minute decrease in VMT for each.

It should be noted that some of the jump in surveyed VMT between 1983 and 1990 might be due to changes in survey methodologies.

Now that the overall trend for the entire population has been shown, below are more specific breakouts for each given age cohort.

Teenagers

There has been a strong decline in teenage VMT, ever since its peak in 1990. There were some differences in survey methodology between the first three and last four NHTS surveys, but all of the survey methodologies are directly comparable across 1990, 1995, 2001 and 2009, so this is a genuine long-term trend of a drop in VMT per teenage driver. (Figure 28)

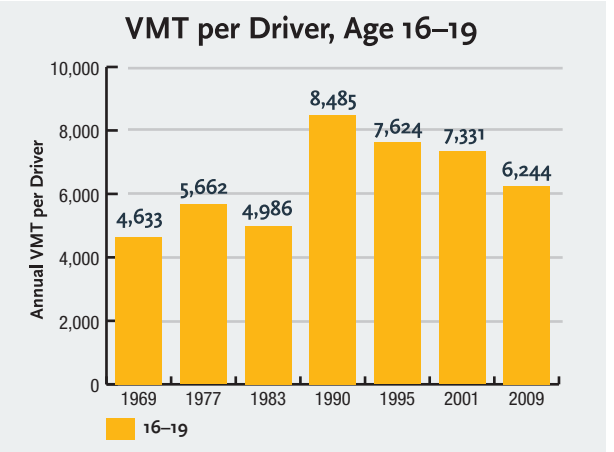

Figure 28: *VMT per Driver, Age 16-19 (Source: National Household Travel Survey, 2009 Summary Trends)*

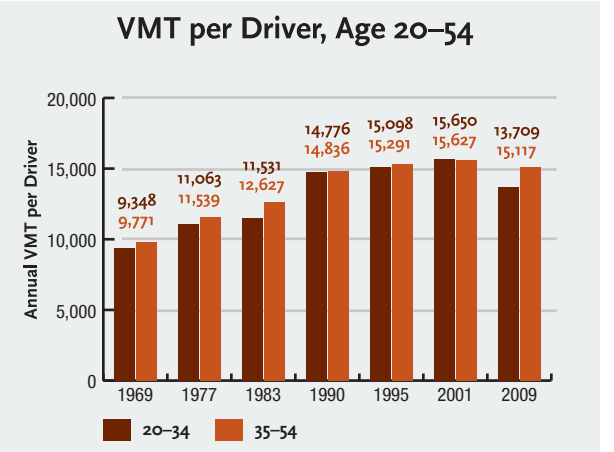

Figure 29: *VMT per Driver, Age 20-54 (Source: National Household Travel Survey, 2009 Summary Trends)*

Middle Adults

Historically, the average driver in the 20-34 and 35-54 age groups, respectively, has driven almost exactly the same amount, and increased and decreased at almost identical rates. (Figure 29) However, between 2001 and 2009, drivers age 20-34 fell off at a much more pronounced rate than drivers age 35-54. It remains to be seen whether this is a long-term trend. The next household travel survey, which will be published in 2015, should cast meaningful light on the direction of the trend.

Figure 30 shows older Baby Boomers, as well as all elderly people above age 65, in comparison to the same age cohorts in previous years. The long-term trend is very definitive: The average older driver is traveling further by vehicle over time. This parallels the noticeable rise in driver licensing rates amongst these older age cohorts.

It can be seen in Figure 31 that those drivers aged 65+ drive only about two-thirds as much as those between age 55-64. This is likely because the vast majority of American adults over age 65 are retired.

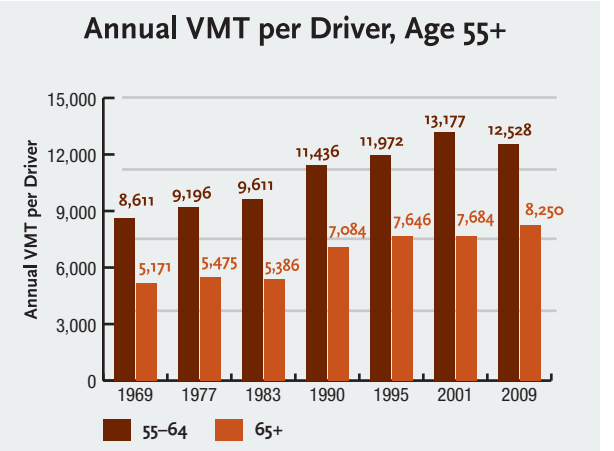

Figure 30: *VMT per Driver, Age 55+ (Source: National Household Travel Survey, 2009 Summary Trends)*

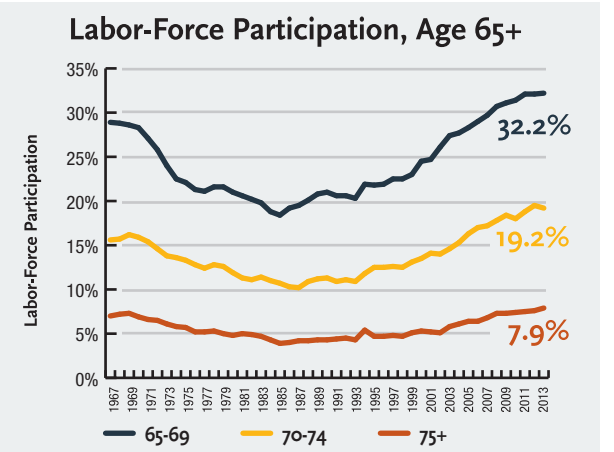

Figure 31: *Labor-Force Participation, Age 65+ (Source: Bureau of Labor Statistics)*

Weighting the Cohorts

To summarize, the VMT equation will be restated here:

$$\text{VMT} = (\text{Number of Drivers}) \times (\text{VMT per Driver})$$

Both variables in the equation have been broken out by age in this section. (Figures 32, 33)

The key question is how to "weight" each cohort's

contribution to annual VMT and how to determine the changes that have occurred over time. For example, if there are more older drivers and they are each driving further, then this will have a different effect than if there are more older drivers but each one drives less distance than younger adults.

The weighting can be done simply by multiplying the data tables of each of the above charts.

For clarity, and for readers who would like to know where the data came from, the tables underlying these charts are presented in Figure 34 and Figure 35.

Each of those matrices can be multiplied in order to achieve the annual VMT for every given age cohort, as presented in Figure 36.

These tables have been provided in their entirety for the purpose of clarity. The intent is to show as clearly as possible how these important findings were achieved. In chart form, the results are shown in Figure 37.

As recently as 1990, adults between age 20-34 contributed almost an identical amount to aggregate VMT as adults between the age 35-54.

However, since 1990, the VMT share of the 35-54 cohort

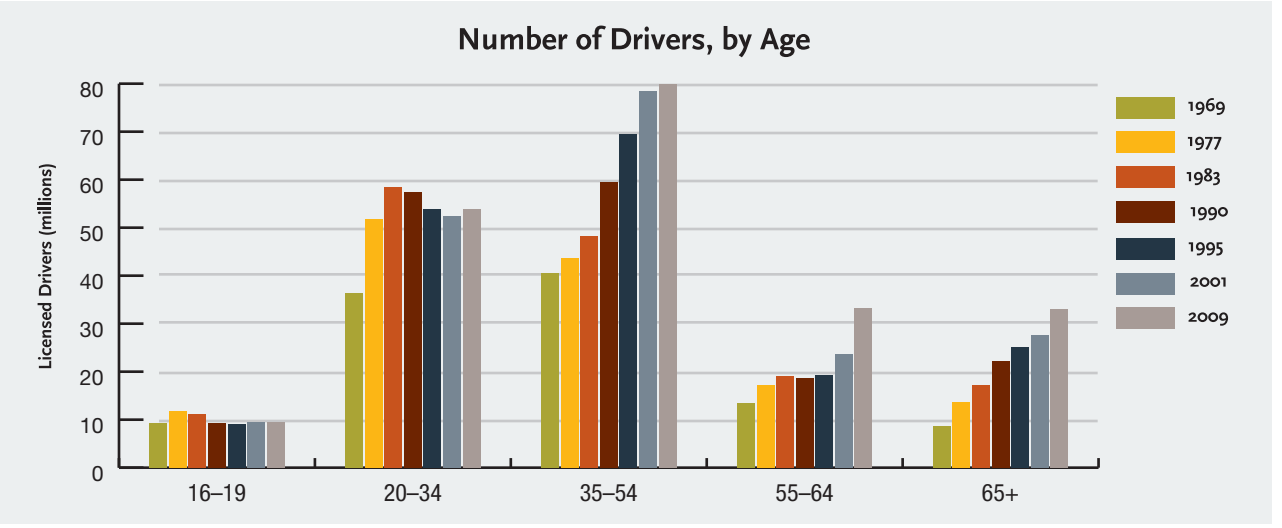

Figure 32: *Number of Drivers, by Age (Source: National Household Travel Survey, 2009 Summary Trends)*

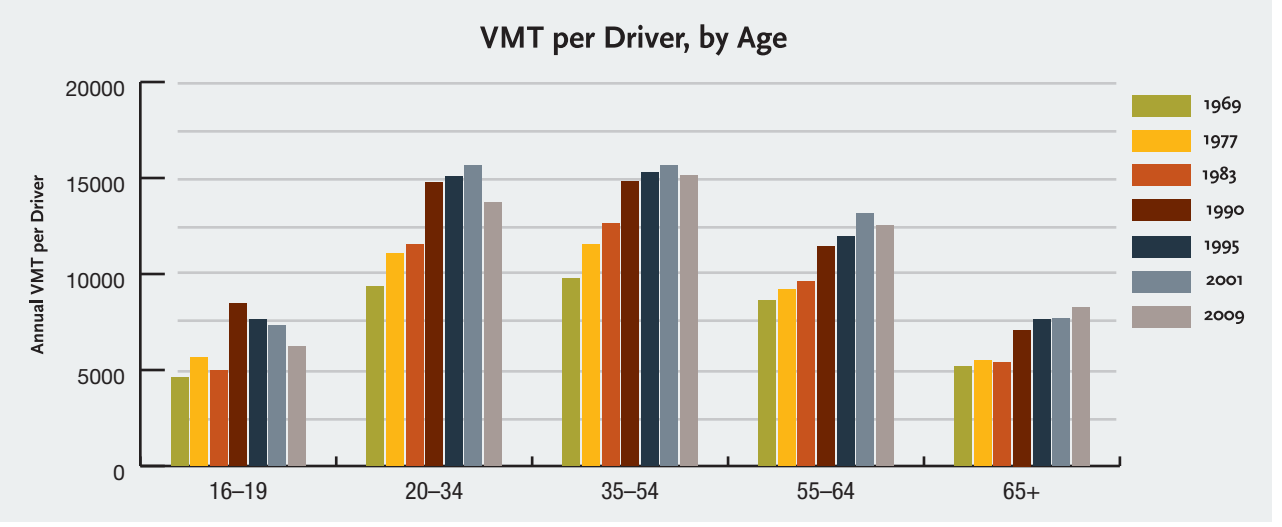

Figure 33: *VMT per Driver, by Age (Source: National Household Travel Survey, 2009 Summary Trends)*

Annual VMT per Driver

	16–19	20–34	35–54	55–64	65+
1969	4,633	9,348	9,771	8,611	5,171
1977	5,662	11,063	11,539	9,196	5,475
1983	4,986	11,531	12,627	9,611	5,386
1990	8,485	14,776	14,836	11,436	7,084
1995	7,624	15,098	15,291	11,972	7,646
2001	7,331	15,650	15,627	13,177	7,684
2009	6,244	13,709	15,117	12,528	8,250

Figure 34: *Annual VMT per Driver (Source: National Household Travel Survey, 2009 Summary Trends)*

Licensed Drivers by Age (thousands of drivers)

	16–19	20–34	35–54	55–64	65+
1969	9,259	36,436	40,423	13,359	8,677
1977	11,702	51,874	43,579	17,130	13,691
1983	11,167	58,537	48,171	19,137	17,251
1990	9,207	57,370	59,464	18,673	22,260
1995	9,066	53,866	69,400	19,184	25,055
2001	9,395	52,334	78,358	23,590	27,573
2009	9,523	53,770	79,824	33,157	32,935

Figure 35: *Licensed Drivers by Age (thousands of drivers) (Source: National Household Travel Survey, 2009 Summary Trends)*

Total Annual VMT per Age Cohort (millions of VMT)

	16–19	20–34	35–54	55–64	65+	Total
1969	42,897	340,604	394,973	115,034	44,869	938,377
1977	66,257	573,882	502,858	157,527	74,958	1,375,483
1983	55,679	674,990	608,255	183,926	92,914	1,615,764
1990	78,121	847,699	882,208	213,544	157,690	2,179,263
1995	69,118	813,269	1,061,192	229,668	191,569	2,364,816
2001	68,881	819,037	1,224,531	310,856	211,861	2,635,166
2009	59,461	737,136	1,206,700	415,389	271,712	2,690,398

Figure 36: *Total Annual VMT per Age Cohort (millions of VMT) (Source: Calculated from Figure 34 and 35.)*

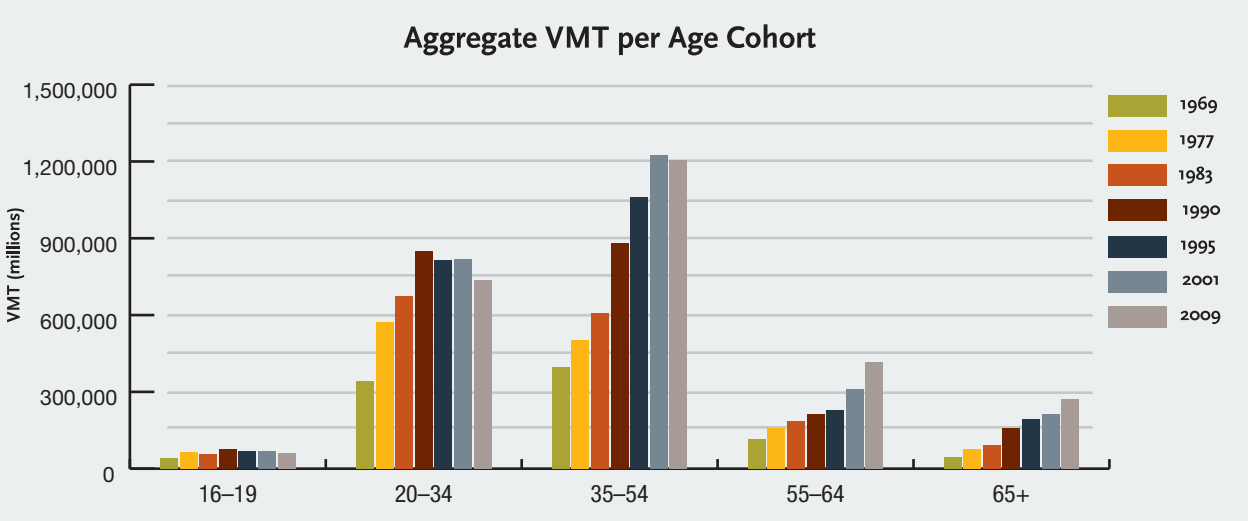

Figure 37: *Aggregate VMT per Age Cohort (Source: National Household Travel Survey, 2009 Summary Trends)*

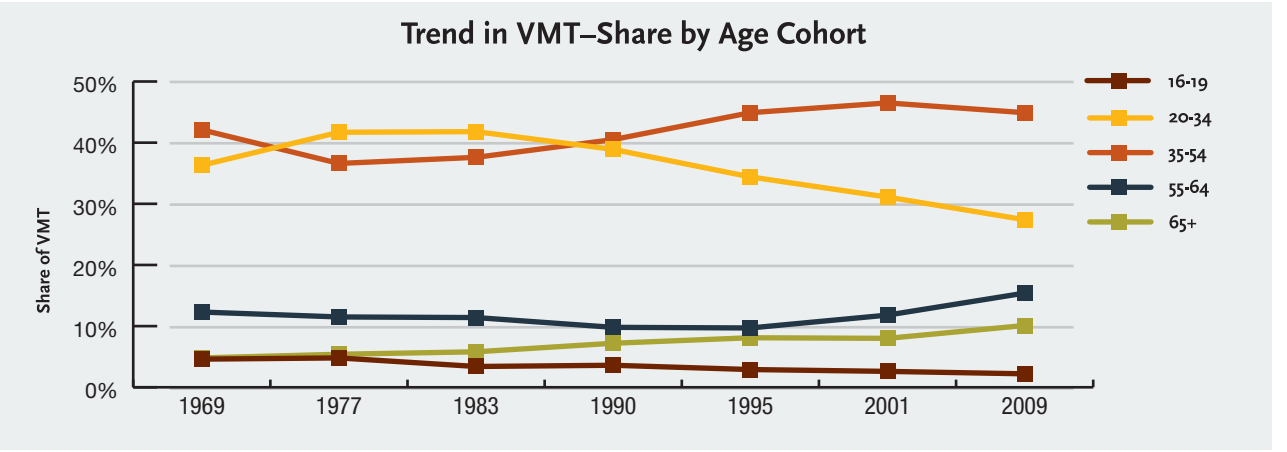

Figure 38: *Trend in VMT-Share by Age Cohort (Source: National Household Travel Survey, 2009 Summary Trends)*

has continued to grow, while the share of the 20-34 cohort has stabilized and then shrunk.

The 55-64 and 65+ cohorts have grown very steadily and consistently, while the cohort of teenage drivers has remained all throughout a tiny contributor to aggregate VMT.

Figure 38 presents these findings as a trend-line graph. It shows each age cohort's share of VMT in every year of the travel survey. For further clarity, the percentages in this graph are tabulated in Figure 39.

Tabulated Percentages, VMT-Share by Age Cohort

	16–19	20–34	35–54	55–64	65+
1969	5%	36%	42%	12%	5%
1977	5%	42%	37%	11%	5%
1983	3%	42%	38%	11%	6%
1990	4%	39%	40%	10%	7%
1995	3%	34%	45%	10%	8%
2001	3%	31%	46%	12%	8%
2009	2%	27%	45%	15%	10%

Figure 39: *Tabulated Percentages, VMT-Share by Age Cohort (Source: National Household Travel Survey, 2009 Summary Trends)*

Summary: VMT by Age

This section has examined VMT by driver age, in light of the VMT equation:

VMT = (Total Amount of Drivers) × (VMT per Driver)

Figure 40, which summarizes the long-term VMT-share trend by age in terms of raw aggregate VMT, brings together the findings of this section.

The overall finding is that the stagnation in annual VMT of young adults has clearly been offset by the soaring VMT of middle-aged adults, as well as the steadily increasing VMT of older adults.

The chart shows that VMT of 35-54 year olds has soared, whereas VMT of 20-34 year olds has leveled off. Between 2001-2009, the drop in VMT among 20-34 year olds was offset by the increase in VMT among 55-64 year olds and people age 65+.

The change in VMT amongst teenaged drivers has been negligible over time. The average teenage driver is driving less, to be sure, but the aggregate VMT of teenage drivers has always been a tiny proportion of total VMT.

It is a valid question, though, to ask whether changes in the average teenage driver's behavior will persist throughout the entire age span.

This touches upon the broader question of cohorts versus generations. This section will conclude by discussing this theme.

Conclusion

This section on Drivers by Age began by asking the question of whether cohorts or generations counts the most in assessing driver behavior over time. It seems that both cohorts and generations have a recognizable effect.

In terms of cohorts:

- Teenagers' driver-licensing rates peaked in 1982 and have steadily fallen ever since.
- Adults in both their 20s and 30s had peak driver licensing rates in 1982, which have steadily fallen ever since.
- Adults in their 30s have always been more likely to have a driver's license than adults in their 20s.
- Adults in their 40s and 50s have long had very high and near-identical driver licensing rates. These rates have had slight but steady decreases since 1992.
- Older adults' driver licensing rates (both 60-69 and 70+ year olds) have steadily risen.

In terms of generations (oldest generation first):

- During the "Greatest Generation" (born before 1928), driver-licensing rates were lower due to lower likelihood for women to have a driver's license.
- The "Silent Generation" (born 1928-1945) actually predated the Baby Boomers in terms of having high driver-licensing rates as young adults, which carried all the way through the life-span.
- The "Baby Boomers" had very high driver-licensing rates as youngsters, and have maintained these extremely high rates as they have grown older.
- The older members of "Generation X" (born 1965-1972) have tended to behave just like the Baby Boomers, in terms of driver-licensing rates.
- The younger members of "Generation X" (born 1973-1979) have known lower driver-licensing rates, halfway between the Millennials and the Baby Boomers.
- The Millenials are the great wildcard. Yes, they drive less than previous generations at this stage of life. But both the number of older drivers, and the amount that each one drives, is higher than it has ever been. In accordance with increased life expectancies and delayed retirement, will Millennials ultimately live longer, and drive far further at older ages, than any previous generation? It is unclear what will happen and the possibility of paradigm shifts renders the long-term future very unpredictable.

The overall finding for age-based driver behavior was stated in the first sentence of the introduction, and will now be restated.

While Millennials' long-term behavior remains the great unanswered (and perhaps unanswerable) question, it is clear that in the short-run, the Millennials' reduction in driving has been almost directly offset by the increase in driving of older adults. As the Baby Boomers work longer, and as retired people live longer, healthier lives, this offsetting of trends may continue for the foreseeable future.

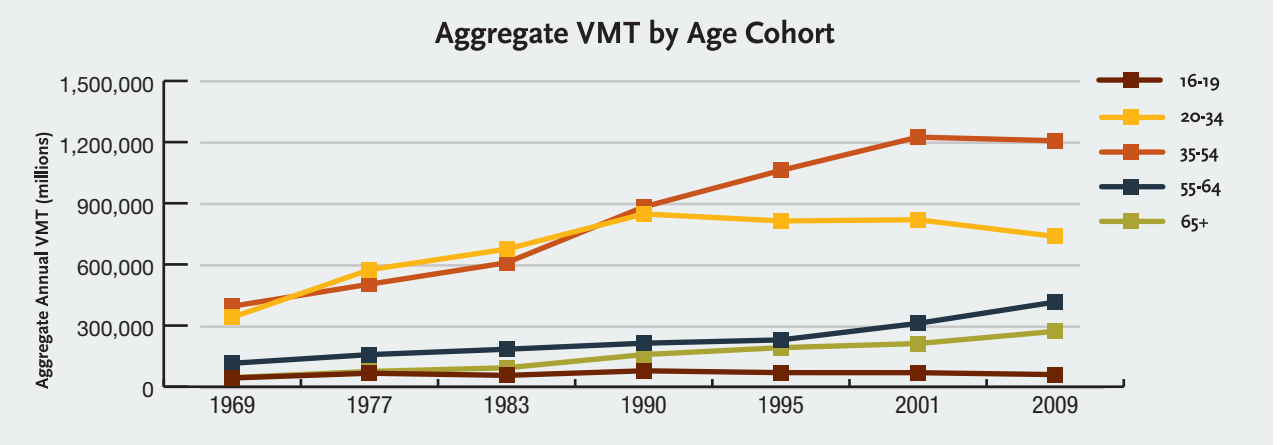

Figure 40: *Aggregate VMT by Age Cohort (Source: National Household Travel Survey, 2009 Summary Trends)*

Economic Factors: Income, Wealth, Employment

MONEY TALKS

HOUSEHOLD INCOME: The higher the household income, the greater the amount of household travel. This might be the strongest, clearest correlation in this entire study.

NATIONAL INCOME: National income—aka GDP—lacks a clear correlation with aggregate vehicle travel. In many past recessions, aggregate vehicle travel has risen, while in some recoveries, aggregate vehicle travel has stagnated or fallen.

INCOME INEQUALITY: Income inequality is rising, and may help explain why vehicle travel can stagnate even in a time of rising overall GDP.

WEALTH INEQUALITY: Wealth at its simplest is simply an accumulation of income. The income inequality has correlated with a growing wealth inequality.

LABOR-FORCE PARTICIPATION: (1) Younger persons (age 16-24) have been participating less frequently in the labor-force, and this trend has predated the Great Recession by many years. (2) The reduction in younger persons in the labor-force has been offset by an increase in older persons' labor-force participation. (3) There appears to be a meaningful positive correlation between an age cohort's labor-force participation and its driving behavior.

UNEMPLOYMENT: (1) Unemployment has a strong inverse correlation with driving behavior for a given age cohort: More unemployment, less driving, and vice versa. (2) National unemployment levels seem to have a weak correlation with national driving amounts. Nationally, driving has sometimes grown robustly during times of high unemployment, and has sometimes stagnated during times of low unemployment.

This section will deal with economic factors, from a demographic, age-based perspective, and at both household and national scales of analysis.

If money talks, then what does it say about transportation patterns?

As seen in the sidebar, it says much about Household Income, National Income, Income Inequality, Net Wealth Inequality, Labor-Force Participation, and Unemployment.

The reader is reminded that the VMT Equation is:

$$VMT = (Drivers) \times (VMT\ per\ Driver)$$

All of the trends in this section are meant to be understood within the context of this equation.

Household Income

The Starting Point: More Income, More Trips

Figure 41, on the next page, shows one of the most clear-cut findings in this entire study.

Across every year for which this has been tabulated, there is a very well-defined relation between income and travel. Put simply—the more people earn, the more they move. The correlation is unmistakable.

From Personal Income to National Income

This can be examined on a national level too. Simply put, there is no direct and consistent relationship between VMT

and recession. When GDP, aka national income, declines, aggregate VMT sometimes declines but other times—it continues growing. Figure 42 brings this to light.

As the chart clearly shows, not every recession has been correlated with a decline in VMT. During the recessions of 1949, 1953, 1958, 1960, 1970 and 2001, VMT continued to grow. During the recessions of 1973–75, the early 1980s and the early 1990s, VMT did indeed decline.

Thus it seems specious to say that the "Great Recession" of 2007–2009 has been the only important factor in the leveling off of VMT since the mid-2000s. If VMT grew very robustly during many previous recessions, then why is it not growing during the current recession? What is different this time?

Answers to these questions play into some very broad issues related to transportation. Factors beyond the drivers themselves, such as the vehicles, the roads, land-use patterns, and so on, must be brought into consideration, to give a complete answer. This is beyond the scope of the current study on driver demographics. But preliminary investigations of publicly available highways data have shown a long-term trend of growth and then saturation, similar to what has been shown for the growth of the driver population.

For now, to summarize the differing effects of household and national income on vehicle travel —the correlation between income and personal travel appears to be stronger at the individual level than at the national level.

Growing Income Inequality

Examining patterns how income differs across age groups over time shows an unmistakable pattern of widening income inequality. In this section, the gap in incomes by age will be traced, and commentary will be provided on how it may affect personal vehicle travel.

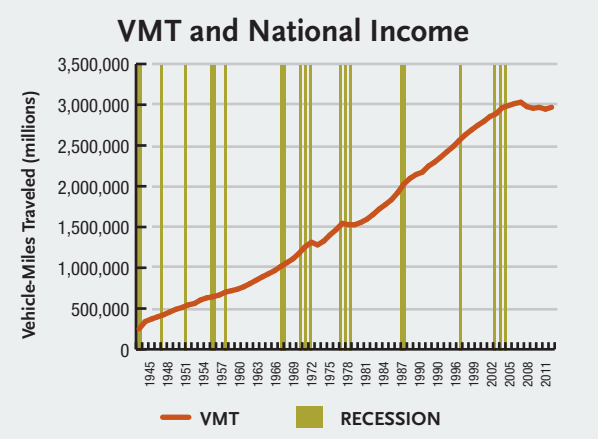

Figure 42: *VMT and National Income (Sources: Federal Highway Administration; U.S. Bureau of Economic Analysis)*

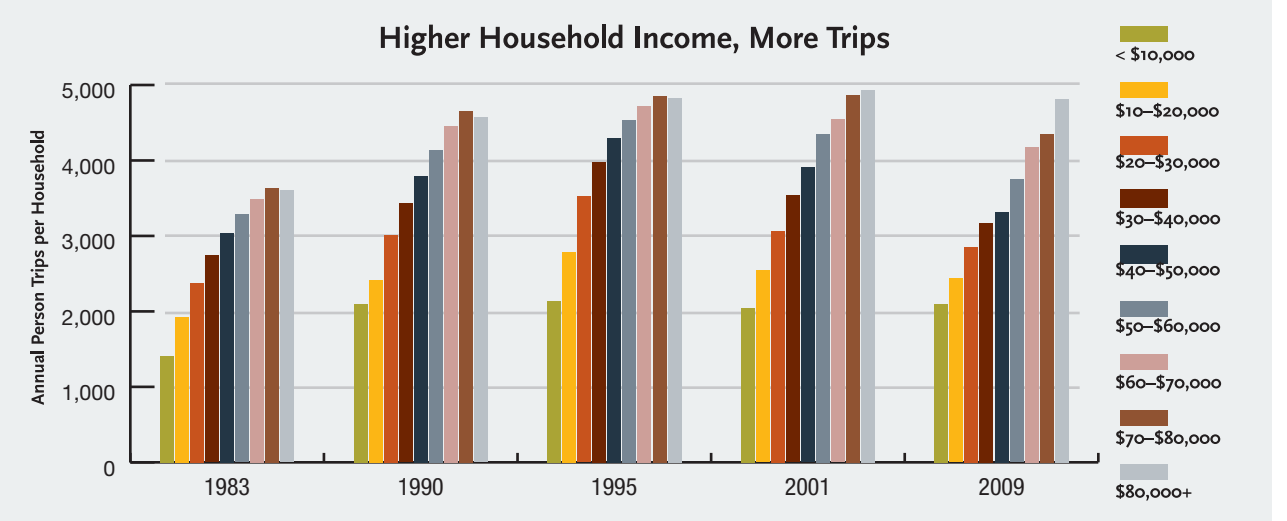

Figure 41: *Higher Household Income, More Trips (Source: National Household Travel Survey,* 2009 Summary of Trends)

Income by Age Groups

Data on personal income by age can be obtained from the U.S. Census Bureau, and extends back to 1974. The following chart (Figure 43) provides a starting point.

The same pattern can be observed as with VMT per age group: There has been a noteworthy increase in income for both the 55-64 and the 65+ cohorts. Given the clear findings earlier in this study, that older drivers are driving more, and that greater household income leads to more travel, it seems a fair inference to say that the increased income of older Americans has had the effect of increasing their driving frequency.

Figure 44 replaces the median with the mean income. This will give a much "heavier" sense of the average, and will be suggestive of wealth effects as well. Due to the way that averages are calculated, with summing up all income and dividing by the total number of wage-earners, a mean is more indicative of lopsided income disparities that lead to accumulations of income, i.e. wealth.

The trend with mean income is even more pronounced than with median income. This is because, statistically, larger incomes weigh heavier into calculating a mean than a median (which is simply the middle value in a list of all incomes).

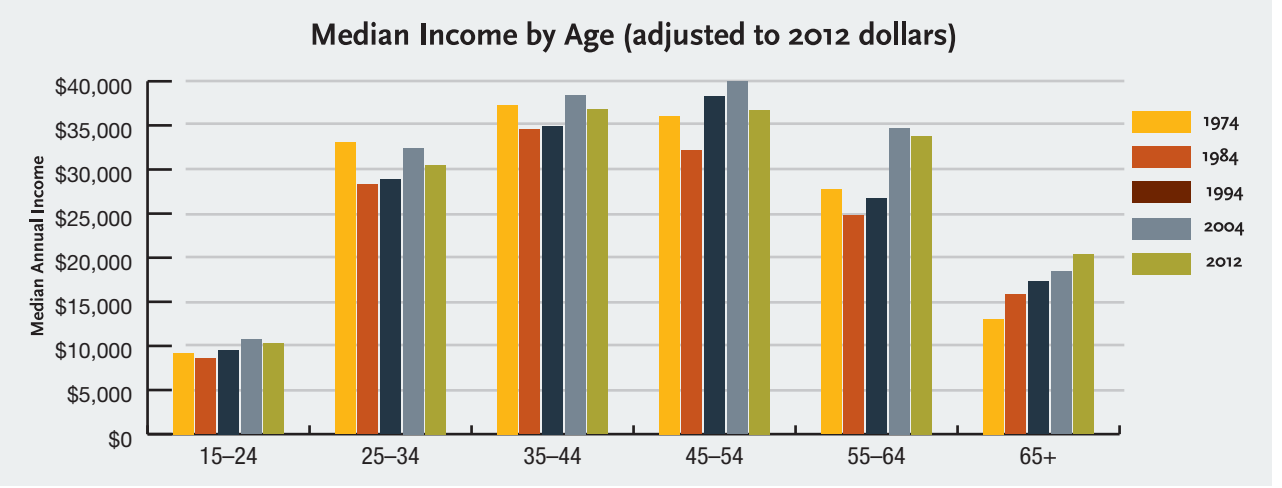

Figure 43: *Median Income by Age (adjusted to 2012 dollars) (Source: U.S. Census Bureau)*

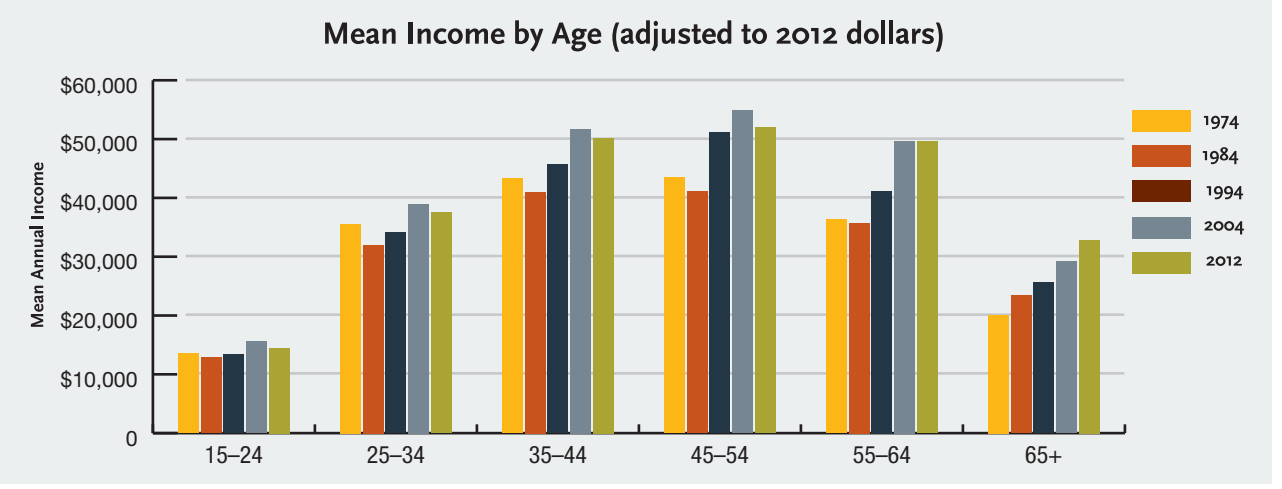

Figure 44: *Mean Income by Age (adjusted to 2012 dollars) (Source: U.S. Census Bureau)*

Inter-Generational Income Distribution: Shifting Toward Older Adults

One of the most salient features of these charts is that incomes are growing for older adults faster than to those of younger adults. This can be pinpointed very precisely by tracing the gap in incomes over time between older age cohorts and 25-34 year olds. (Figures 45 and 46)

The most striking finding of these charts is the way in which income disparity has grown between the oldest cohort of working adults, age 55-64, and the youngest working adults, age 25-34. This conforms to the general pattern in this study of a demographic shift towards more activity by older adults, and will be corroborated in the Wealth section where the growing disparities in income have piled up and become noticeable.

Whether looking at the mean or the median, the evidence is quite dramatic that the older generations' earnings are outpacing those of young adults age 25-34. The evidence is equally dramatic that this gap is increasing as time passes.

Income Inequality Within Generations

If that was not enough, the inequality of income within every given cohort has also been increasing at a rapid clip. If one subtracts the median income from the mean income, for any given year, a simple, straightforward measure of income inequality can be obtained, as shown in Figure 47.

Every single cohort, with the exception of 15-24 year olds, has seen a large and growing income inequality even within its own ranks.

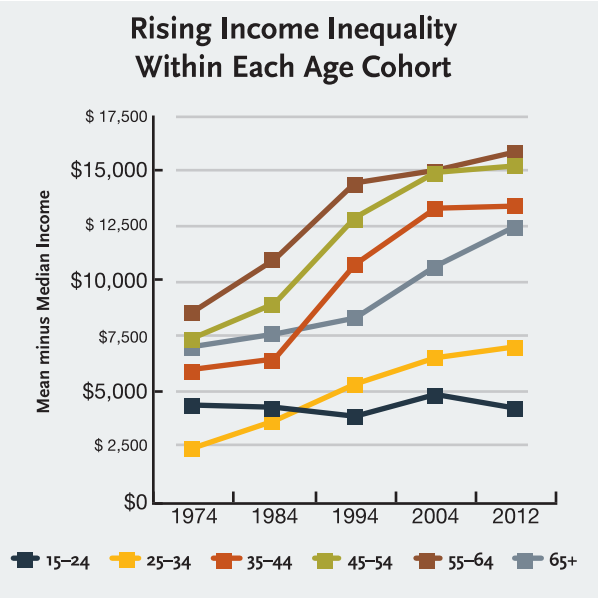

Figure 47: *Rising Income Inequality Within Each Age Cohort (Source: U.S. Census Bureau)*

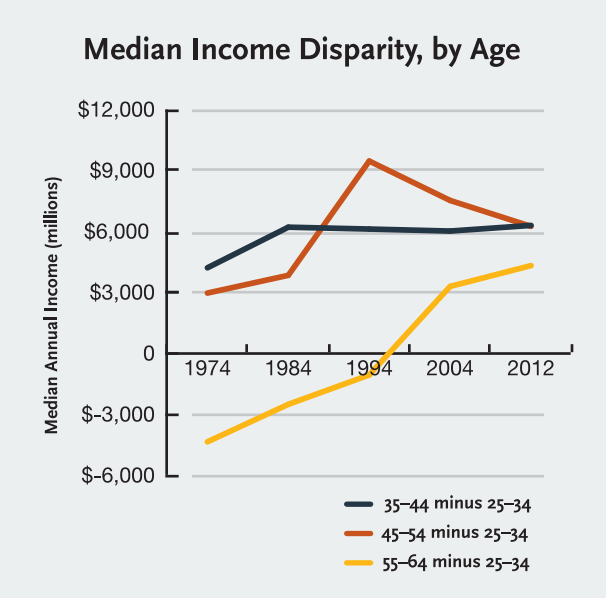

Figure 45: *Median Income Disparity, by Age (Source: U.S. Census Bureau)*

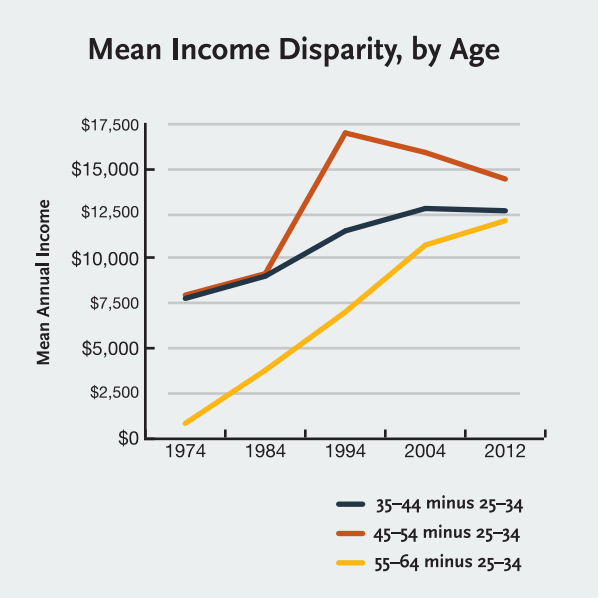

Figure 46: *Mean Income Disparity, by Age (Source: U.S. Census Bureau)*

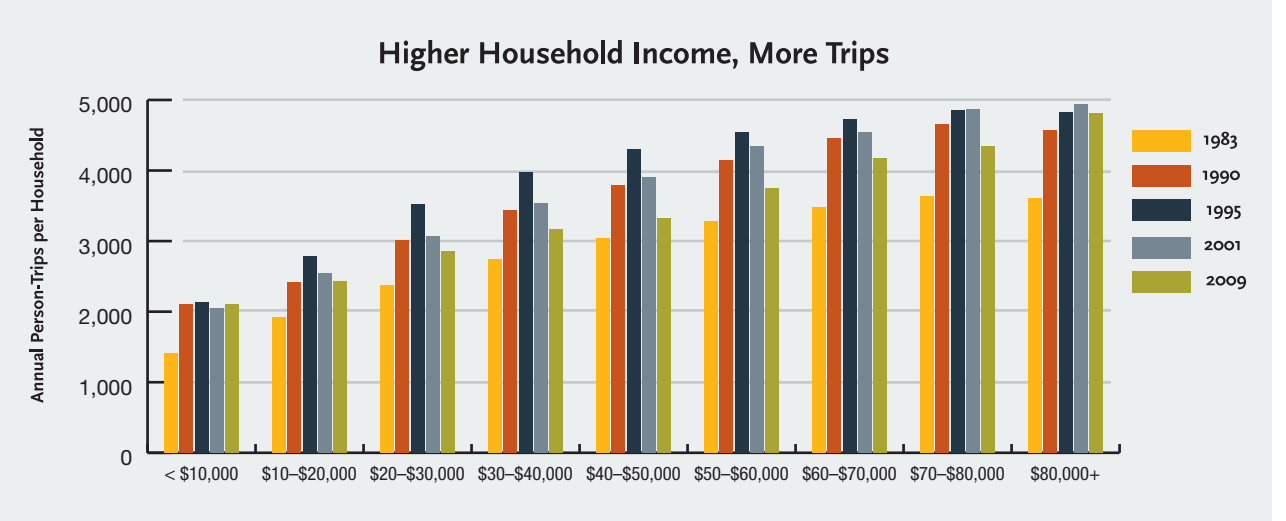

Figure 48: *Higher Household Income, More Trips (Source: National Household Travel Survey, 2009 Summary Trends)*

Summary

The evidence shows that income inequality, both across and within generations, is a pervasive trend that is always lurking in the background. Income inequality must permeate any thoughtful, well-informed discussion of the future of transportation.

There is a clear and unmistakable correlation between income and personal travel. The graph relating income to travel is worth restating here, because the correlation is so strong. (Figure 48)

Note that this graph has leveled off at the highest income levels in every year except for 2009. The key question for the fuels and automotive industries is whether there is an upper level where more income does not lead to more travel—in other words, when does saturation occur?

The other issue of great importance concerns the lowest-income persons. What is preventing the lowest-income persons from traveling? What are the specific obstacles which demotivate travel from occurring?

The overall point is that income inequality may be choking off aggregate travel growth. If most of the income has been accumulating with the rich, *then it is accumulating amongst a population for which more income will not spur more travel*. The travel of the richest Americans must ultimately saturate at some point; there are natural limits to the amount of time that one is willing or able to spend traveling. On the other hand, the poorest Americans may be far more likely to spend their extra marginal dollars on significant increases in personal travel, given that this would likely make a big difference in the functionality of their daily life. But in the face of growing income inequality, the people in the lower income brackets may not only find that they cannot travel more, but that they lose even further income in the future and as a result, need to travel even less. It is a self-reinforcing "vicious cycle" or "death spiral."

Income inequality, and concentration of wealth (addressed in the next section), could very well be contributing to today's stagnation of travel even while the economy has technically recovered from recession. If it is a "stock market recovery" more so than a "jobs recovery," then the relatively few investors who reap the benefit from the recovery cannot possibly travel enough to make up for the very large segments of the population who remain either jobless, underemployed or stuck with stagnant wages.

The next section will look at inequalities of wealth. Similar dynamics obtain with this variable. Everything expressed in the above analyses can also apply to inequalities of wealth.

From Income to Wealth

At its simplest, wealth is simply an accumulation of income. Given the remarkable clarity of the relation between household travel and household income, it seems safe to assume that household wealth correlates with travel as well. Although no systematic measure has been surveyed, it seems highly likely that wealthy households will take more person-trips per year.

The question, though, is how to measure wealth across generations. Data on this topic is surprisingly scarce. The concept of net worth is generally quite hard to measure, due to the range of different places in which people can keep their financial wealth, and so it is a blind spot in most official statistics.

Pew Research Center

The Pew Research Center, an independent, non-profit "fact tank" in Washington, D.C., provides one of the few anchors of data to explain wealth patterns across generations. The Pew Center has examined federal survey data from the Census Bureau's Survey on Income and Program Participation (SIPP). The results are presented in Figure 49.

This is one of the few data-sets to examine net wealth directly, across generations. Therein lies its significance.

Even though overall net worth among householders has increased slightly since 1984, the gains are entirely weighted towards householders age 65 and older. All other age groups of householders have seen their net worth decline. A householder is defined by the Census Bureau as "a person in whose name the housing unit is rented or owned. This person must be at least 15 years old." (www.census.gov/hhes/families/about/)

The data drives home the tight financial squeeze on today's younger-than-35 group, the Millennials. The growing income inequality in America has also become a growing wealth inequality. This inequality does not take place exclusively across professions, industries, race or region. It also takes place across age.

The import of this finding for transportation is that it may very well play into the reduction in driving by younger drivers. The closest statistical bridge between wealth by age and driving by age is shown in Figure 50.

There does indeed appear to be a strong correlation between the increased net wealth of the 65-and-over householders and the driving habits of that age group. The 65-and-older cohort shows both the greatest increase in wealth and the greatest increase in driving mileage.

Second, despite all of the alarm about Millennials' driving habits, they are still driving more per driver than their predecessor cohort of 1983. Their decreased net wealth seems to mean that they drive somewhat less than they otherwise might, but more than previous generations at the same age.

Median Net Worth by Age of Householder 1984 and 2011 (in 2011 dollars)

	1984	2011	Change, 1984 to 2011
All	$67,354	$68,828	2%
Younger than 35	$11,884	$6,676	**-44%**
35–44	$73,362	$35,000	-52%
45–54	$117,094	$84,542	-28%
55–64	$151,884	$143,964	-5%
65 and Older	$124,259	$170,516	**37%**

Figure 49: *Median Net Worth by Age of Householder, 1984 and 2011 (Source: Paul Taylor and the Pew Research Center.* The Next America: Boomers, Millennial, and the Looming Generational Showdown. *New York: Public Affairs, 2014. Page 61.)*

Annual VMT by Age of Driver

	1983	2009	Change, 1983 to 2009
20–34	11,531	13,709	19%
35–54	16,627	15,117	-9%
55–64	9,611	12,528	30%
65 and older	5,386	8,250	**53%**

Figure 50: *Annual VMT by Age of Driver (Source: National Household Travel Survey,* 2009 Summary Trends*)*

The Labor Market: From Drivers to Workers

The demographic interplay between one major population—the drivers—and another major population—the workers—is pivotal.

At this stage of the report, a subtle, transitional shift is occurring. Until now, the population that has most directly been examined has been the drivers themselves.

To study the effect of the labor market on driver demographics, however, it is necessary to directly study the population of workers. Most workers are drivers, too, but not all.

One of the underlying theses of the current study is that there are a whole series of "parallel populations" that have a bearing on the total amount of personal travel, as represented by VMT. Some of these populations are animate—the drivers, the workers—and some are inanimate—the vehicles, the roads.

This is the first section where the interplay of drivers with another population takes place. This will become a commonplace occurrence, but this is the first time that it happens.

Readers should keep in mind, as they review the charts and analysis below, that nearly every chart represents an interaction between one major population—the drivers—and another major population—the workers.

Raising an awareness of this demographic shift—and its implications—is pivotal. The viability of introducing new fuels depends on establishing economies of scale, and economies of scale in turn depend upon the complex interplay of several large-scale populations (i.e. consumers, vehicles, drivers, workers, filling stations, businesses). To analyze these large-scale populations, demographics is the cornerstone method, since demographics is essentially the art and science of analyzing shifts in large-scale populations.

If one accepts this chain of reasoning, and thus the applicability of the demographic method for transportation demand, then it becomes of vital importance to always be aware of which specific populations are being tracked. Such awareness can give keen insight into the dynamic processes of chicken-and-egg market development problems. In many ways, chicken-and-egg processes are problems of the reciprocal interplay of large-scale demographic populations with one another.

In summary, readers are strongly encouraged to pay close attention to the specific populations at hand. They should try to conceptualize how these populations relate to specific problems such as chicken-and-egg hurdles to market

development, and how the interplay of various populations frames the more general themes of social, economic, business, policy and environmental context.

This has been an interlude of broad, reflective commentary; it is time to return "to the numbers." Nevertheless, the conclusion of this study will return to the broader commentary—demographic, historical and otherwise—in order to situate the findings of this study in a useful context from which business leaders, policymakers, and the general public can draw useful insights.

Labor Market: How Many Workers Are There?

The fundamental variable of the labor market is a count of the workers, as shown in Figure 51.

During the past half-century, the working population has grown faster than the general population. (Figure 52)

As seen in Figure 53, this can also be expressed as a long-term increase in the employment-to-population ratio, which is simply the ratio of employed workers divided by total population.

How Does This Relate to Driving?

The VMT equation is:

VMT = (Drivers) × (VMT per Driver)

One of the main findings of this section is that workers drive more than non-workers. The correlation is strong but not absolute.

If the amount of workers has increased over time, and if workers drive more than non-workers, then it stands to reason that over the long-term, the growth of the labor market has contributed to the growth in overall driving. It is equally clear that the saturation in the labor market ought to have contributed to the saturation in VMT.

It is important to note that during the recession of the early 1980s, the ratio of workers to population had a much milder dip than during the recession of the late 2000s and the economic aftermath of the early 2010s. Unemployment levels were at comparably high rates, but the underlying demographics were different and VMT continued to grow, whereas during the recession of the late 2000s, VMT stagnated.

This is a crucial point of difference to comprehend, in

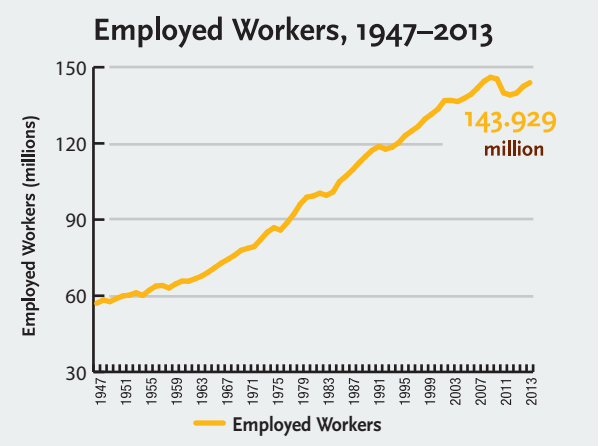

Figure 51: *Employed Workers, 1947–2012*
(Source: Bureau of Labor Statistics)

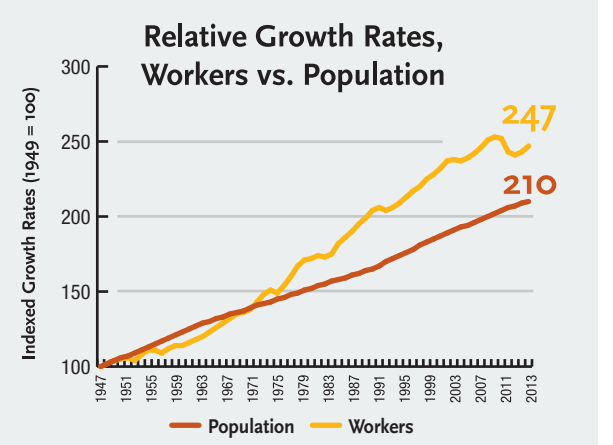

Figure 52: *Relative Growth Rates, Workers vs. Population*
(Sources: U.S. Census, Bureau of Labor Statistics)

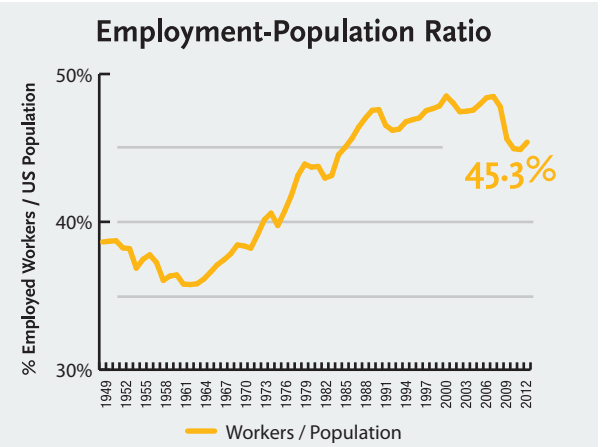

Figure 53: *Employment-Population Ratio*
(Sources: U.S. Census, Bureau of Labor Statistics)

terms of the pivotal interplay between demographics and travel demand (aka mass consumer markets). In the analyses below, the demographic saturation of workers that has occurred has had a greater effect on limiting the growth of travel demand than the rate of unemployment. Unemployment rate exhibits a strong but not absolute correlation with VMT; Figure 53 highlights a crucial reason why. Demographics with its large-scale population counts can give a far better sense of overall scope, than can a "scale-less" variable such as unemployment. Both types of statistics are important, but one is more akin to "symptom," and the other more akin to "cause."

The assertion that workers drive more than non-workers is hard to pin down. There is no single, direct data point for teasing this out. It has not been directly queried on consumer surveys. The rest of this section will be devoted to pinpointing statistical evidence that workers tend to drive more than non-workers.

The two best-known labor market statistics—labor-force participation and unemployment—are examined. An exhaustive listing of charts, comparing the labor market to VMT in the aggregate and then by specific age cohorts, are wielded.

To "set the table," and give context, journey-to-work statistics will be presented first.

Prelude: Journey-to-Work Statistics

Before dealing directly with the employment statistics, let's examine the highly enriched "journey-to-work" survey data that has been collected for several decades.

This gives a clear sense of how work commuting fits into the overall context of driver behavior. It will also motivate the discussion to follow by pinpointing the large amount of VMT that derives directly from workers, and the crucial role played by income in facilitating all other types of trip purposes other than work.

Mode of Travel to Work: Driving Alone Dominates

The vast majority of workers travel in a motor vehicle. Both the National Household Travel Survey and the U.S. Decennial Census have tracked this behavior for decades. It is one of the best-documented behavioral patterns in all of the travel literature.

First, data from the National Household Travel Survey, dating back to 1969, will be shown in Figure 54.

Next, the Census Bureau collects similar data in the decennial census. Its figures stretch back to 1960. (Figure 55)

Both sources show that the vast majority of workers drive to work in a private vehicle. Not only that, the vast majority of all commuters drive alone. (Figure 56)

As a consequence of worker commute patterns, trips to work have by far the lowest vehicle-occupancy rates of any kind of trip. (Figure 57)

Importantly, trips to/from work have long been at saturation levels of vehicle-occupancy, since it is impossible to have fewer than one person in a car. (Figure 58)

In addition, trips to work are the longest trips other than social and recreational trips. (Figures 59, 60)

As a result of all this, vehicle travel to/from work has historically taken up a very large proportion of household travel. (Figure 61)

In addition, the income earned from working facilitates all of the other types of travel. One needs to have money in order to shop, visit the doctor, visit relatives, and undertake recreational outings.

Therefore it is very important to track labor-market trends because these will have a significant effect on overall VMT.

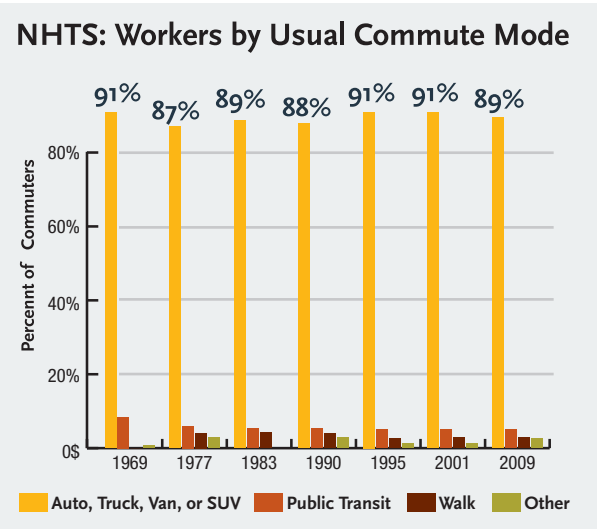

Figure 54: *NHTS: Workers by Usual Commute Mode (Source: National Household Travel Survey, 2009 Summary Trends)*

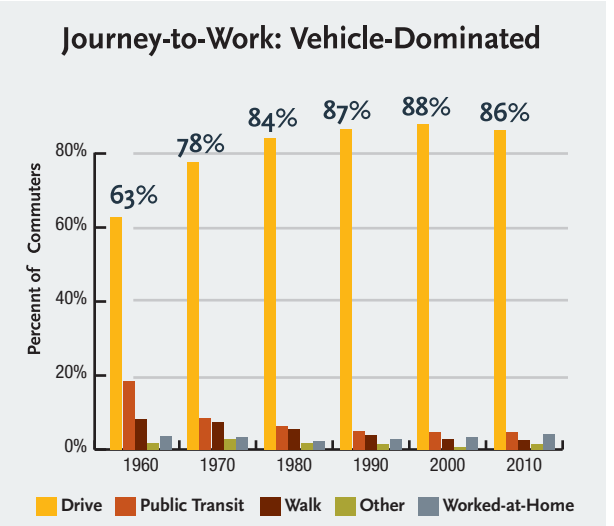

Figure 55: *Journey-to-Work: Vehicle-Dominated*
(Source: Decennial Census, U.S. Census Bureau. Retrieved from National Historical Geographical Information System, University of Minnesota Population Center, www.nhgis.org)

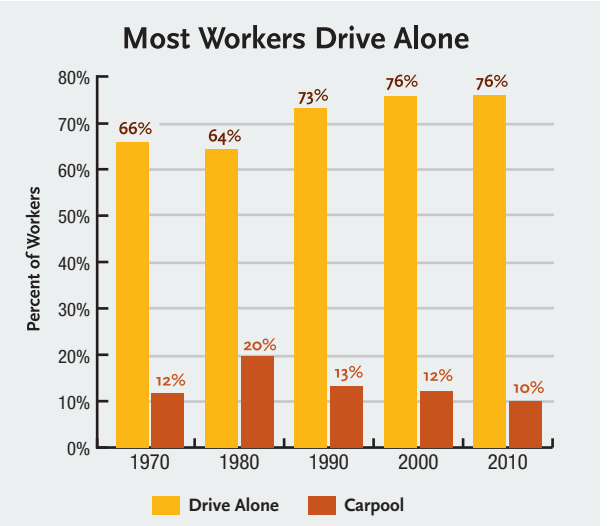

Figure 56: *Most Workers Drive Alone*
(Source: Decennial Census, U.S. Census Bureau. Retrieved from National Historical Geographical Information System, University of Minnesota Population Center, www.nhgis.org)

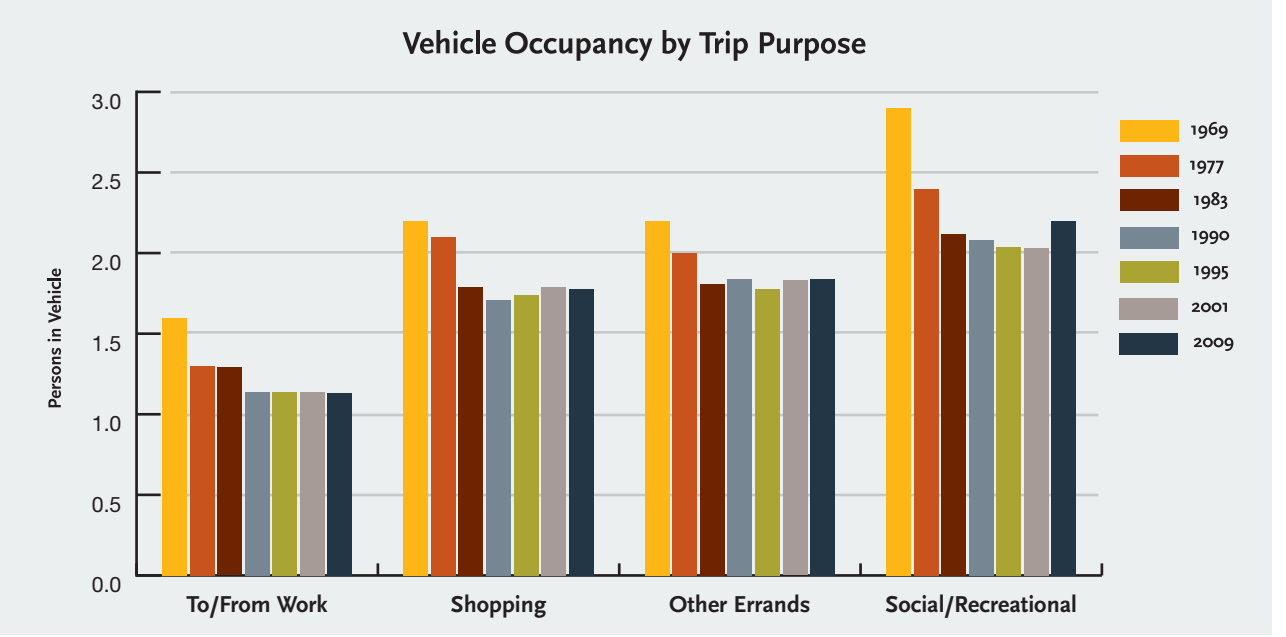

Figure 57: *Vehicle Occupancy by Trip Purpose*
(Source: National Household Travel Survey, 2009 Summary Trends)

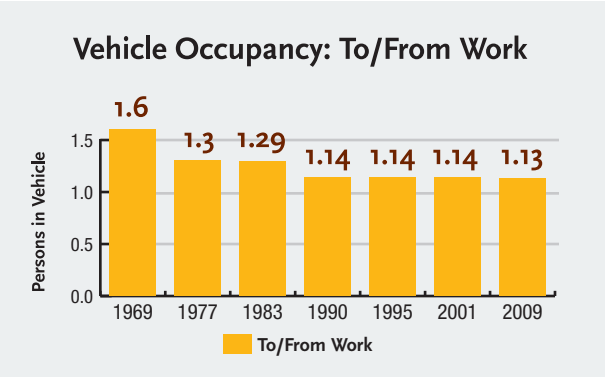

Figure 58: *Vehicle Occupancy: To/From Work (Source: National Household Travel Survey, 2009 Summary Trends)*

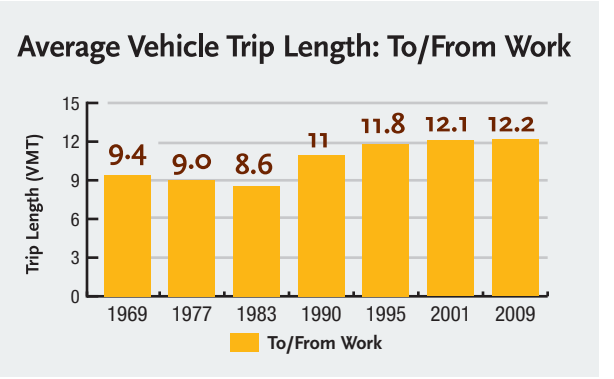

Figure 59: *Average Vehicle Trip Length: To/From Work (Source: National Household Travel Survey, 2009 Summary Trends)*

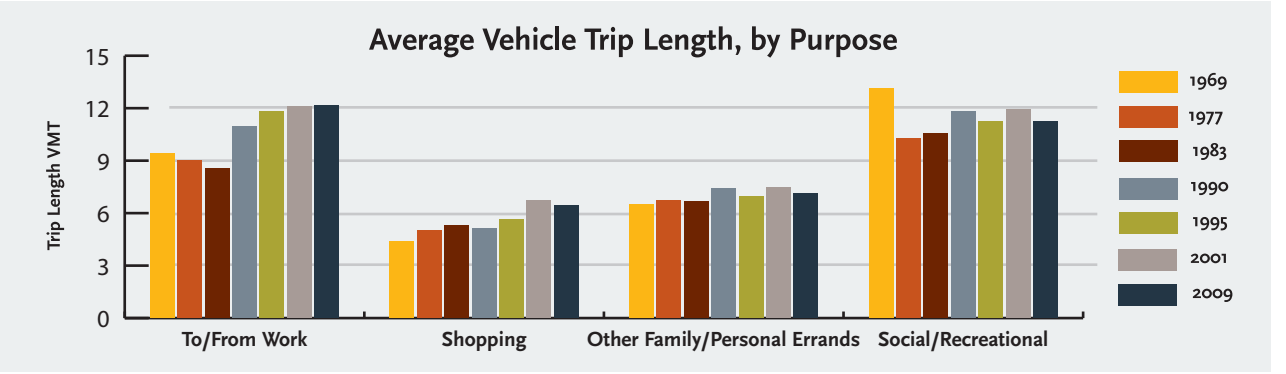

Figure 60: *Average Vehicle Trip Length, by Purpose (Source: National Household Travel Survey, 2009 Summary Trends)*

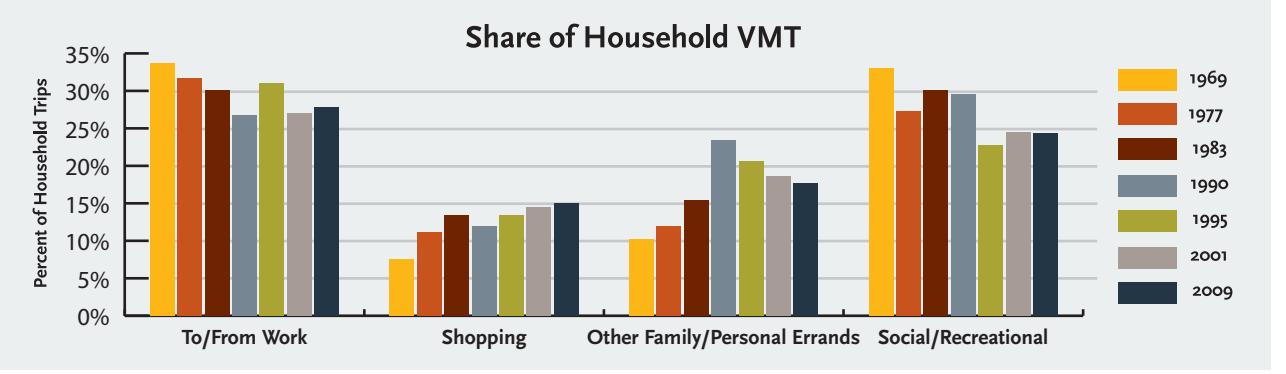

Figure 61: *Share of Household VMT (Source: National Household Travel Survey, 2009 Summary Trends)*

Labor-Force Participation

The place to continue is not yet with unemployment rates, but rather with labor-force participation. This is because unemployment can miss the full scope of the labor market, due to the way in which it is defined. The unemployment rate is defined as:

Unemployment Rate = Unemployed Workers / Labor-force

The labor force in the denominator only contains those who are either employed or actively searching for work. Discouraged job-searchers are not included, even though they might like to work if they could find a job.

To get a truer measure of the growth of the labor market, it is better to begin directly with labor-force participation. This statistic is defined as:

Labor-Force Participation = Labor-Force / Population

Note that this is essentially a "per capita" statistics where the variable of interest is directly divided by the general population. This is a subtle, but important, shift.

Historical Labor-Force Participation Rates

Labor-force participation statistics by age date back to 1967. (Figure 62) This chart shows the first hint of a trend: Older people are working somewhat more often than they used to. The older age groups, 60-69 and 70+, are the only two groups where labor force participation has actually been increasing between 2002 and 2012.

For younger people, the chart shows the first hint of another trend: They are in the labor-force less frequently than they used to be. There has been a significant drop-off for the 16-19 age group in 2012, and a slight drop-off for the 20-29 age group.

Since younger people are of particular interest for the future of driving, it will be instructive to zoom in further on

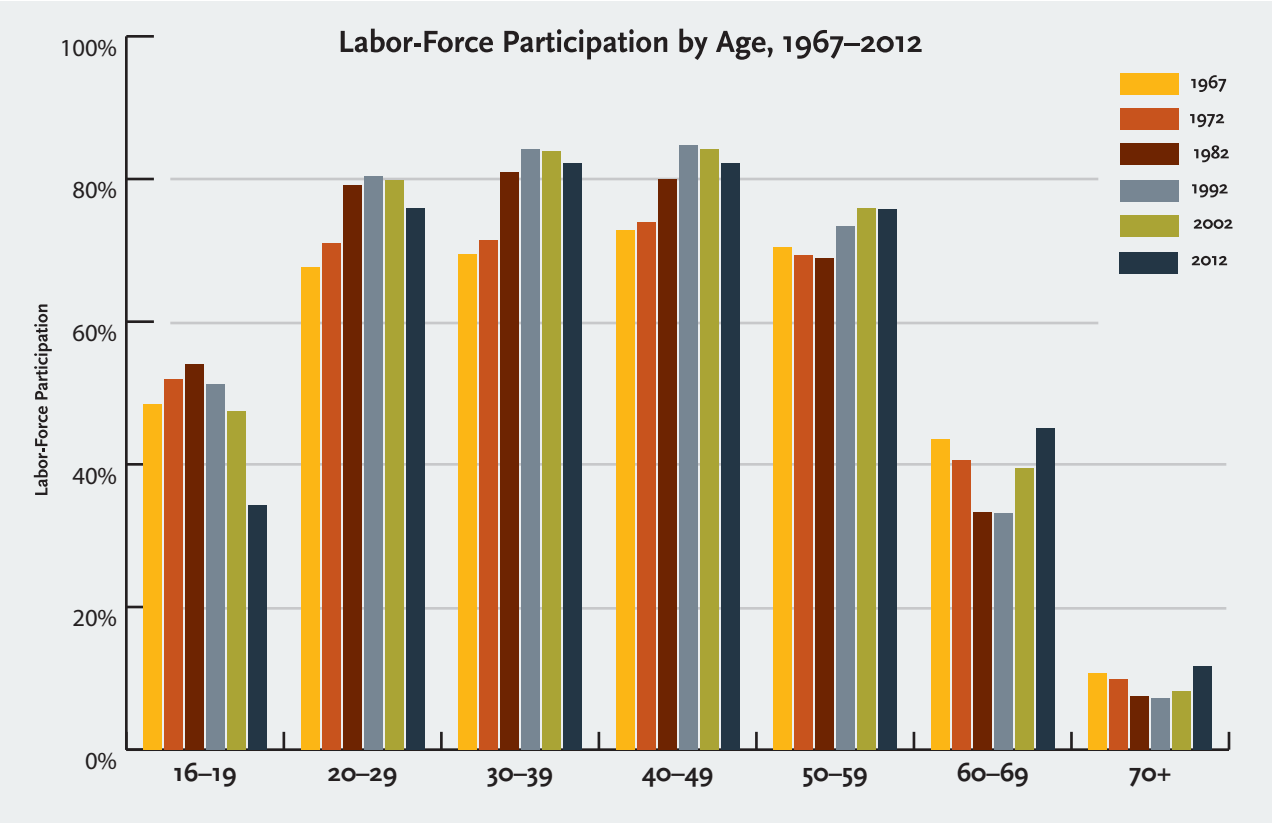

Figure 62: *Labor-Force Participation by Age, 1967-2012 (Source: Bureau of Labor Statistics)*

their circumstances. Age 16-19 and 20-24 are the only two ages which have tracked labor-force participation all the way back to 1948. (Figure 63)

What is striking about Figure 63 is that labor-force participation among the youngest adults has declined since well before the 2008 Great Recession began. It's clear that for older teenagers, labor-force participation has been declining since 1999 or so. The rate for 20-24 year olds is much higher than that of teenagers, but it crested as well around the year 1999, at approximately 78%, and has been in slow, steady decline ever since.

This strongly suggests that enduring structural changes have been taking place for some time. The financial crisis of 2008, while it clearly contributed to the further plunge in workforce participation rates among young workers, was not the sole catalyst. Could there have been some demographic

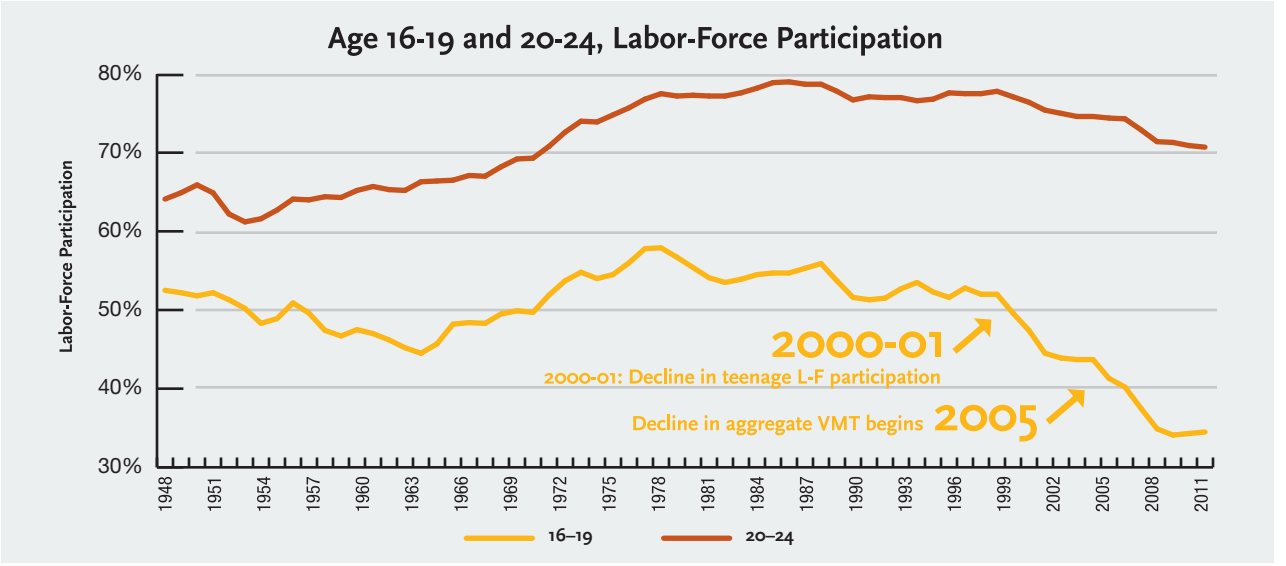

Figure 63: *Age 16-19 and 20-24, Labor-Force Participation (Source: Bureau of Labor Statistics)*

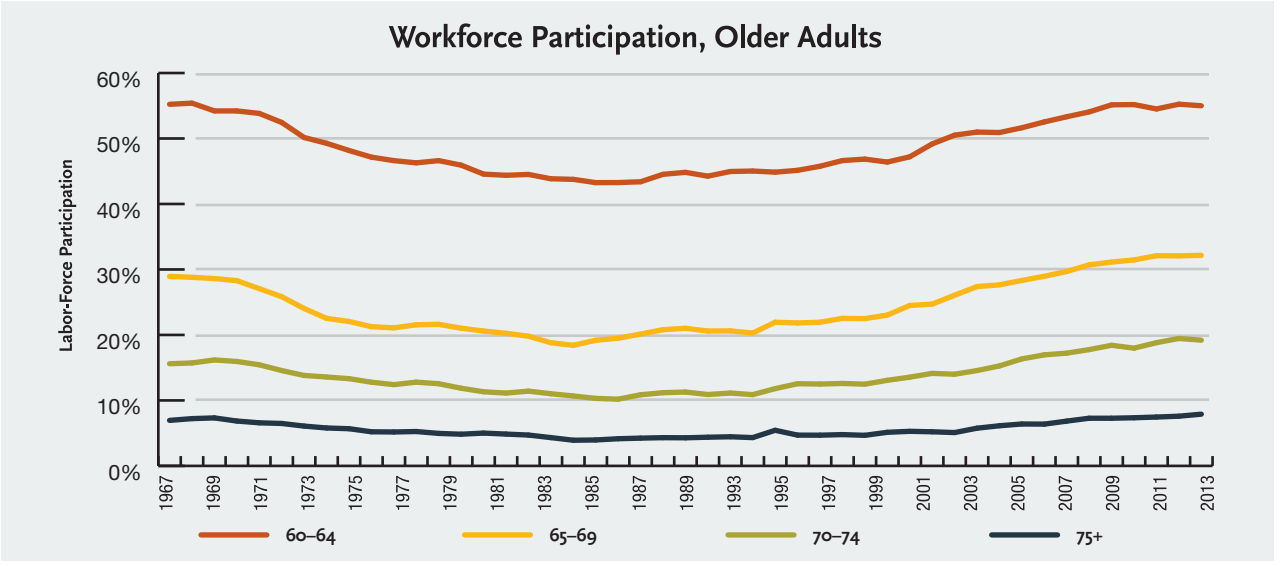

Figure 64: *Workforce Participation, Older Adults (Source: Bureau of Labor Statistics)*

influence to this situation? Figure 64, portraying labor-force participation of older adults, may provide some insight.

The trends for older adults almost seem to be the mirror image of that for younger adults. It is an intriguing question (although beyond the scope of this study) to ask whether the concurrent increase in workforce participation by older workers, in the 60-69 and 70+ age groups, has effectively shifted away some of the opportunities from younger workers.

Particularly for adults in their 70s, the question is what kind of jobs are they doing? Are they working at their professional careers a few years longer? Or are they semi-retired and taking jobs as waiters, clerks, and call center reps that the 16-24 age bracket previously used to take? If the latter, this would indicate increased competition for the very same jobs, and it would mean that the increase in life expectancy has led to an aging population which is undermining the employability of the younger workers. This would certainly be unprecedented. It is beyond the scope of the current study to answer this—but the question is well worth asking.

Another intriguing question, also beyond the scope of the current study, is whether there have been societal changes in expectations for young adults, in terms of education or work ethic, affecting the trend in the workforce participation graph shown above.

Linking Labor-Force Participation to VMT

Figure 65 contrasts national labor-force participation statistics with national aggregate VMT. This shows that overall, a rising long-term rate of labor-force participation has strongly correlated with a long-term growth of VMT. Since the mid-2000s, a stagnating and then falling rate of labor-force participation has strongly correlated with a stagnation of VMT.

However, there are also some extended periods of ambiguity in this seeming correlation. From 1947-1964, labor-force participation was fairly constant between 59% and 60%, yet VMT grew strongly during these years.

From 1990-2003, labor-force participation was fairly constant between 66% and 67%, yet again, VMT grew strongly during these years.

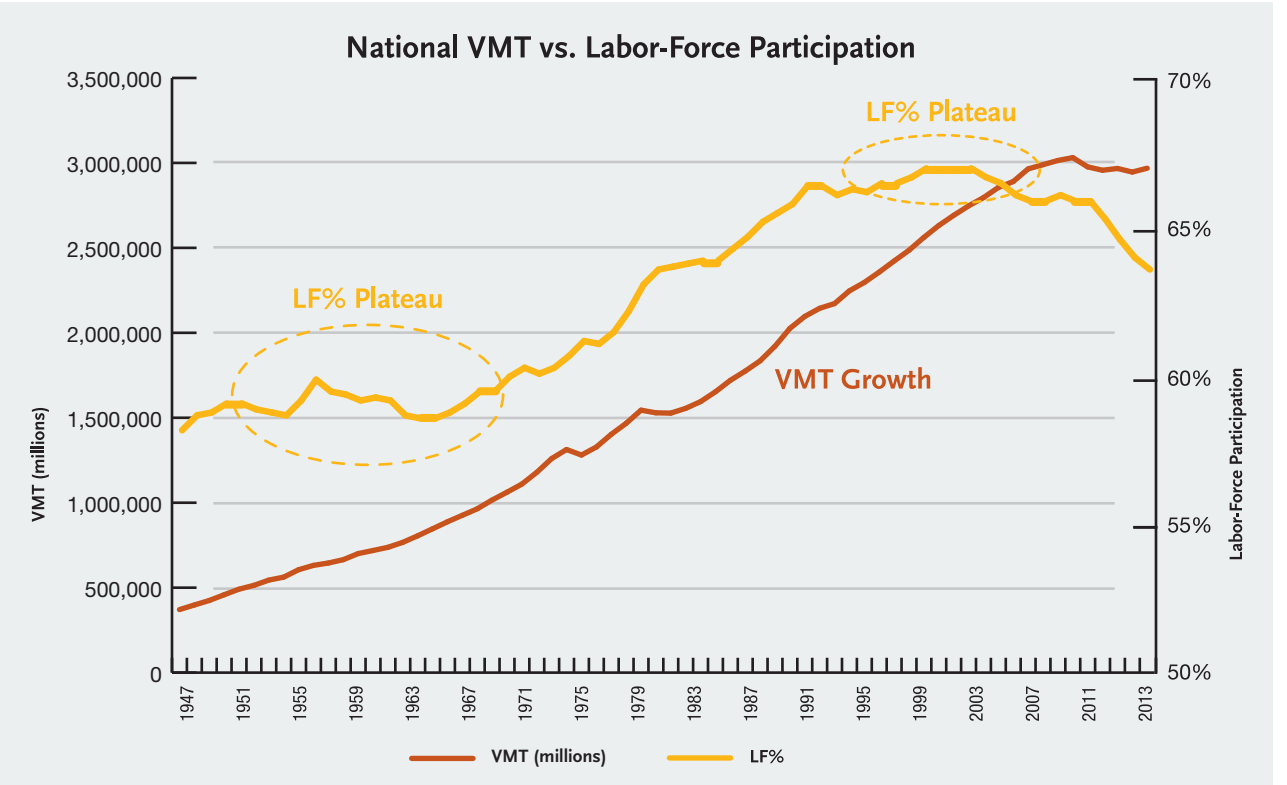

Figure 65: *National VMT vs. Labor-Force Participation*
(Sources: Federal Highway Administration; Bureau of Labor Statistics)

Overall, this is a very useful—but not definitive—statistical correlation in the aggregate.

Age-Based Breakouts of VMT vs. Labor-Force Participation

This section provides specific age-based breakouts, comparing labor-force participation for a given cohort, to average annual VMT for that cohort. The goal is to see whether this more focused lens will show specific, age-based correlations.

The first chart will deal with teenagers. (Figure 66) The data for 1969-1983 should be taken with a grain of salt, since due to different survey methodology they may be somewhat tainted by systematic under-reporting of vehicle-miles for these years.

Regardless, this chart shows an intriguing pattern for 1990-2009, where labor-force participation is directly correlated with driving for this cohort. The less participation, the less driving occurs.

The next charts will show the same breakdown except for 20-34 year olds and 35-54 year olds, respectively. (Figure 67, 68)

For each of these age cohorts, there is a very clear positive correlation—when LF% increases, VMT increases, and when LF% decreases, VMT decreases. In fact, both of

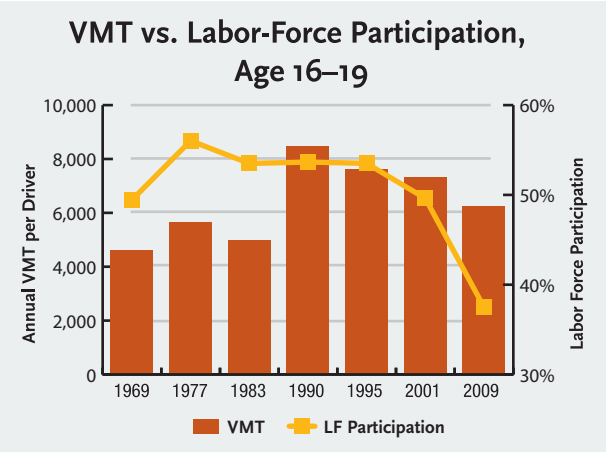

Figure 66: *VMT vs. Labor-Force Participation, Age 16-19 (Sources: Federal Highway Administration; Bureau of Labor Statistics)*

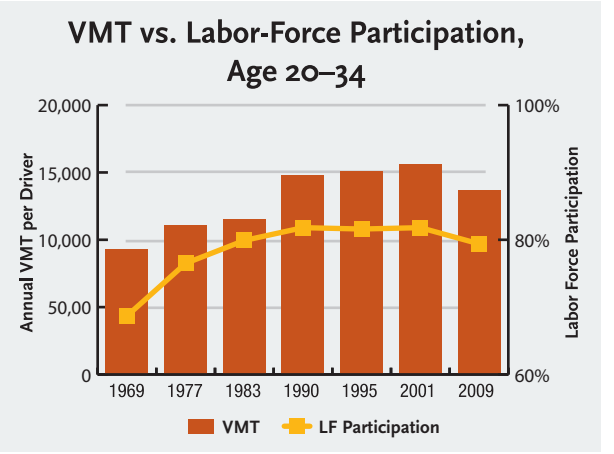

Figure 67: *VMT vs. Labor-Force Participation, Age 20-34 (Sources: Federal Highway Administration; Bureau of Labor Statistics)*

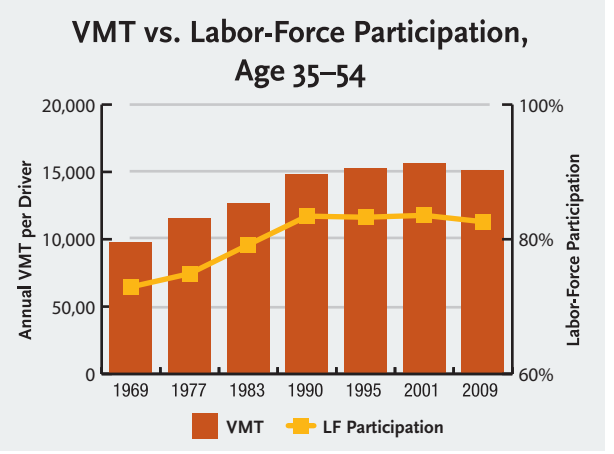

Figure 68: *VMT vs. Labor-Force Participation, Age 35-54 (Sources: Federal Highway Administration; Bureau of Labor Statistics)*

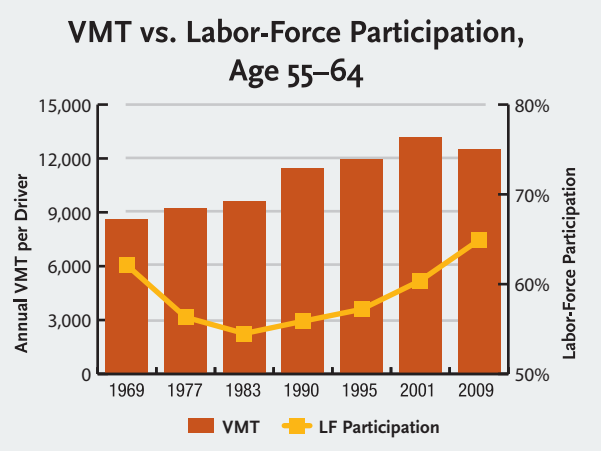

Figure 69: *VMT vs. Labor-Force Participation, Age 55-64 (Sources: Federal Highway Administration; Bureau of Labor Statistics)*

these charts are striking in the acute sensitivity, for these age groups, of VMT and labor-force participation. The data for the older age groups, however, are murkier. (Figure 69)

Curiously, labor-force participation among the 55-64 age bracket has shown a V-shaped curve. It is unclear why this might have been the case. It is equally unclear why driving rose for this age cohort even as labor-force participation fell during 1969-1983.

For more recent years, 1990-2009, the pattern seems much more obvious: Labor-force participation grew in lockstep with vehicle travel for age 55-64. These years demonstrate the same strong correlation as in the other age cohorts.

The next chart deals with ages 65 and over. (Figure 70) This age group shows the same perplexing V-shaped trend, in labor-force participation, and the same lack of a clear correlation between 1969-1983.

The most telling results are shown for 2009, where labor-force participation was at its highest rate since 1969 for age 65 and over, and annual VMT per driver was at its highest level ever.

Labor-Force Participation: Summary

Overall, it seems that decreased rates of labor-force participation amongst young Americans have been traded off against increased rates among older adults. This resembles the drop in VMT among teenagers and the parallel increase in VMT among older drivers.

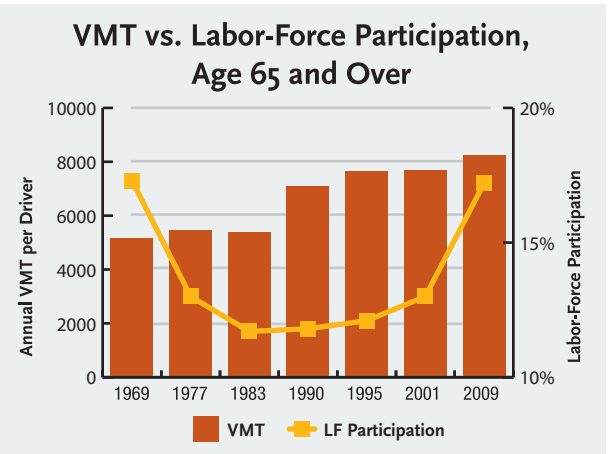

Figure 70: *VMT vs. Labor-Force Participation, Age 65 and Over (Sources: Federal Highway Administration; Bureau of Labor Statistics)*

Comparison of national labor-force participation rates against national VMT, historically since 1947, shows that the upward trends in each line are strongly correlated. Nevertheless, the correlation is not universal, and there are some instances where labor-force participation holds steady but VMT continues growing. This suggests strongly not only that the positive correlation does not hold true in all times, but also that there must be confounding, additional variables at play. This is particularly true at the current time of persistent low levels of labor-force participation following the Great-Recession. While these low levels of participation may very well contribute to the historic stagnation of VMT, there are likely additional, confounding variables at play.

Finally, for specific age cohorts there is a very compelling, direct correlation between labor-force participation and VMT. This is strongest amongst the younger cohorts: 16-19, 20-34, and 35-54. The older cohorts, 55-64 and 65+, have shown an intriguing V-shaped pattern of labor-force participation, over the past four decades, and only since the early 1990s has there been a strong, direct correlation for these ages between labor-force participation and VMT.

In all, it is fair to conclude, based on the data, that labor-force participation has a meaningful correlation with VMT. It may not be 100% total correlation, but it is certainly existent and has shown up in the vast majority of the charts presented here.

Unemployment: "Failure to Launch"?

The next step is to examine the relationship between unemployment and VMT.

There has been a general assumption made, that in the aftermath of the Great Recession, young adults are stuck in a "failure to launch" situation, whereby they cannot get jobs, cannot form their own households, and consequently cannot purchase automobiles nor travel by vehicle as much as previous generations could. There is concern among industry on how long "failure to launch" will persist, and its implications for the future. This section of this study aims to lend insight on the employment situation, how it compares to the historical precedent, and how unemployment rates correlate (or don't correlate) with rates of personal vehicle travel.

Unemployment: Long-Term Overview

Figure 71 describes unemployment in age cohorts, at intervals since 1967, the year when most of this data was first tracked by the Bureau of Labor Statistics.

Historically speaking, teenagers have always had the highest unemployment rates, followed by young adults in their 20s, and these rates have always fallen as the generations have proceeded through life. In this sense, "failure to launch" is a universal phenomenon that has always occurred, and has always abated.

The post-recession economies of the early 1980s and early 2010s are clearly reflected in the graph. These two recessions have had the highest unemployment rate in nearly every age cohort. In switching axes on the graph, we can see that unemployment rates in the early 1980s were higher for almost every age group in comparison with the early 2010s. (Figure 72)

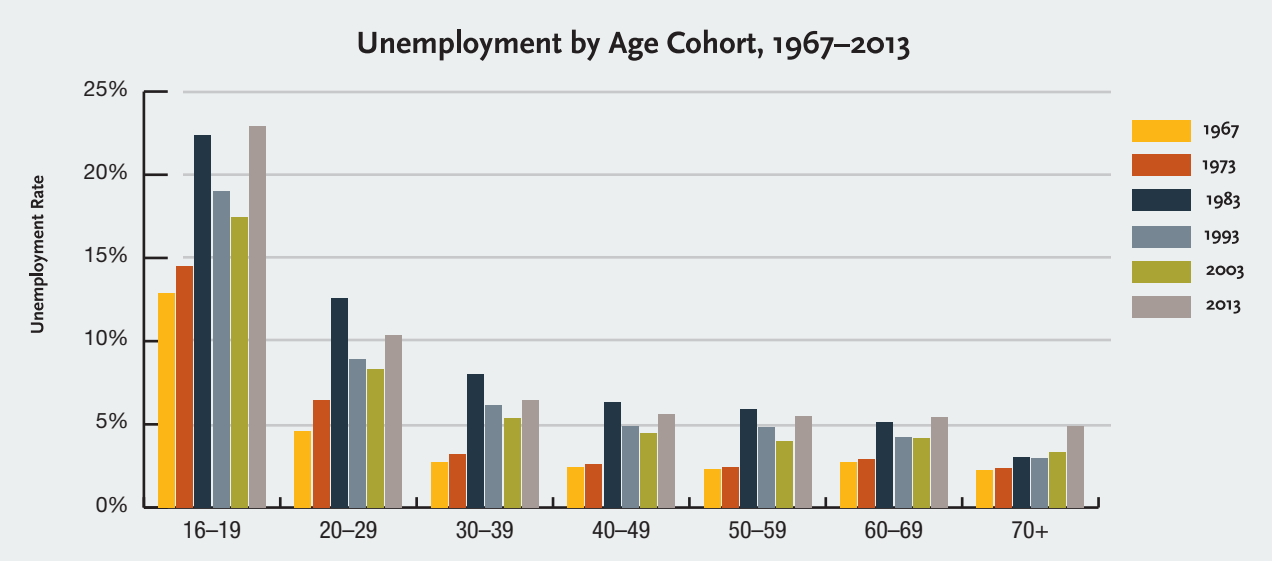

Figure 71: *Unemployment by Age Cohort, 1967–2013 (Source: Bureau of Labor Statistics)*

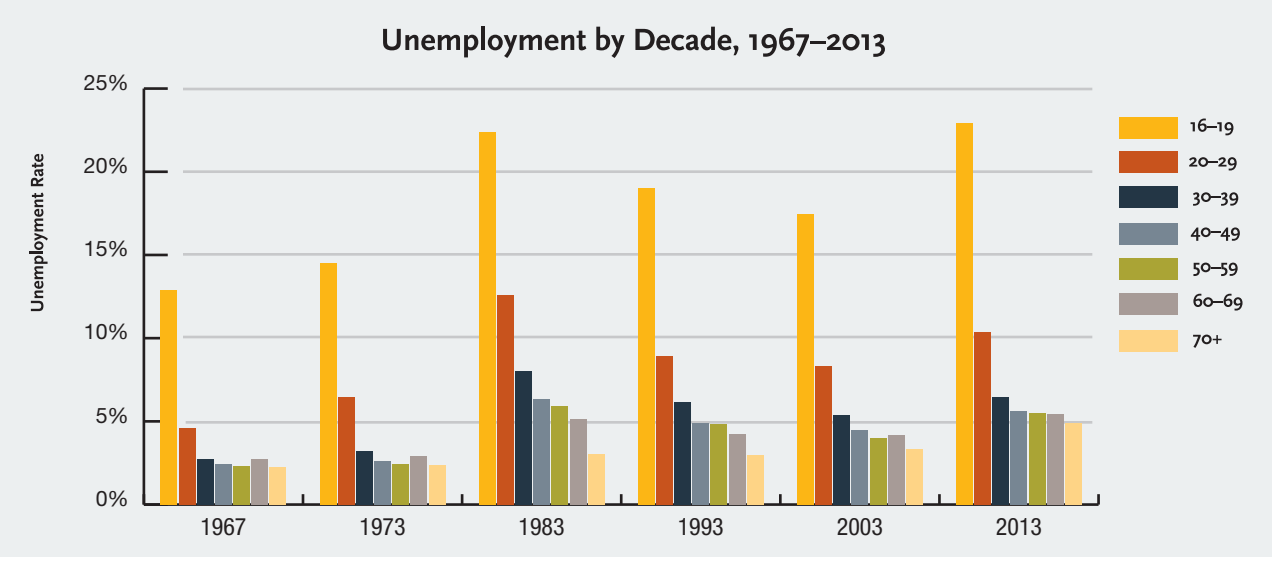

Figure 72: *Unemployment by Decade, 1967–2013 (Source: Bureau of Labor Statistics)*

Switching the axes has revealed yet another trend: The age cohort with the lowest unemployment rate has normally been the 50-59 cohort. This is particularly true if 60-69 and 70+ cohorts are excluded, as those older cohorts have much lower labor-force participation rates, and so are not directly comparable to the younger ages.

Connecting National Unemployment to Aggregate VMT

The open question, at a national level, is whether or not changes in the national level of unemployment correlate strongly with changes in overall, aggregate VMT. Conceptually, this seems like a reasonable hypothesis, but empirically—does it hold water?

The fact that the high unemployment rates in 1983 and 2013 are so similar yields a very interesting opportunity for a "natural experiment." In social sciences, it is very challenging to run a controlled experiment in order to tease out the effects of different variables, as in physical sciences, since the field of experimentation would be an entire society in real-time, and this is not feasible to control. However, occasionally situations arise in general society where two situations are so similar, empirically, that they can be compared almost as if they had been a purposeful, intentional experiment.

The similarity of unemployment rates for 1983 and 2013 is one such "natural experiment." Did the high unemployment rates in 1983 lead to depressed amounts of driving, either for specific age cohorts or overall? If so, did these depressed amounts of driving eventually recover? Figure 73 sheds light on the topic.

The clear answer, as uncovered by this chart, is that aggregate VMT was rising relentlessly during the early 1980s, despite the record-high unemployment rates that are comparable only to the late 2000s and early 2010s.

In addition, aggregate VMT began to slow down and then reach a plateau in approximately 2005, well before the extremely low unemployment rate of 2007. If unemployment were the primary determinant of aggregate VMT, this would not be the case.

These observations make the point that in 2014, factors other than unemployment are likely at play for the decade-long stagnation of aggregate national VMT.

That being said, it is still worthy to note that the

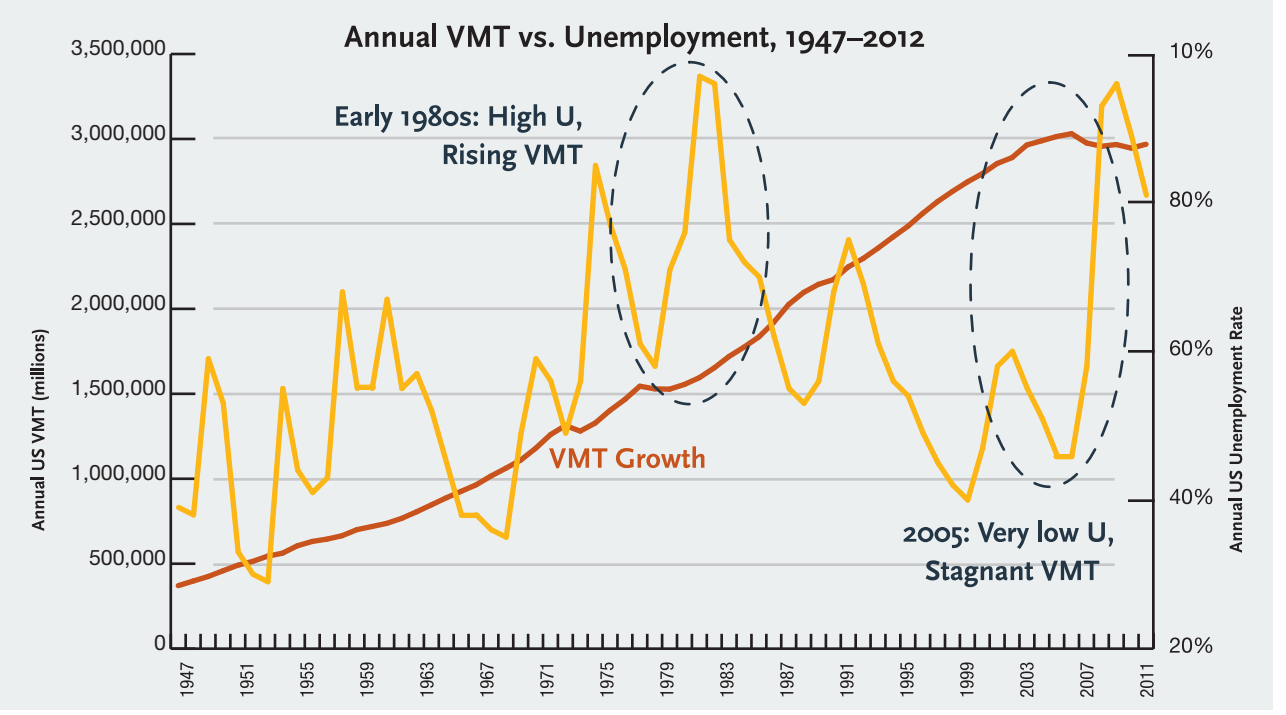

Figure 73: *Annual VMT vs. Unemployment, 1947–2012*
(Sources: Federal Highway Administration; Bureau of Labor Statistics)

record-low unemployment in the 1990s did coincide with the steep growth of VMT, and the record-high unemployment of the late 2000s does coincide with the longest stagnation of VMT. If one were only looking at the 25 years from 1987 through 2012, this is what one would see—and incomplete, faulty conclusions of correlation could easily be drawn. A long historical perspective helps to tease out a truer sense of norms and possibilities.

Age-Based Breakouts: VMT vs. Unemployment

This section breaks out age-specific unemployment rates and compares these to age-specific VMT.

The first chart deals with teenagers. (Figure 74) One pattern shown in this chart is very clear: The two greatest increases in unemployment have been directly correlated with the two greatest drops in VMT per driver, in 1983 and 2009, respectively.

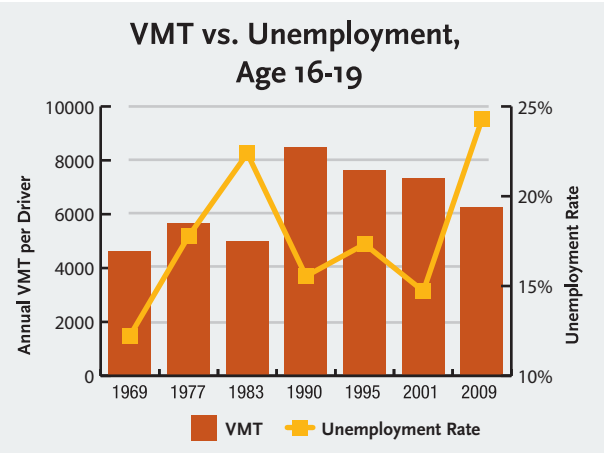

Figure 74: *VMT vs. Unemployment, Age 16-19 (Sources: Federal Highway Administration; Bureau of Labor Statistics)*

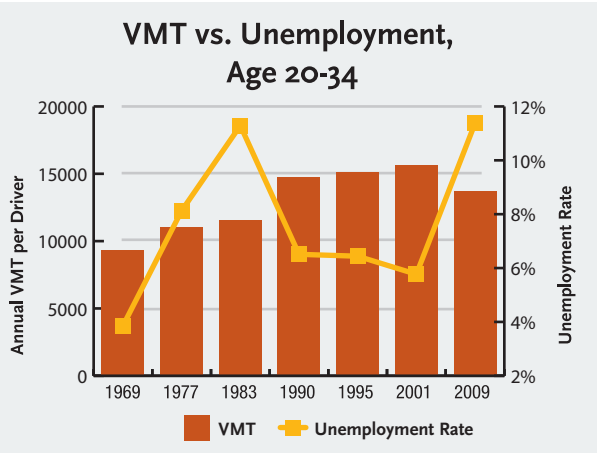

Figure 75: *VMT vs. Unemployment, Age 20-34 (Sources: Federal Highway Administration; Bureau of Labor Statistics)*

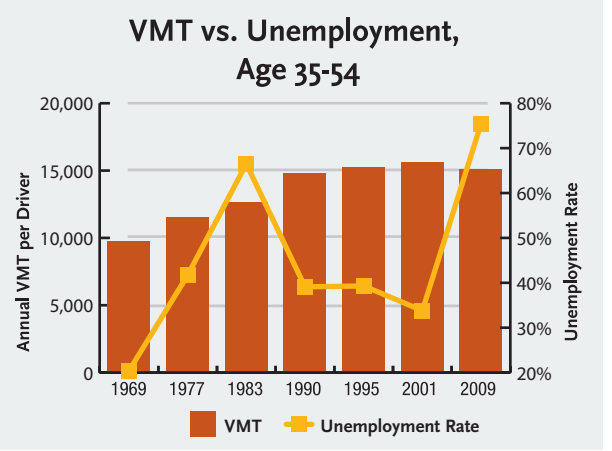

Figure 76: *VMT vs. Unemployment, Age 35-54 (Sources: Federal Highway Administration; Bureau of Labor Statistics)*

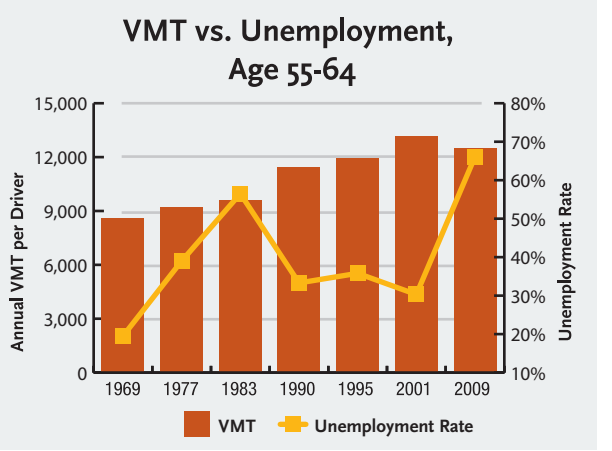

Figure 77: *VMT vs. Unemployment, Age 55-64 (Sources: Federal Highway Administration; Bureau of Labor Statistics)*

Other patterns, however, are less clear. In 1977, both unemployment and VMT went up. In 2001, both unemployment and VMT fell. This goes against the grain of the inverse relationship shown in years of large spikes in unemployment.

These ambiguities suggest a strong but not absolute inverse correlation between unemployment and VMT for teenaged drivers. The correlation is most obvious in years with a very high spike in unemployment, but less obvious across other years where unemployment is steadier. The inverse relationship doesn't necessarily hold in every year.

The next three graphs, for the cohorts of working-age adults (20-34, 35-54, and 55-64) show very similar findings to one another: (Figures 75,76,77)

For each the following correlations hold true:

- From 1969-1983, both unemployment and VMT rose.
- In 1990, 1995 and 2001, low unemployment coincided with increased VMT per driver in those years.
- In 2009, unemployment spiked and VMT fell off.

Finally, the last cohort to examine is the 65+ age grouping. This is the one cohort to break from the mold in 2009. (Figure 78)

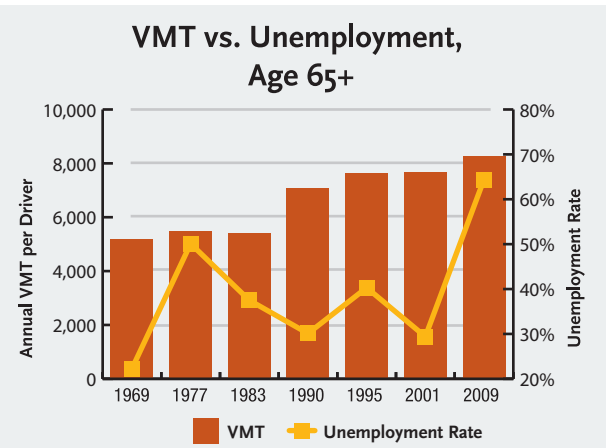

Figure 78: *VMT vs. Unemployment, Age 65+ (Sources: Federal Highway Administration; Bureau of Labor Statistics)*

This graph shows a telling sign of the shifting of VMT towards older drivers. The age-specific unemployment rate spiked in 2009 to its highest level ever—and nevertheless, the VMT of the typical 65+ driver increased to its highest level ever.

This is all the more noteworthy given that it flies against the otherwise well-established trend. For every other age cohort in 2009, the spike in unemployment led to a noticeable fall in VMT.

Summary: Unemployment and VMT

Unemployment has a meaningful, inverse correlation with VMT. However, the strength of the correlation is somewhat weaker than it was for labor-force participation.

At the national level there is no clear relation between the national unemployment and total aggregate VMT of all drivers. This is probably because confounding factors, such as the growth of the driving population, the entry of female drivers, and suburbanization (to name just a few factors) have also played a role.

But for specific age cohorts, a correlation can definitely be observed. For any given cohort, at any given time, age-specific unemployment rates do seem to have a strong correlation with the age-specific VMT of the average driver. This has been clearly demonstrated in the age-specific breakout charts.

The extent that "failure to launch" can be captured by unemployment statistics alone, the youngest workers have always had the highest unemployment rates, and this has always abated as these generations have proceeded throughout their lives.

It is an open question, the extent to which this will continue happening. Has the economy shifted in such a fundamental manner that the traditionally high unemployment rates of the youngest workers will persist longer than usual? Answering this question is beyond the scope of this current study, but in terms of the tension between cohorts and generations, this is the question to ask. Will the current young generation's economic struggles be restricted to the time this generation spends occupying the youngest age cohorts, or will these struggles persist in the shape of elevated unemployment rates as this generation proceeds all the way through life? The answer is unknown but the question is important.

Summary of Labor-Market Trends

Shifting to the Most Direct Demographic Counts: Employment-to-Population Ratio

The analysis in this section implies a subtle, transitional shift in the frame of reference. Namely, the shift goes from appearances to reality, or from symptoms to cause. Labor-force and unemployment rates are very useful symptoms, but like any symptoms, they can be misleading at times, sending off "mixed signals."

An implicit thesis of this present study is that a demographic analysis provides a clearer look at the underlying causes. This begs the question—what exactly is a demographic analysis? And the further question—what are the most important demographic variables for assessing VMT trends?

The following equation has been presented throughout:

VMT = (Drivers) × (VMT per Driver)

If one looks directly at labor-force participation or unemployment, they graze the amount of drivers but do not directly hit the target in the bull's eye.

The statistic presented at the beginning of the chapter—the total amount of workers—is a truer demographic variable. It is a large-scale count of an important population. If we perform the same type of age-cohort analysis for this variable against VMT, as was done for labor-force participation and unemployment rates, then the clarity of the correlation is refined even further. (Figures 79-83)

What is noteworthy about these graphs is the exceptional clarity in which they are cast. The earlier correlations, with labor-force participation and unemployment, were quite clear, but these employment-population vs VMT graphs show an additional level of acute sensitivity in the interplay between the two variables being presented. The most minute shifts in one of the variables, for most years, are accompanied by the most minute shifts in the other variable.

One is reminded of the importance of cross-referencing. With empirical research, it is extremely important to

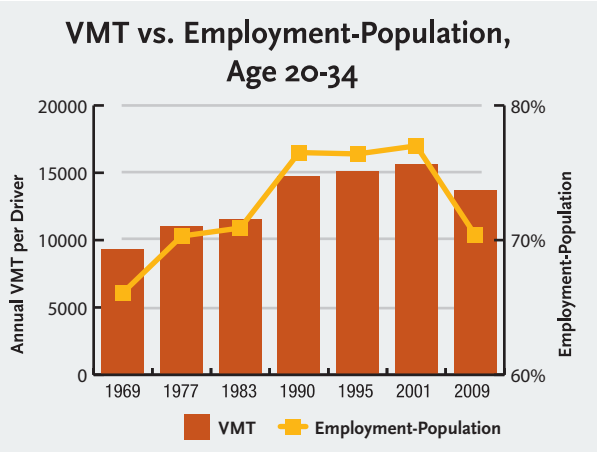

Figure 80: *VMT vs. Employment-Population, Age 20-34 (Sources: Federal Highway Administration; Bureau of Labor Statistics; U.S. Census Bureau)*

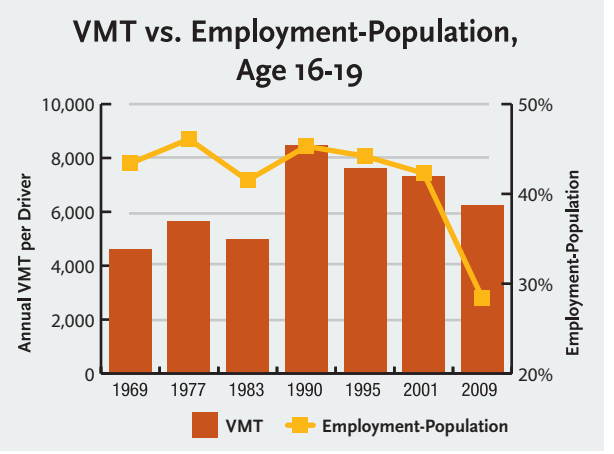

Figure 79: *VMT vs. Employment-Population, Age 16-19 (Sources: Federal Highway Administration; Bureau of Labor Statistics; U.S. Census Bureau)*

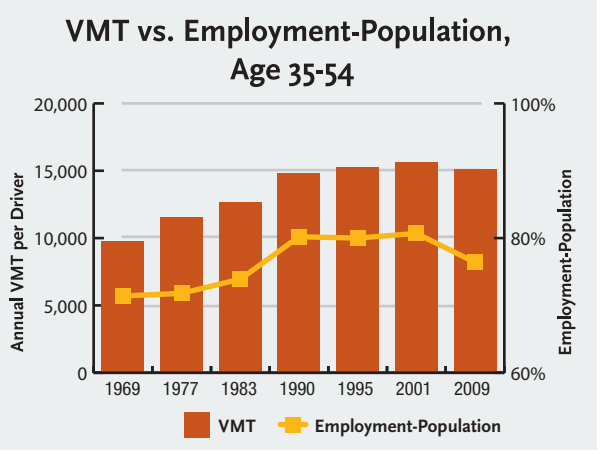

Figure 81: *VMT vs. Employment-Population, Age 35-54 (Sources: Federal Highway Administration; Bureau of Labor Statistics; U.S. Census Bureau)*

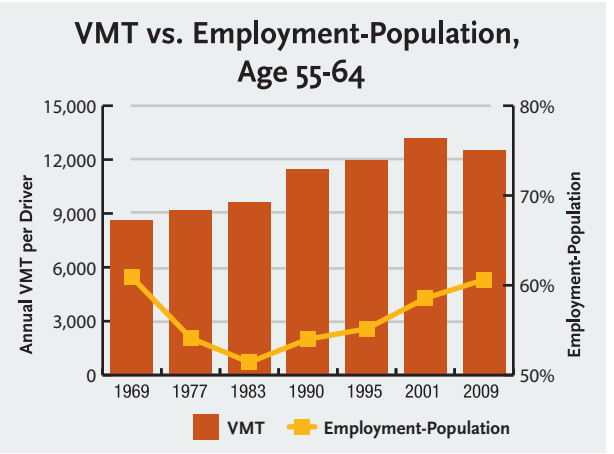

Figure 82: *VMT vs. Employment-Population, Age 55-64 (Sources: Federal Highway Administration; Bureau of Labor Statistics; U.S. Census Bureau)*

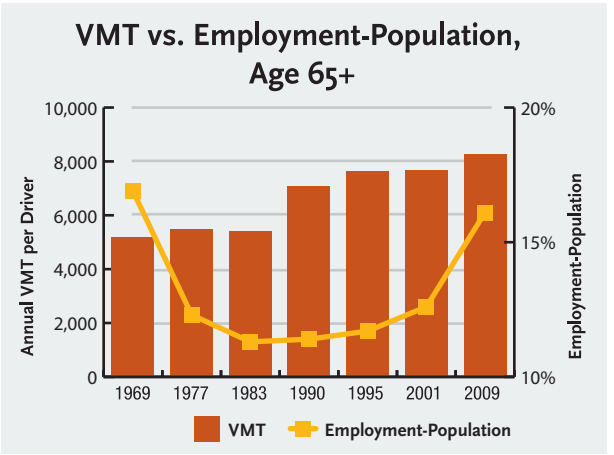

Figure 83: *VMT vs. Employment-Population, Age 65+ (Sources: Federal Highway Administration; Bureau of Labor Statistics; U.S. Census Bureau)*

triangulate data in order to cross-check the validity of the answers. The richness of the labor market data has permitted cross-checking of three variables (labor-force participation, unemployment, employment-population) against one another, a unique opportunity to check and re-check the correlations being studied. The extra-fine clarity of employment-population would not be fully appreciated unless labor-force participation and unemployment had first been studied.

Introducing the Concept of "Parallel Populations"

The analysis of the employment-population ratio points the way towards answering the question: "What are the most important variables for assessing VMT trends?" What occurred in analyzing the labor market is that correlations were revealed when the actual underlying populations—the workers and the general U.S. population—were indexed against one another and then compared to driving behavior.

This leads the way to fresh insight on a classic analytical issue: differentiating between what is the symptom and what is the cause. In a demographic study, it is important to make a distinction between demographic variables, and the demographic populations that these variables are meant to describe. The current volume has presented the behavioral variables of gender, age, income and labor market dynamics, and has examined the strength (or weakness) of their respective effects on driver behavior.

While the study is titled "Driver Demographics," this is in fact somewhat misleading, as it has been built upon not one, but two important populations: drivers and workers. Every variable examined, such as age, income or labor-market dynamics, has actually been like a lens focused on one or the other of these underlying populations.

The point is that the underlying populations—the drivers and the workers—are ultimately what drive the aggregate count of VMT. For drivers, the variables of age, income, wealth, and gender simply focus different lenses on the underlying population of drivers, and for the workers, the labor-force participation rate, the unemployment rates, and employment-population ratio simply focus different lenses on the underlying population of workers. As the previous analysis of the employment-population ratio suggests, a more direct look at the underlying populations can give a finer appreciation of the factors most directly impacting travel demand.

Both the drivers and the workers are derived directly from the U.S. population, so it is very important to present these within the context of the overall U.S. population. Neither one can ever exceed the size of the general population, nor even a proportion of the population (since individuals under 16 can't drive, and under 14 can't work, and since

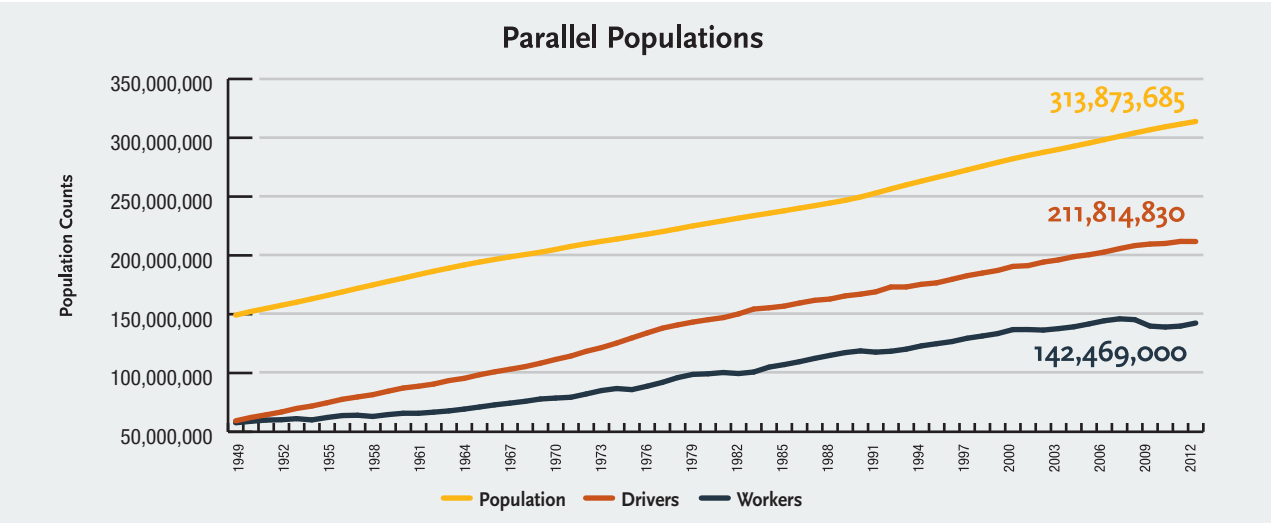

Figure 84 *Parallel Populations*

(Sources: U.S. Census Bureau; Federal Highway Administration; Bureau of Labor Statistics)

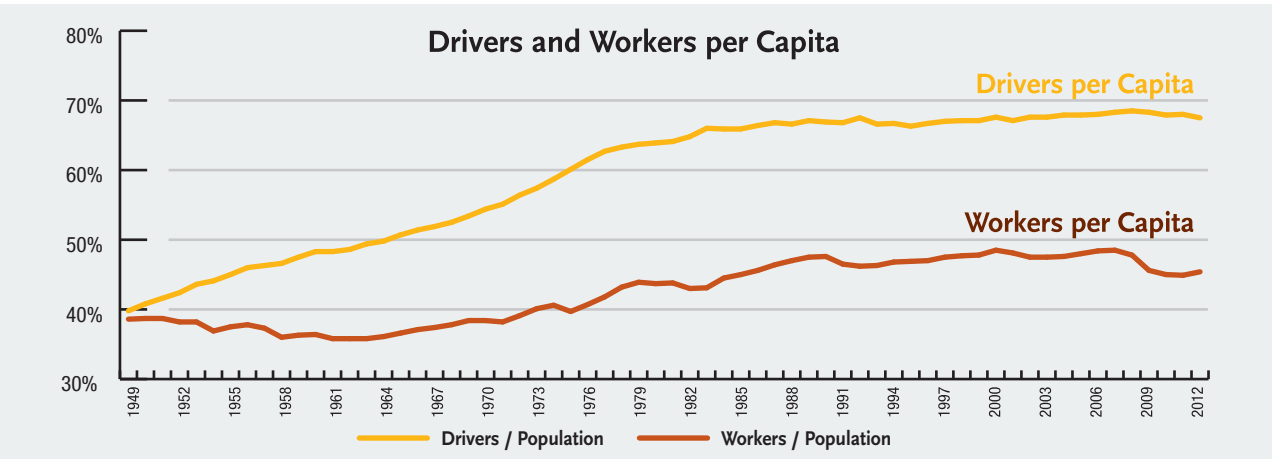

Figure 85: *Drivers and Workers per Capita*

(Sources: U.S. Census Bureau; Federal Highway Administration; Bureau of Labor Statistics)

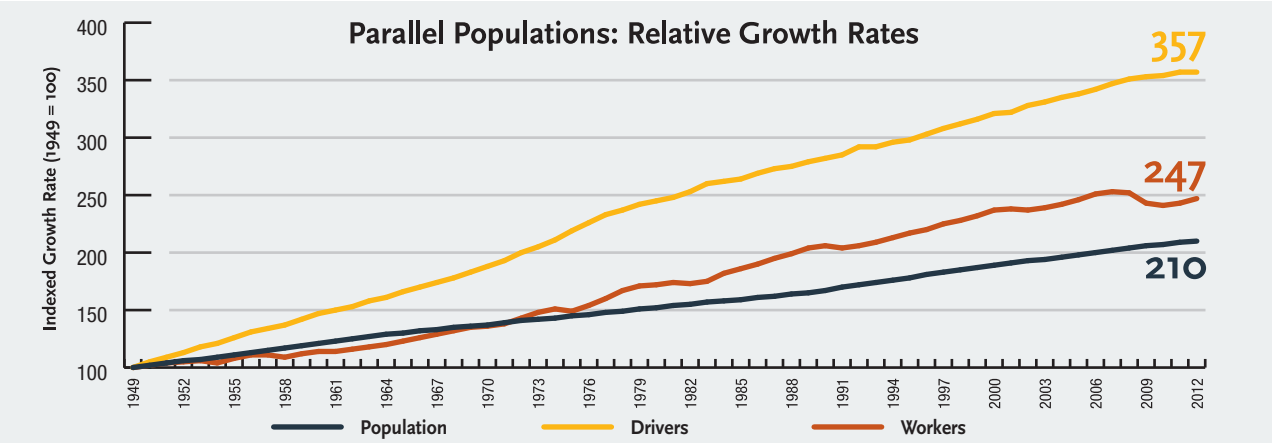

Figure 86: *Parallel Populations: Relative Growth Rates*

(Sources: U.S. Census Bureau; Federal Highway Administration; Bureau of Labor Statistics)

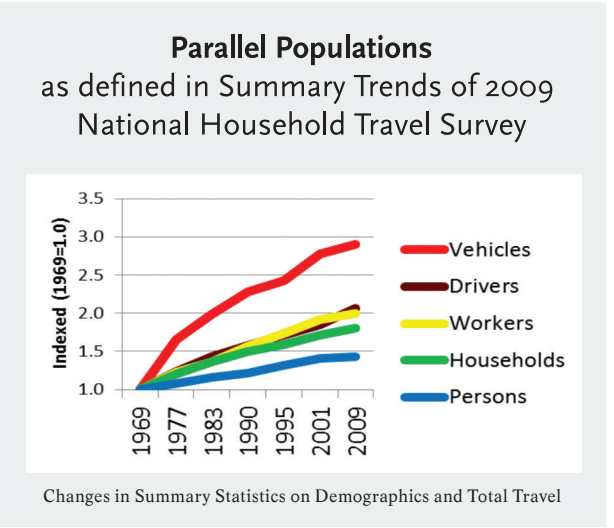

Figure 87: *Parallel Populations (Source: National Household Travel Survey, 2009 Summary Trends, Figure 1, page 14)*

the very elderly are unlikely to either drive or work). Figure 84 shows the trends in each—drivers, workers, population—since 1949.

This can be compressed, accordion-style, by indexing both the drivers and the workers against the general population. (Figure 85)

The same overall trend of saturation has emerged. When directly indexing the drivers and the workers against the population, the natural carrying capacity of both drivers and workers becomes clear.

Finally, the relative growth rates of each population can be examined in Figure 86. In many ways, this graph simply restates what the first two graphs had already shown. Nevertheless, it is important to view this graph in its own right, since it links directly to a major finding of the National Household Travel Survey's *2009 Summary Trends*. This document serves as the foundation of all driver demographic research since 2009. (Figure 87)

The Fuels Institute's purpose to create a common frame of reference necessitates tying back the findings of the present "Driver Demographics" study to the FHWA's indexed growth rates. Synthesizing the FHWA's touchstone chart into the driver demographics framework in this study can help to create deeper understanding of what has been happening with transportation demand. (Figure 87)

What stands out about the chart is that vehicles, drivers, and households are in fact only three of the five populations considered relevant by the FHWA as growth factors which feed into aggregate VMT. It turns out, in fact, that the population with the highest growth rate—the vehicles—is also the only inanimate, non-living population on the above graph. The vehicle growth rate has been so far above the other growth rates that it cannot be ignored—it stands to reason that the very high vehicle growth rate must have had a significant effect on VMT growth. Vehicles have not even been examined in the current study—and yet it seems, from simple common sense, that the increase in vehicles relative to the other factors must have had a major effect on VMT.

Looking at Figure 87, then, gives rise to the notion that there are additional large-scale "populations," in addition to the drivers, which have an effect on VMT growth. The vehicles are one of these populations, and Fuels Institute independent research has revealed another important population to be that of the roads. What relates both vehicles and roads to one another, and differentiates them from the drivers, workers, etc., is that the vehicles and the roads are both inanimate—neither one is sentient or alive. The common analytical ground is that every vehicle, and the surface of every mile of roadway, can still be demographically analyzed, in the sense that every member of the group is born, ages, and dies, and this in turn affects the rate of growth, decay, or stability of the entire group.

Relevance of Parallel Populations

The concept of parallel populations is relevant because it gives deeper perspective on saturation. It identifies how close the underlying populations which most affect VMT have approached to their natural carrying capacity. Identifying the natural limits of each underlying population is very important for identifying the natural limits of transportation demand—it is a market-sizing exercise. In addition, focusing on the "parallel populations" directly addresses the need to separate symptom from cause, which confronts any study of a complex system. It is a major step forward towards defining a wider, more comprehensive frame of reference, and further investigation into this concept is the natural next step for sequel studies to the current report on driver demographics.

With this in mind, we move into the conclusion of the study.

Conclusion

The motivation for this study was to assess personal transportation demand through the lens of driver demographics. The study's findings indicate that total transportation demand has been stable for 10 years, and will likely be stable for the foreseeable future. This trend stands in contrast to the 100 years before, when it grew continuously.

Today, every significant growth factor is saturated because, on a per capita basis, each factor has reached its natural limit. The only remaining area for growth is in the general population; but even the effects of this increase will be constrained by the natural limits of every other growth factor. *The coming changes in industry can be summarized as "transformation within a context of saturation."*

The original equation for fuel consumption given in the introduction to this paper, is:

$$\text{Fuel consumption} = \frac{\text{(vehicle-miles traveled)}}{\text{(fuel efficiency)}}$$

As the introduction explained, VMT and fuel efficiency are the main determinants of fuel consumption, and fuel demand is essentially a "derived demand" from transportation demand. Throughout this paper, we have only examined VMT and we have determined that the growth factors for VMT are mostly saturated. This in itself would present the strategic business problem of *fragmentation*. For every alternate fuel or vehicle, industry will need to do a mass introduction of that technology—and how can one use the proceeds from retail fuel sales to pay for new investments, when the amount of infrastructures will multiply but the total size of the end market will either remain the same or shrink? The major obstacle here is the chicken-and-egg problem: what comes first, the vehicle or the fuel? This is made even more challenging by the situation of "transformation within a context of saturation."

If we reintroduce fuel-efficiency into the equation, the strategic problems become even sharper. Vehicle fuel efficiency could dramatically change the equation for fuel consumption. The reason is that most of the new vehicles propose to change the vehicle-miles per gallon from today's average of 20 mpg to 50-100 mpg or even more, on a gasoline-gallon equivalent basis (GGE). The saturation of VMT combined with the prospect of radically improved fuel efficiency means that not only will the end user market be fragmented, but the total amount of fuel sold will be dramatically reduced.

Personal vehicle travel will remain roughly the same in the aggregate, but the market for fuel will be reduced, and moreover, the overall market for any given new *fuel* will be even further reduced. In other words, *transportation demand will remain the same but fuel demand will decline drastically.* This finding has alarming implications for the future of the fueling industry. It will make the market climate for the introduction of any new fuel much more difficult to achieve, because *resolving the chicken-and-egg problem requires establishing economies of scale, but the very process of introducing new fuels will undermine the process of achieving economies of scale.*

The coming changes in industry can be summarized as "transformation within a context of saturation.

Travel Demand Saturation and Parallel Populations

One of the most promising areas of research lies in an examination of the "inanimate" populations determining driving behavior. Drivers are "animate"—they are alive. But the roads, vehicles, land-use patterns, and so forth, are "inanimate" factors which have a profound effect around age on transportation. Each has its own demographic characteristics; the members of these inanimate populations are "born," age, and "die," at rates that can be measured systematically.

It is proposed to construct a holistic new framework for understanding transportation demand through a demographic examination of these "inanimate" growth factors. This might be coined as the study of "parallel populations." The growth rates of all these factors have had a major influence on the growth of transportation, and it is important to create a holistic perspective in which the complex interactions of all these factors can be illustrated. Context can be hard to convey. The proposed new framework for transportation would be a direct attempt to frame the context of the coming changes in the fuels and vehicles industries, and to provide a clearer basis for responding to "transformation within a context of saturation."

Next Steps

The diversity of alternative fuels and alternative vehicles being introduced is likely to undermine current business models and to create a need for large-scale investment into unproven business models. In order to reduce this uncertainty, the current study of driver behavior and vehicle travel demand has been undertaken. The introduction of radically improved forms of transportation may sow the seeds of a dramatic trimming of the herd of the current fuel industry. It is unclear as of yet how to respond to this problem, but it is a subtle and unmistakable strategic issue confronting the future of the fueling industry. The prospect of severe market fragmentation justifies further research into the topic of transportation, so that these problems can be better understood and so that a wider and more comprehensive frame of reference can be established.

KEY TAKE-AWAYS

1. RESOLVING THE CHICKEN-AND-EGG PROBLEM requires establishing economies of scale, but the very process of introducing one or more new fuels will undermine the ability to achieve an economy of scale for any given fuel.

2. ONE OF THE MOST PROMISING AREAS OF RESEARCH lies in an examination of the "inanimate" populations determining driving behavior

3. THE INTRODUCTION OF RADICALLY IMPROVED FORMS OF TRANSPORTATION may sow the seeds of a dramatic trimming of the herd of the current fuel industry.

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