ANL/ESD-14/20

Will We Drive Less?: A White Paper on U.S. Light-Duty Travel

Energy Systems Division

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Summary

After decades of inexorable (though gradually slowing) growth, U.S. vehicle miles traveled (VMT) dropped from 2007 to 2008 and have been relatively flat since; and VMT per capita actually peaked a few years earlier, in 2004, and has dropped since then. Specifically, from 1971 through 1995, average VMT growth was 3.1%/year; this growth rate dropped to about 2%/year from 1996 through 2007 and has been close to zero since then. This reversal in VMT growth has been observed throughout the industrialized world with the exception of rapidly developing economies such as China. Several authors have speculated that 2007 was a true peak in vehicle travel in the U.S. and other developed nations, with VMT likely stagnating or dropping in the future.

For a variety of reasons, it is quite clear that future VMT growth in the U.S. will be well below pre-2000 rates. Many of the factors that drove past growth have essentially run their course. These factors include:

- Increased levels of participation in the labor force by women (now essentially saturated)
- Increased access to vehicles, as the ratio of vehicles to potential drivers soared and the number of zero vehicle households dropped (saturated, the number of vehicles per person 16 and older is nearly one, and the percentage of zero vehicle households has dropped below 10%)
- Largely in response to growing access to vehicles, sharp drops in vehicle occupancy (halted and — apparently — somewhat reversed)
- Increasing speeds on U.S. highways, allowing more travel on a constant time budget (highway speeds have stabilized)
- Sharp drops in transit usage, with former users shifting to cars (halted, with some recent growth in transit usage)
- Substantial migration from the inner core of cities to their suburbs, with greater distances to access services (halted and somewhat reversed)

Other factors, such as the “baby boom” population surge reaching peak driving age, also played a role in past VMT growth….and many of these trends have eased or reversed, e.g., baby boomers are now beginning to retire. Further, the largest drop in VMT over the past few years occurred among youth (and especially young men), who appear to be the first generation in recent times to show a sharply reduced interest in automobiles, identifying their cell phones and

tablets as being of far greater importance. The persistence of this behavior as this generation ages, and as younger teens move into this age group, will be a major factor in future VMT trends.

Despite these changes, it is far from clear that VMT will not soon resume growing at a moderate rate. First, a significant portion of the recent VMT decline is likely to have been caused by the sharp rise in gasoline prices that began around 2003, and gasoline prices may not continue to rise. Further, stringent fuel economy standards will make future vehicles considerably more efficient, driving down per mile fuel costs….which should tend to stimulate VMT growth. And some other trends will tend to work towards VMT growth. Most importantly, U.S. population will continue to grow; EIA's 2014 Annual Energy Outlook projects population growth of 0.7%/year from 2011–2040. Further, growth in trip length — a significant factor in past VMT growth — may not have stopped. And although some authors argue that the worldwide recession was not the cause of the VMT decline — because VMT growth began to slow a few years before its 2008 onset — the recession clearly played a role in holding down VMT from 2008 onwards; also, in the U.S. at least, income growth had stopped a few years earlier for the bottom three quintiles of income — so 60% of the U.S. population were already experiencing income declines well before the 2007 VMT "peak." In other words, U.S. economic growth, and especially a rise in median income, should stimulate VMT growth. Of course, median income could continue to stagnate, which would likely hold down future VMT growth.

The 2014 Annual Energy Outlook clearly accepts the idea that future U.S. growth in VMT will be slow. The 2014 Reference case projects a compound annual rate of growth in LDV VMT of 0.9% from 2012–2040 — about half the growth rate of the decade before 2007. With an estimated population growth of 0.7%/yr, this implies an annual increase in VMT/capita of only 0.2%, versus a 1994–2004 annual growth rate of 1.2% (that is, for the decade before its peak). The Low VMT case projects an annual VMT growth rate of only 0.2%; since population still grows at 0.7%/yr for this case, this yields an annual *decrease* in vmt/capita of 0.5%. Further, the High VMT case projects a VMT growth rate of only 1.1% (VMT/capita growth of 0.4%), a much lower rate than the actual growth rate before 2007.

In projecting future VMT, a number of key determining factors are highly uncertain. In particular:

- What will be the trajectory of world oil prices and fuel prices? And how much will increasing efficiency in conventional vehicles and adoption of new technology vehicles reduce the fuel cost of vehicle travel?
- What is the future of U.S. income growth, and how will it be distributed? In particular, will most income growth continue to accrue to the highest income quintile?
- Will current disinterest in auto travel among young Americans continue as they age, and will they stay in inner cities as they marry and have children?
- Will new technologies and services, e.g., car-sharing, continue to expand rapidly? Will increasing vehicle automation reduce the perceived time cost of auto travel?

In planning for future infrastructure development and energy development and research, and in conducting transportation and energy policy analysis, it appears prudent to assume that future U.S. VMT growth will likely slow from its pre-2007 rate and to entertain the possibility that VMT will actually continue to stagnate or even decline (though the uncertainty is such that a "high VMT" case, perhaps a bit higher than the AEO2014 high case, should still be considered). Some of the obvious implications:

- Oil consumption and/or greenhouse gas emission targets will be somewhat easier to achieve
- Transportation infrastructure budgets, and especially the split between maintenance and new construction, should be reexamined
- Gasoline taxes, a primary source of funds for infrastructure construction, will continue to decline; new sources of funding will be required
- As the precise causes of recent VMT trends become clear, it may be useful to take actions that amplify some of the causes of VMT declines.

1 History

The history of vehicle travel in the United States has generally been one of inexorable increase, as shown in Figure 1. Until about 2005, growth in VMT (and VMT/capita) basically shrugged off recessions and oil price spikes alike with small perturbations. However, after the period of 1971 through 1995, when VMT growth averaged 3.1% per year, growth slowed to 2.0%/yr from 1996 through 2004 and then slowed and dropped sharply — the 2005, 2006 and 2007 growth rates were 0.8, 0.6 and -0.3%, respectively (Puentes and Tomer, 2008). Post 2008, VMT has been relatively flat.

In contrast to VMT, VMT/capita dropped consistently after its peak, although 2013 showed a small uptick. Before its peak, VMT/capita followed basically the same path as VMT but actually peaked earlier — in about 2004; only population growth kept national VMT growing a few more years.

An analysis by the Center for Urban Transportation Research (Polzin, 2010) disaggregated some basic factors that contributed to U.S. VMT growth during 1977–2001, shown in Figure 2. Mode shifts, 16% of the total, reflect substantial reductions in transit and walking share. Trip length, 10%, reflects higher speeds (with a relatively constant time budget for travel) and substantial movement from cities to suburbs — that latter also influencing modal choice. Trip frequency, the largest factor (46%) reflects a combination of women entering the work force and much lower vehicle occupancy (associated in large part with growing numbers of vehicles), among other factors.

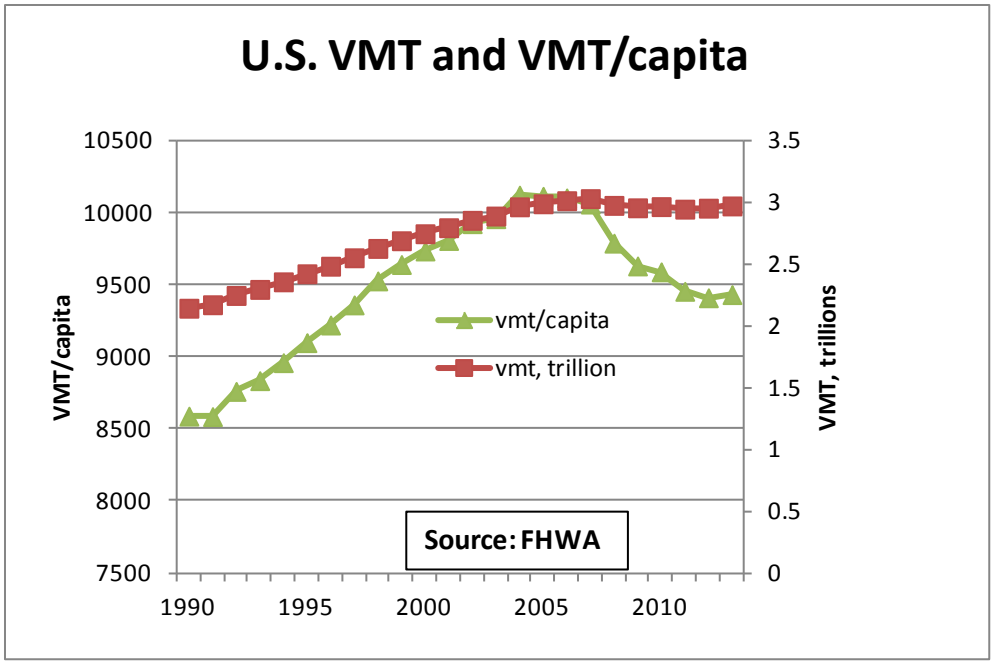


Figure 1 Recent Trends in U.S. VMT and VMT/Capita

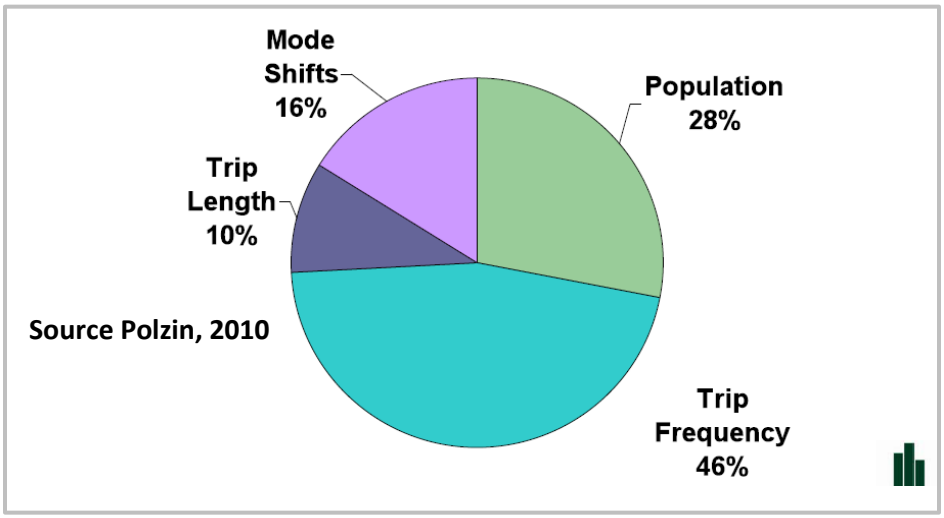


Figure 2 Factors Contributing to U.S. VMT Growth, 1977–2001

An examination of the numerous factors that combined to create the VMT growth record will be extremely useful in understanding why the growth occurred and the likelihood of future growth. In general, many of the factors that created this growth record have played themselves out and are unlikely to play much of a role in the future. This is not a new observation: Dr. Charles Lave of the University of California at Berkeley recognized the inevitability of a large slowdown in VMT growth in a prescient 1991 paper (Lave, 1991). The various factors that will dictate future growth, most of which Lave recognized over two decades ago, are the following:

Population Growth and Characteristics. U.S. population grew vigorously throughout the 1971–2007 period, averaging 1.1% per year, providing a large driver for VMT growth. One factor that drove growth during much of the period, beyond just the overall population growth, was the movement of the Baby Boom surge in population into different age cohorts. As shown in Figure 3, the mid-twenties through mid-fifties are the peak driving years. During the 1971–2007 period, Boomers were moving into their peak driving years, and have more recently been moving into age groups with somewhat lower annual VMT. In fact, the overall U.S. population has been aging, implying a significant reduction in per capita travel as U.S. age distribution shifts towards the 60 and over cohorts. However, it is not clear that past differences in travel behavior with age will continue, with recent trends in greater activity levels among the elderly…as shown in the 2009 data in the figure.

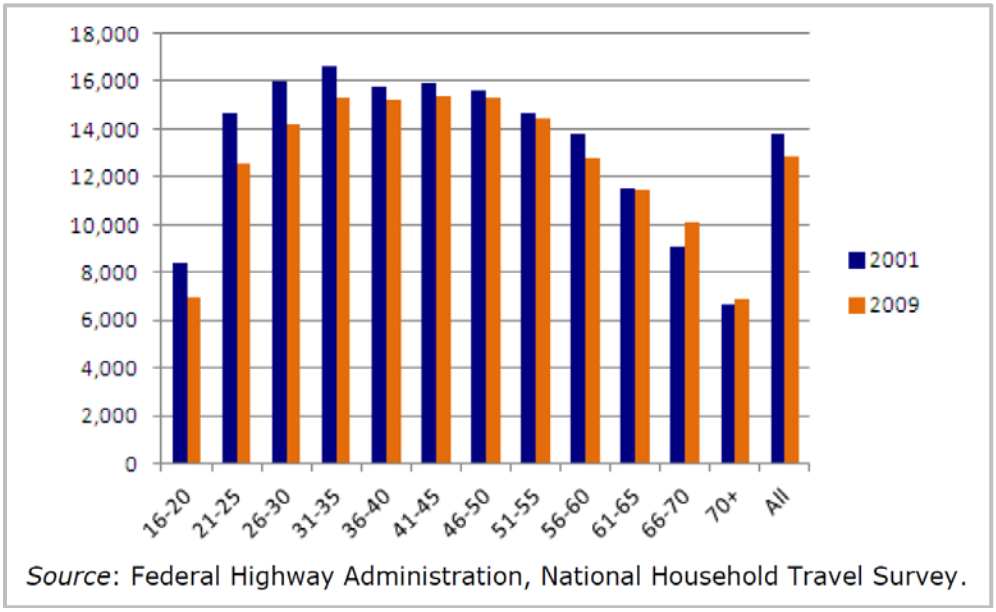


Figure 3 Annual Vehicle Miles Travelled/Driver by Age Group, 2001 and 2009

An especially interesting observation from Figure 3 is the significant reductions in annual VMT/driver for younger drivers during 2001–2009. Each pair of bars do not represent the same drivers….the second (red) bar represents drivers who are 8 years younger than the current age of those represented by the first (blue) bar in each pair. However, the reductions imply that something has happened to younger drivers during the 2001–2009 period. This is explored below.

Women in the Workplace. Stabilization of past increasing levels of labor participation (and vehicle licensing) of women, a major past driver of VMT growth, should slow such growth in the future. As shown in Figure 4, women's work force participation grew from about 30% in mid-century to about 60% by the mid-1990s and appears to have stabilized…though recently it has declined somewhat. It is unlikely that the gap between men and women's labor share, currently about 10%, will shrink dramatically given women's continuing primacy in childcare.

Further, the actual decline in total workforce participation rates should have a negative effect on VMT.

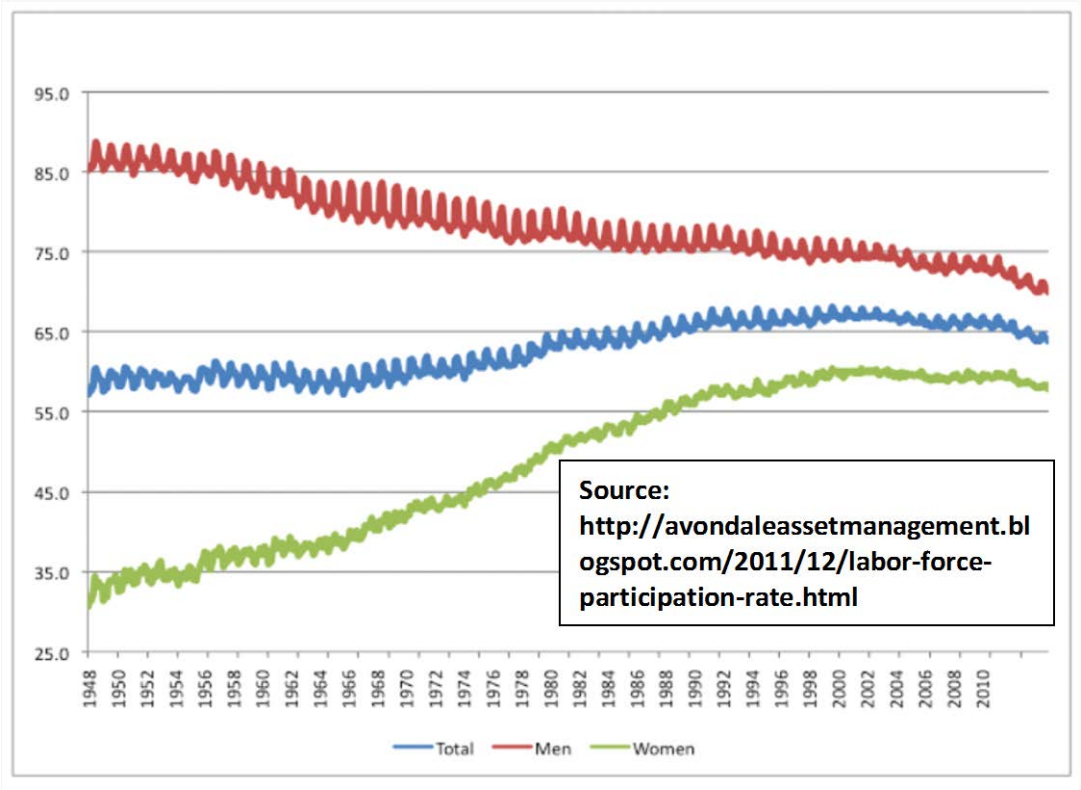
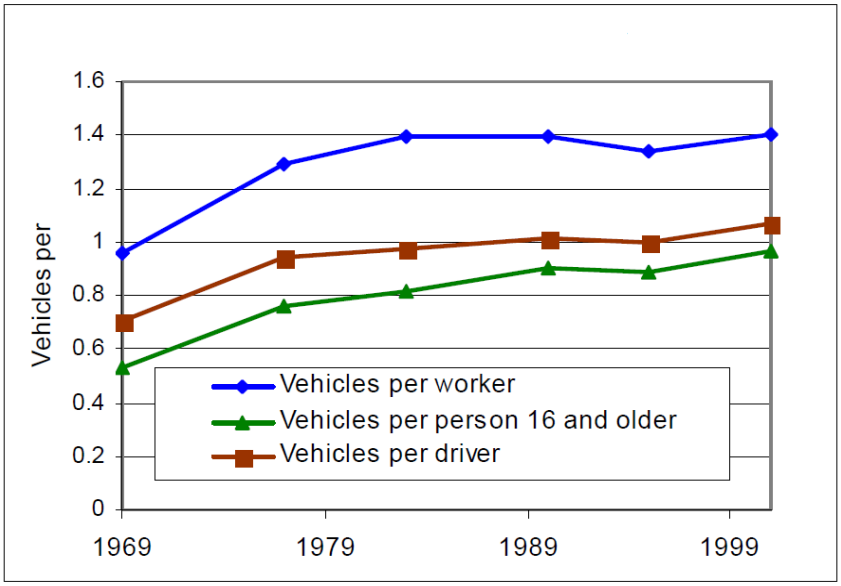


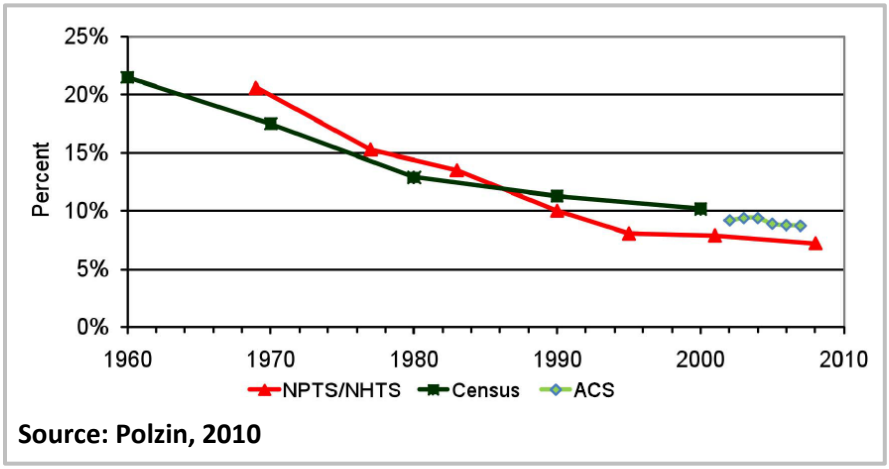
Figure 4 Labor Force Participation Rate

Consumer Access to Personal Vehicles. The steady increase in the number of vehicles available in relation to potential drivers has been a major source of VMT growth during the second half of the twentieth century, driving down vehicle occupancy (because better access sharply reduces the incentive to share rides), reducing the incentive to use mass transit and reducing the number of zero-vehicle households. Figure 5 shows that, by 2000, the number of vehicles per person age 16 and older approached 1.0. Figure 6 shows that the percentage of zero-vehicle households has declined to well below 10%. Although some of the remaining households remain so because of economic circumstances and would purchase a vehicle if they had the means, many will remain without vehicles because of disabilities or purely by choice. Although there may be some room remaining for some increase in access to vehicles, the current level of saturation is high enough to indicate that this is unlikely to be a significant driver of future VMT growth.



Source: CUTR analysis of NHTS/NPTS data. **in Polzin, 2006**

Figure 5 Vehicle Availability



Source: Polzin, 2010

Figure 6 Declining Zero-Vehicle Households

Vehicle Occupancy. Between 1977 and 1995, vehicle occupancy dropped steadily, from 1.9 in 1977 to 1.75 in 1983, 1.64 in 1990 and 1.59 in 1995, requiring higher vehicle miles traveled for the same amount of personal travel. However, the 2009 National Household Travel Survey shows that, from 1995 to 2009, occupancy reversed course, rising to 1.63 in 1990 and 1.67 in 2009 (DOT, 2011). In fact, occupancy for every vehicle category either remained the same or increased (e.g., sport utility occupancy increased from 1.70 to 1.92) in the 1995–2009 period. Although the 2009 occupancy values may have been affected by the recession, the result is virtually the same in comparing 1995 and 2001 values — occupancy increased in all categories except for passenger cars, which sustained a small decrease , from 1.59 to 1.57 (DOE, 2010). Apparently, vehicle occupancy has bottomed out and may now be increasing.

Highway Infrastructure. Access to adequate roads with low levels of congestion and high allowable vehicle speeds can be an important driver of vehicle travel demand. In the U.S., highway infrastructure improved through the 1980s, with increasing travel speeds, helping to drive rapid VMT growth in this period. Litman (2006) claims that infrastructure development then essentially stagnated, and travel speeds declined. As shown in Figure 7, however, between 1980 and 2008, rural road (interstate and other) infrastructure declined by over 2000 miles, but urban road infrastructure *increased* by over 7,000 miles and apparently showed no signs of slowing growth. It seems difficult to make a case that reduced road availability has played a significant role in the recent VMT decline.

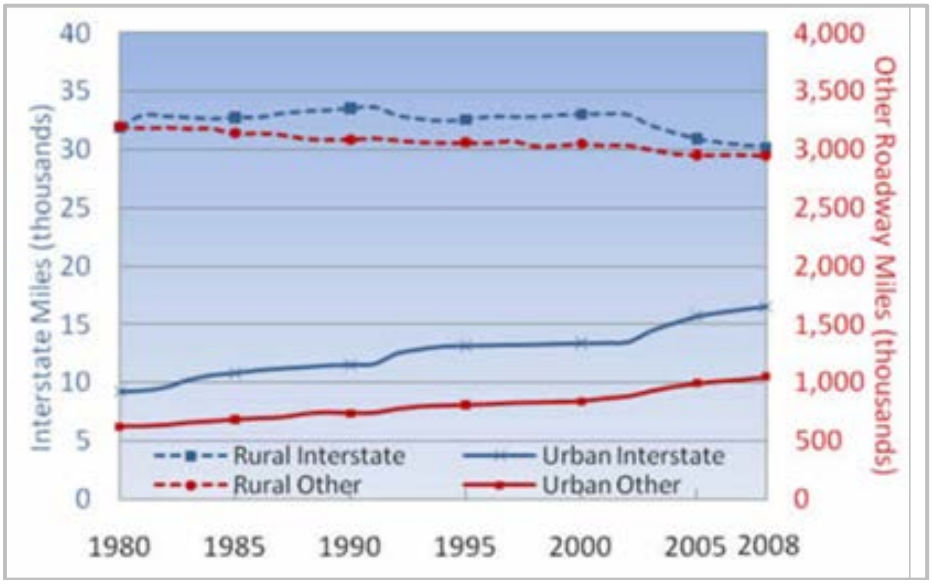


Figure 7 Miles of U.S. Highway Infrastructure (Source: Federal Highway Administration [http://www.fhwa.dot.gov/policyinformation/pubs/hf/pl11028/chapter1.cfm])

2 What Caused the 2007 Break in VMT Growth?

None of the reviewed literature identified the causes of the sudden break in VMT growth that occurred in 2007 for total VMT and 2004 for VMT/capita (see Figure 1). In fact, most papers are explicit in stating that the precise reasons for the break are unclear. Several papers have noted that the break preceded the Great Recession, and thus probably cannot be explained purely by economic reasons (Baxandall, 2013; Davis and Baxandall, 2013; Puentes, 2012).

As noted above (for Figure 3), younger drivers show the largest drops in VMT between 2001 and 2009, so it is useful to focus on this group. It would be highly useful if we had age-group breakdowns, as in Figure 3, on a yearly basis; however, such data is collected only for the National Household Travel Surveys, which are conducted only on a periodic basis (at about 5–8 year intervals). However, the annual *total* VMT trend shows that, until 2004 or so (actual

VMT *reduction* began in 2007, and VMT/capita reduction began in 2004), there was steady VMT growth.[1] It is reasonable to suspect that the 2001–2009 VMT changes in younger drivers began as early as 2004.

Figure 8a shows unemployment trends for different age groups. Basically, the patterns for all the younger age groups are similar….a moderate rise in unemployment in the early 2000s followed by a modest decrease until 2008–2009, when rates shoot up. At the very least, unemployment rates cannot explain why the 2007 VMT drop occurred, although this age group was certainly vulnerable financially before 2007.

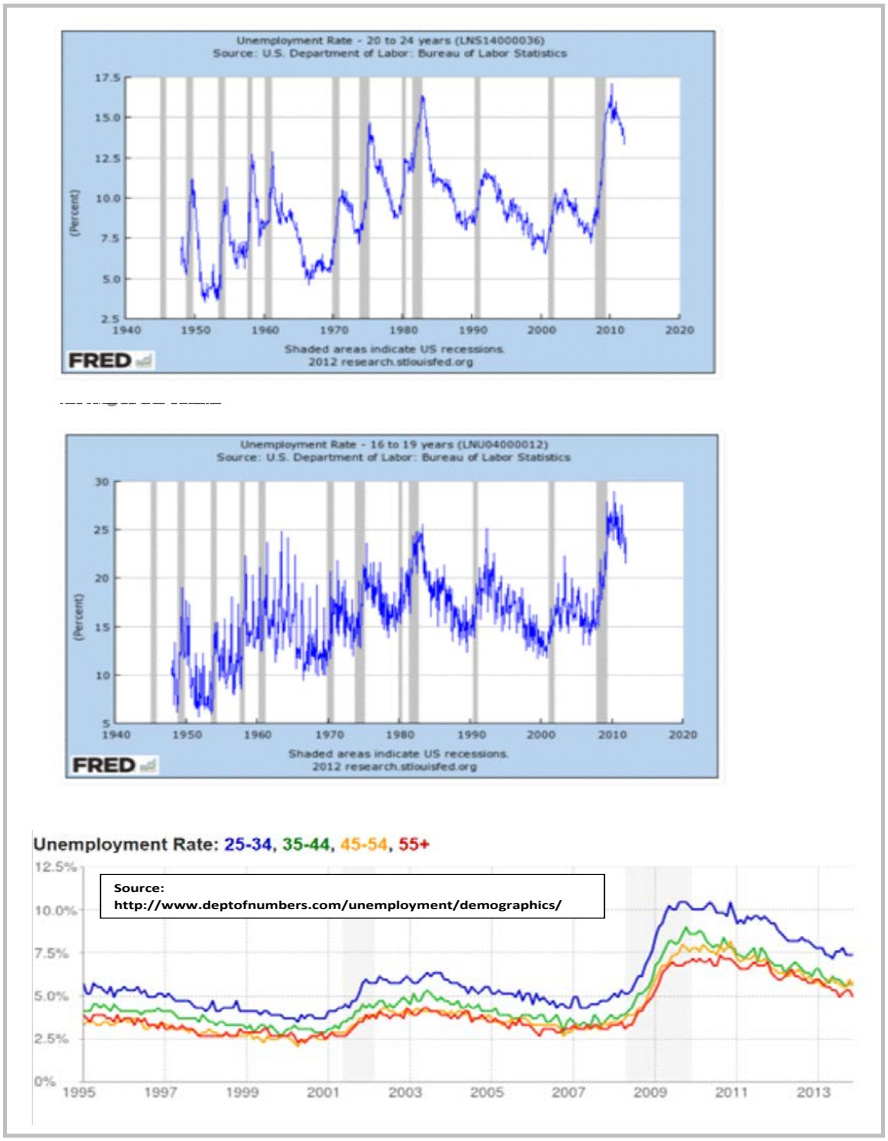


Figure 8a U.S. Unemployment Rates for Various Age Groups

[1] And for VMT/capita, the break point was even earlier.

Figure 8b shows another side to this, however. “Unemployment” rates show only the percent of people out of work who are looking for work, i.e., who are in the labor pool. The employment-population ratio, on the other hand, shows employment as a percentage of the entire population cohort; Figure 8b shows that youth employment has taken a nose dive since 1990. In other words, if employment is an important indicator of whether or not one has the means as well as incentive to drive, both means and incentive have declined substantially for 16–25 year olds over the past two decades.

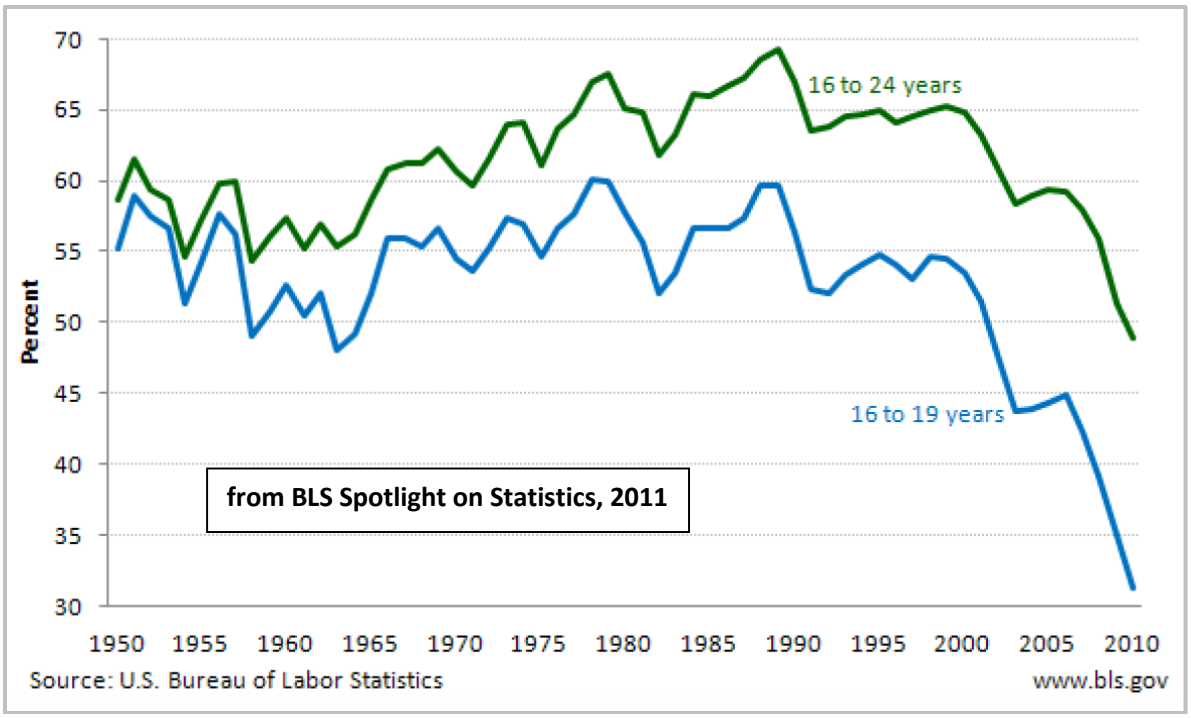


Figure 8b Employment-Population Ratio, Age 16–19 Years and 16–24 Years, July, 1950–2010

Another clue that the Recession may not be the primary cause of the drop in VMT is that, between 2001 and 2009, VMT per employed worker dropped considerably more than VMT per non-worker — 8.3%, 12,900 to 11,800 vs. 3.6%, 3,600 to 3,500 (Davis and Baxandall, 2013). For some reason, employed adults were more ready to decrease travel than those not employed. And a State-by-State examination of travel trends (Baxandall, 2013) strongly implies that the economy is not the foremost reason for the VMT decline — because those States with the largest economic problems were not the ones with the largest reductions in driving.

Several authors have pointed to different lifestyles as a crucial factor in the disproportionate decline in VMT among young adults. Aside from preference for urban areas and transit use (discussed directly below), young adults are viewed as being the first generation that is not especially interested in automobiles, and as substituting electronic interaction for physical interaction (Goodwin and Van Dender, 2013; Institute for Mobility Research, 2013; Dutzik and Baxandall, 2013).

Several papers have attributed an important role in the VMT decline to increased transit use and non-motorized travel, NMT (Dutzik and Baxandall, 2013; Puentes, 2012; Newman and Kenworthy, 2011). Puentes notes small increases in walk trips in 2009 vs. 2001, a 9.2% increase in transit ridership in the same time period, and especially strong increases (31%) in rail ridership during this period. Newman, Kenworthy and Glazebrook (2013) associate the peaking in car use with strong increases in urban rail ridership. However, it is important to put transit use into perspective, especially in the U.S. — transit accounts for approximately 1% of U.S. passenger miles. In other words, unless transit use has a very strong (negative) multiplier effect of vehicle travel, even a doubling of transit use would not appreciably affect VMT. Many planners believe that a multiplier effect does exist, i.e., that adding one transit trip reduces considerably more than one automobile trip because of subsequent changes in urban density and traveler behavior[2] (Holtzclaw, 1991), but demonstration of the effect relies primarily on "cross sectional" studies that compare different cities at a single point in time, which makes it very hard to prove cause and effect. Further, the effect is not immediate, but instead is dependent on longer-term changes in land use caused by increased transit usage. It seems unlikely that recent increases in transit use can explain more than a small fraction of the recent decline in VMT.

Surprisingly, few papers have acknowledged the potential role of fuel prices in shaping recent VMT trends. As shown in Appendix A, real gasoline prices rose nearly 60% between 1998 and 2004 and had more than doubled by 2008. The precise effect of fuel prices on travel is controversial, and any effects will play out over time — in the short term, potential travelers may forgo trips, combine trips, and use existing transit more intensively; in the medium term, people and businesses may move to reduce travel requirements; in the long term, high fuel prices may affect transit planning and land use. However, a value of -0.1 for the long-term fuel price elasticity of travel has become somewhat accepted as a reasonable estimate based on work by Greene (2010) and Small and Van Dender (2007). As shown in Appendix A, accepting this -0.1 long-term value of fuel price elasticity of travel implies that the actual changes in gasoline price during the period 2003–2011 might explain a third or more of the VMT/capita reduction from a "trend line" during that period. If the elasticity is higher than -0.1, as suggested by Littman (2012), gasoline price might have been the dominant factor explaining why VMT growth faltered during this period.

3 International Studies

The sudden downturn in VMT growth in the U.S. has been detected in much of the industrialized world, and there is a vibrant literature describing and dissecting the phenomenon. Newman and Kenworthy (2011) have discussed the phenomenon in multiple papers and have concluded it represents a peak in VMT in several industrialized countries. Among other factors, they identify an increase in rail transit as both a driver of the phenomenon and a key to its continuance. Goodwin and Van Dender (2012) discuss a broad group of papers in a Transport

[2] In other words, large increases in transit use allow urban density to increase and allow more urban residents to reduce car ownership and use — creating an effect that goes well beyond the simple substitution of one car trip for one transit trip.

Reviews Journal devoted to the phenomenon. Millar-Ball and Schipper (2011) examine vehicle travel in 8 countries (the United States, Canada, Sweden, France, Germany, the United Kingdom, Japan and Australia) and note that vehicle travel has leveled off relative to GDP, but do not see a peak in absolute travel in most countries and refuse to predict a continuation of the slowdown. The Institute for Mobility Research (IMfR) examines the phenomenon in 6 countries (Germany, France, Great Britain, Norway, Japan and the United States) and focus explicitly on young adults, who they identify as Generation Y. Common themes of most of the studies include a positive identification of a sharp slowdown in vehicle travel based on the saturation of a number of trends that have fed past growth; a recognition that the slowdown has been sharpest among young adults, especially young men; the existence of strong differences among countries in both underlying factors affecting travel and in overall travel trends — and that it is not possible to accurately predict future changes in vehicle travel *even if one could predict many of the underlying variables (oil price; economic growth; transportation policies)* — which one cannot.

Both IMfR and Goodwin and Van Dender note that the impact of telecommunication advances have been identified as a possible reason for the slowdown in young adult travel, and both conclude that its effect is quite unclear — though IMfR thinks the effect is negligible. IMfR notes that, in 5 of the 6 countries studied, young adults now have lower car availability than they had pre-2000, and licensing rates have dropped in all 6 countries, substantially in half of them — with, again, much of the effect focused on young men. They note that many factors may affect licensing rates — for example, increasing difficulty in the licensing test in the UK, and abolition of national military service in France, which may have affected the licensing rates of lower income young men.

Goodwin and Van Dender identify an important economic factor — that the price and income elasticities of travel,[3] formerly strong determinants of travel trends as incomes have grown and travel price has increased, have grown weaker as countries' wealth has grown, and further that individuals achieving high income levels have not shown a greater propensity to travel in private vehicles (and may actually show declining vehicle travel with income).

Newman and Kenworthy and IMfR note the importance of declining modal shares for private vehicles, with IMfR noting that Germany's modal share (on a "per trip" basis, not weighted to distance) declined from 2/3rds in the 1990s to barely more than one half after 2000. However, IMfR notes that this shift has negligible effect in the U.S. given its miniscule baseline share for transit and non-motorized travel. This is particularly true when viewed on a "per unit of distance" basis, since NMT has a near-zero share of longer trips.

[3] That is, the changes in travel caused by changes in travel price and travelers' income levels.

4 Annual Energy Outlook Projections for 2014

The new AEO2014 has adopted significant changes in both underlying economic and social conditions and a new VMT model that lead to substantially lower projected VMT for light duty vehicles than AEO2013 — which substantially lowered projected VMT increases from earlier years. Figure 9 shows the VMT projections for the Reference Case and two sub-cases, a High VMT and Low VMT case.

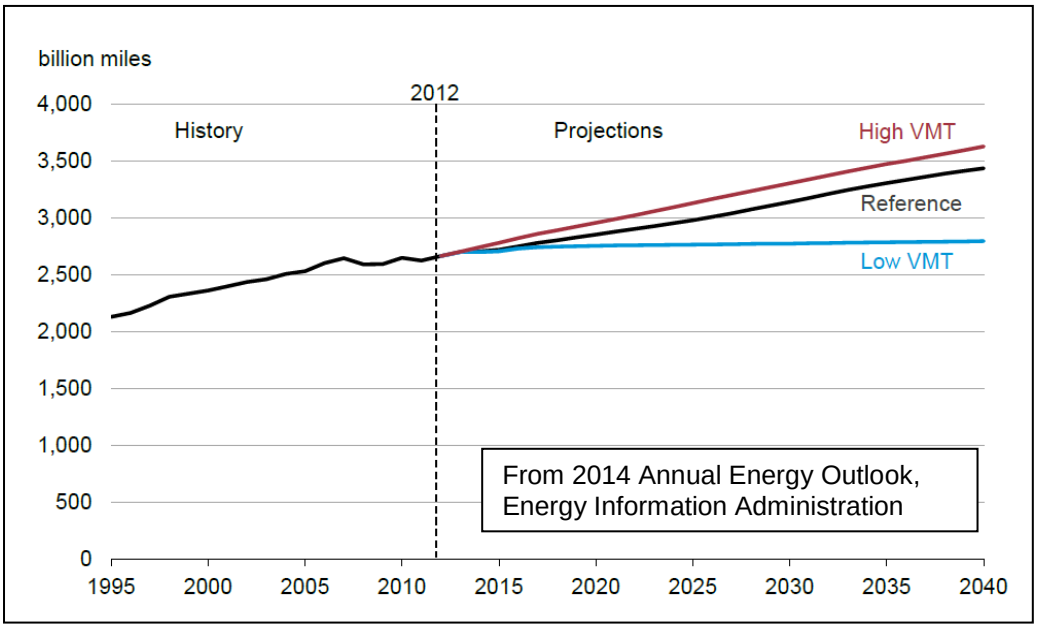


Figure 9 2014 AEO VMT Projections

For the three cases, 2040 light duty vehicle VMT ranges from a low of 2793 billion to a high of 3624 billion. The high VMT case is 30% greater than the low in 2040. The 2014 Reference case projects a compound annual rate of growth in LDV VMT of 0.9% from 2012–2040 — about half the growth rate of the decade before 2007. With the estimated population growth of 0.7%/yr, this implies an annual increase in VMT/capita of only 0.2%, versus a 1994–2004 annual growth rate of 1.2% (that is, for the decade before its peak). The Low VMT case projects an annual VMT growth rate of only 0.2%; with the same 0.7% population growth rate, this yields an annual *decrease* in vmt/capita of 0.5%.

The High VMT case projects a VMT growth rate of 1.1% (VMT/capita growth of 0.4%), a much lower rate than the actual growth rate before 2007. Although this rate reflects the changes that EIA perceives in the demographic and socio-economic forces affecting vehicle travel, it may not fully reflect the extent to which higher fuel prices affected VMT during the 2003–2007 period or the potential for significantly higher LDV fuel economy to reduce future fuel costs. A continuance of the 1% growth rate of VMT/capita that prevailed during the decade preceding 2007 — which is not implausible — would yield a 2040 VMT value 60% higher than

the “low” case even with population growth at the reference value of 0.7%/yr — and population growth conceivably could be faster than this.

5 What Does the Future Hold for U.S. VMT?

As noted above, although some analysts have concluded that U.S. and European VMT has likely peaked and may well decline further in the future, most of the literature we have reviewed stays well clear of such claims. Instead, it concludes only that slow growth in VMT is highly likely but that we can neither accurately project the future trends of likely determinants of VMT, such as economic growth and oil prices, nor do we adequately understand the relationship between these determinants and future VMT. As Goodwin and Van Dender (2012) conclude, “the aggregate trends…do not allow us to forecast with any certainty the levels of car use that we can expect in the future. In fact they make it clear that a number of different future possibilities are plausible, which could lead to a rise, a fall, or stability in levels of car travel….it is logically necessary to consider the robustness of future policies and projects in terms of *scenarios* about the future, not *forecasts* of it.” This conclusion could easily be interpreted as a trivial one, since the future is always uncertain. However, what Goodwin and Van Dender are trying to tell us is that things really have changed, that what was once a seemingly inexorable rise in travel with population and economic growth has now become much less predictable….it appears that we can conclude *only* that it is likely that VMT growth in the future will be slower than it was through the early 2000s, but we cannot say just how much more slowly VMT will grow, or whether it might actually decline.

Some of the determinants of future VMT growth include:

1. **The behavior of young Americans.** Will the travel behavior preferences for urban living of young Americans hold up as they age (and marry, have children)? And will future young Americans have the same preferences?
2. **The economy.** How rapidly will U.S. GDP grow, and how will the rewards of a growing economy be distributed? Will the size of the labor force grow significantly, or will labor force participation continue to drop? Will the income growth of the lower 60% of U.S. cohorts continue to stagnate?
3. **Driving costs.** How will fuel prices change, and how efficient will the fleet become? Will growing congestion increase the time costs of vehicle use, or will intelligent vehicle technology decrease congestion and reduce the real and perceived time costs of vehicle travel.
4. **Car sharing.** Will nascent growth of car sharing continue to expand and become a major factor in U.S. travel? Although current car sharing service membership is relatively small (in the U.S., 560,000 as of July 2011, cited in Crane et al., 2012), membership growth has been very fast and membership appears to substantially reduce members’ VMT (Shaheen et al., 2009).

5. **Other modes.** Will non-motorized travel (biking and walking) become important in determining VMT trends? Will U.S. transit ever become a significant part of travel trends, on a national basis? (And what is the true VMT replacement factor of NMT and transit trips?)
6. **Immigration and population growth.** Will immigration remain a major portion of U.S. population growth, and will immigrants behave (re car ownership) more in line with the aspirational goals of their home countries or else more in line with recent U.S. trends?

6 Policy Implications

The likely slower growth, or even stagnation or decline of U.S. vehicle travel will have profound implications for all levels of government. For the federal government and DOE, the obvious impact is on policies that are based on projections of future GHG emissions and oil consumption. For example, the relatively modest change in VMT growth projections between AEO 2013 and AEO 2014 (growth rate decreasing from 1.2%/yr to 0.9%/yr) implies, with all else equal, a reduction in light-duty vehicle energy use of about 8% by 2040. The low growth case, which projects a net *decline* in VMT from 2013 onwards, would make a huge difference in energy use over time — since a *zero* growth case would yield 2040 VMT that is 23% lower than the projected 2040 VMT in the 2014 Reference Case. The implications: lower future energy use/GHG emissions/oil imports, but also sharply lower revenues for the Highway Trust Fund and state transportation funds — including funds for transit. All this has profound implications for energy policy and energy R&D choices as well as transportation policy.

The federal government and DOE may also want to consider whether they have a role in influencing travel behavior. For example, if young people do continue to show locational preferences for urban areas and greater propensity to rely less on cars and more on transit and NMT, governments at all levels may well want to encourage such behavior by strengthening the factors that will allow them to continue these preferences — by supporting growth in transit systems and strengthening urban school systems (to allow young families to remain in dense urban areas). DOE has no direct role in such activities, but it certainly can play a consulting role. However, given the weakness of evidence concerning the factors that have created the strong declines in driving among young adults, there clearly is a need to continue a research focus on evaluating these factors.

And DOT as well as State and local governments should be keenly interested in how VMT trends develop, given the multitude of decisions they must make about, for example, the tradeoff between roadway expansion and maintenance and repair of existing roadways, as well as the future of the Highway Trust Fund (and State highway funds) — already stressed by rising fleet fuel economy — as well as privately financed toll roads.

Appendix A Effect of Gasoline Prices on VMT

The fuel cost per mile of driving will affect travel demand, measured as vehicle miles traveled (VMT) and VMT/capita. For example, the well-known "rebound effect" describes the increase in driving expected when increased fuel efficiency reduces the gasoline consumed by each mile of travel. Similarly, increases in gasoline price should *reduce* the amount of travel, all else equal. The ultimate effect on VMT of changes in fuel cost/mile will take time; for example, in response to higher fuel costs, people can reduce travel in the short term by foregoing trips, combining trips, shifting to available transit options and carpooling, but over the long term can take additional measures such as changing home and work locations and using new transit options (built in response to increased demand for transit resulting from higher fuel prices).

A look at gasoline prices before and after the recent peaks in VMT and VMT/capita is informative. Figure A-1 shows average U.S. retail gasoline prices for the years 1992 through 2013.

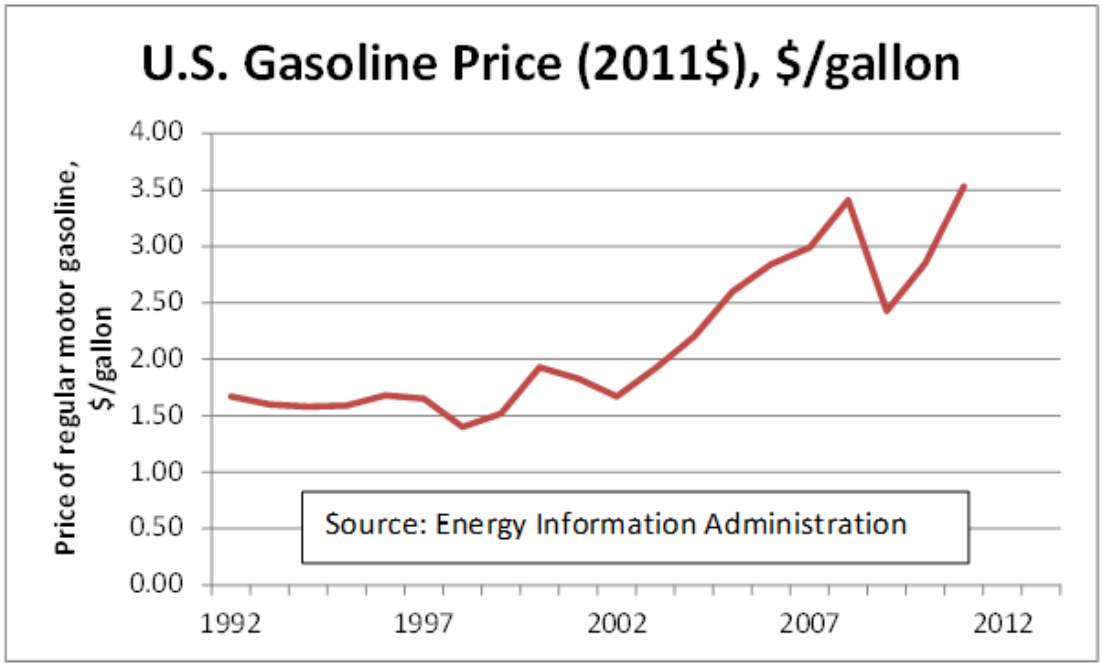


Figure A-1 U.S. Gasoline Price Trends in Constant 2011 Dollars

Shortly before 2000, gasoline prices began a sharp rise; between 1998 and 2004, prices rose nearly 60%, and had risen nearly two and a half times by 2008 (the recession caused prices to plunge after that, although prices have since recovered). It is useful to examine this same plot with VMT/capita also displayed (Figure A-2). As gasoline prices begin to rise around 1998, VMT/capita growth begins to subtly shift downwards and then abruptly stops in 2004 and turns negative in the middle of a sharp spike upwards in prices.

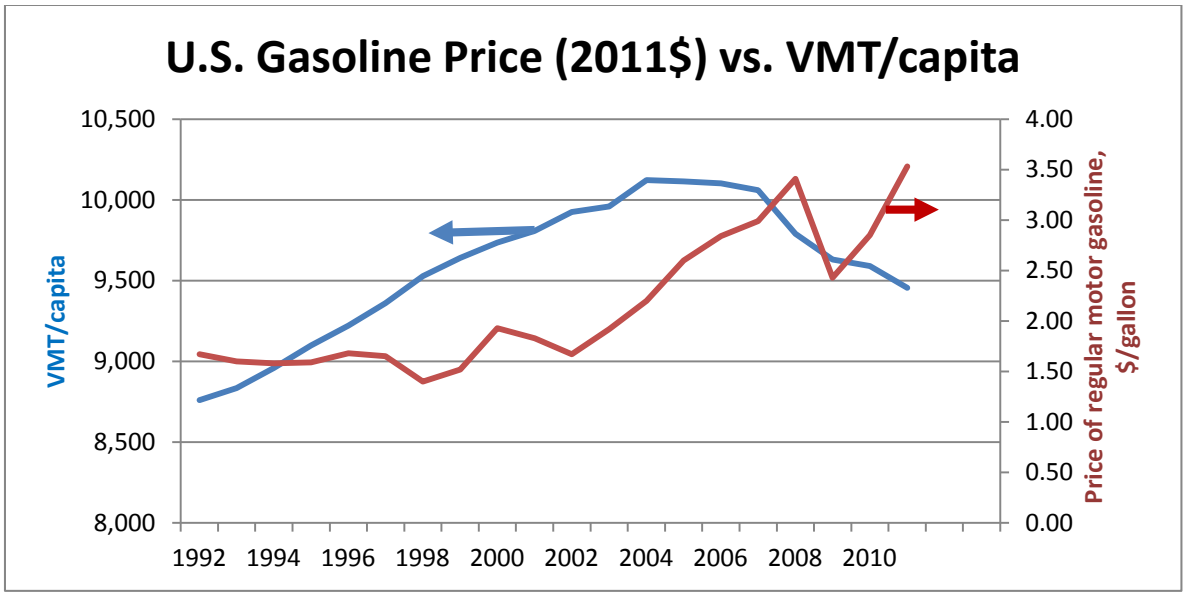


Figure A-2 U.S. Gasoline Price versus VMT/capita

There is no consensus on the precise effect on VMT of fuel cost changes. There have been numerous studies, however, although these are confounded by the multiple factors that can affect VMT, including the overall state of the economy (certainly a factor in recent VMT declines) and social trends whose longevity is uncertain. Generally, earlier studies (based on data from 1960 to 1990) tended to yield higher values, centered around values of about -0.2 for the long-run elasticity of VMT with respect to fuel cost (Greene, 1992). Later studies have yielded lower elasticity values, of about -0.1, probably because of higher incomes and a more efficient vehicle fleet (Greene, 2010). Small and Van Dender (2007) concluded that recent (from 1997–2001) data show a long term elasticity of about -0.107, with a short-term elasticity of -0.022, with elasticity likely to fall with rising income and rise with rising fuel prices. A recent paper by Litman (2012) discusses a range of fuel price elasticity values and concludes that elasticity has recently increased to long-run values well above -0.1. And Hughes, Knittel and Sperling (2008) showed that the recent (2001–2006) short-run price elasticity of gasoline demand ranged from -0.034 to -0.077; most of this elasticity would likely come from changes in vmt.[4]

It is not likely that any estimate of the precise effect of the post-2000 increase in gasoline prices on VMT/capita would be widely accepted. However, it is useful to obtain a rough estimate of the effect to see if it may have played an important role in recent VMT declines. Such an estimate can be obtained by comparing three values: the *actual* VMT attained in 2011; the 2011 VMT that *would have occurred* had earlier VMT trends simply continued, which we'll call the "trend VMT;" and the trend VMT adjusted by applying a fuel price elasticity to account for

[4] Other sources of short-run changes in gasoline demand could come from purchase of more efficient vehicles; shifts in use to more efficient vehicles in multi-vehicle households, and changes in driving behavior to improve fuel efficiency, e.g., slower speeds, more gentle acceleration.

changes in fuel costs during the period. What portion of the actual decline in VMT that occurred in 2003–2011 might have been caused by changes in gasoline prices?

Extending the pre-2003 trend line (a growth rate of about 1%/yr) is shown in Figure A-3; the trend line yields a 2011 value of about 10,850 VMT/capita. An initial estimate of the effect of higher gasoline prices is obtained by applying a postulated fuel price elasticity of travel of about -0.1 (based on Greene, 2010, but here ignoring the time delay between the short term VMT response and the longer-term response). The 2003 gasoline price of $1.92/gallon (in $2011) represents a 45% reduction from the 2011 gasoline price of about $3.50/gallon….implying that the increase in gasoline price during this period should have reduced VMT by about a factor of $(1.0\text{-}.45 = 0.55)^{0.1} = 0.942$ or a 5.8% reduction (about 630 VMT/capita) from the 2011 VMT "trend value" of 10,850….yielding about 10,220 VMT/capita. The actual 2011 VMT/capita was 9455, a difference from the trend line of about 1,400. In other words, a *very* rough estimate of the effect of increased fuel price on VMT/capita, ignoring the issue of timing, implies that it could have accounted for a bit less than half (45%, in this case) of the actual drop in VMT/capita from a trend projection.

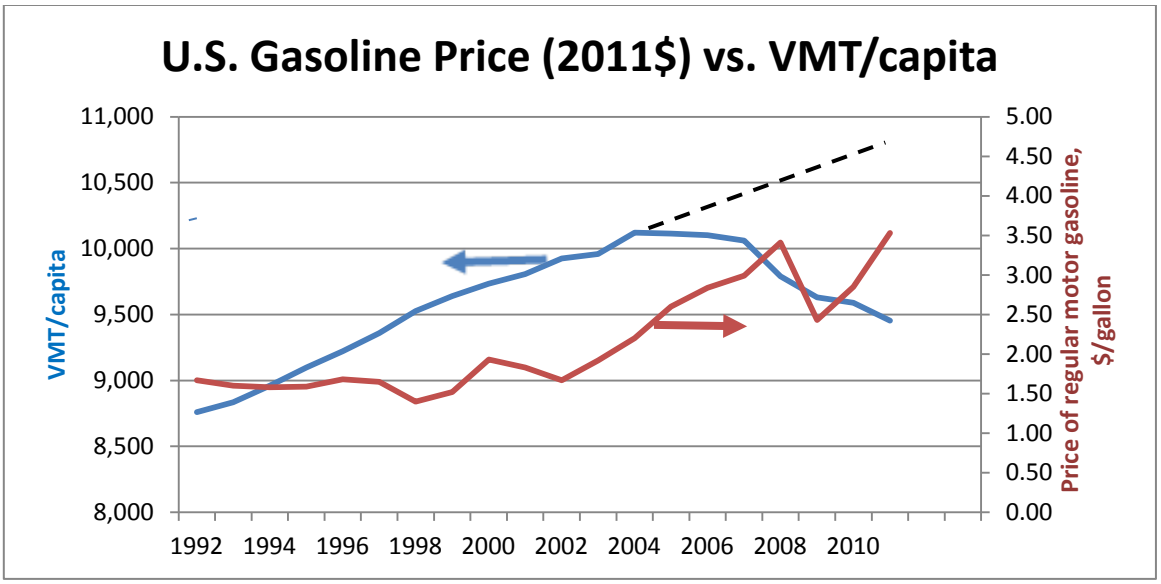


Figure A-3 U.S. Gasoline Price (with Post 2003 Trend Line) vs. VMT/capita

Accounting for the time it takes for some of the price effects to take place would reduce the expected effect in 2011. Small and Van Dender (2007) developed a simple model of the way that VMT will change over time after an idealized one-time (sustained) increase in fuel price. Assuming that the postulated -0.1 fuel price elasticity has a short-term component of -0.03 attained a year after the price increase, 94% of the total VMT change would have occurred by the end of year 8 according to this model. The actual price increases occurred over an eight year period and do not resemble the idealized "sustained increases" of the model; ignoring this issue however, the average elasticity in 2011 for the full 8-year price increase would be about 62% of

the full long-term elasticity, or -0.62.[5] Applying this new "time adjusted" elasticity yields a factor of $(0.55)^{0.062} = 0.964$, or a 3.6% reduction in VMT — a reduction of about 390 VMT/capita from the 2011 VMT "trend value" of 10,850, leaving about 10,460 VMT/capita. Using this approach, the difference in fuel prices would account for about 390/1400 or about 28% of the total difference in VMT between the actual 2013 value and the trend line. Over time, the "remaining" expected long-term VMT reduction from the gasoline price increases would drive down total VMT still further.

These two estimates of the possible effect of gasoline price increases on U.S. VMT during the 2003–2011 time period — that the increases accounted for about 30-45% of the actual decline in VMT from a "trend" result — should be treated with caution. No consensus exists about the two crucial factors in the calculations — the magnitude of the fuel cost elasticity of VMT, and the approximate timing and relative significance of the multiple actions that together create the full set of (long-term) VMT changes. It is the author's opinion that the assumed -0.1 long-term fuel cost elasticity is likely to be thought of as being on the low side of the range, and the roll-in of VMT effects associated with Small and Van Dender's model is likely to be viewed as being on the "rapid" side of the range. The best conclusion one can draw from this exercise is that the changes in gasoline price over the 2003–2011 period almost certainly played a significant role in the unusual peaking and decline in VMT and VMT/capita during this period.

It is worth repeating that fuel cost sensitivity works both ways….if fuel costs decline, VMT should increase. Because LDV fleet fuel economy is likely to increase significantly during the next 20 years (because of the stringent fuel economy standards now imposed on the industry), fuel costs per mile will decline during this period unless higher oil prices offset this effect. This will tend to push VMT higher.

[5] This value was obtained by assuming that the gasoline price increase over the time period was linear.

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