University Transportation Research Center - Region 2

Final Report

Do Consumer Expenditures Affect the Demand for Driving?

Performing Organization: Cornell University

October 2017

Sponsor:
University Transportation Research Center - Region 2

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The Region 2 University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

The UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, the UTRC represents USDOT Region II, including New York, New Jersey, Puerto Rico and the U.S. Virgin Islands. Functioning as a consortium of twelve major Universities throughout the region, UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium. The Center, through its consortium, an Agency-Industry Council and its Director and Staff, supports research, education, and technology transfer under its theme. UTRC's three main goals are:

Research

The research program objectives are (1) to develop a theme based transportation research program that is responsive to the needs of regional transportation organizations and stakeholders, and (2) to conduct that program in cooperation with the partners. The program includes both studies that are identified with research partners of projects targeted to the theme, and targeted, short-term projects. The program develops competitive proposals, which are evaluated to insure the mostresponsive UTRC team conducts the work. The research program is responsive to the UTRC theme: "Planning and Managing Regional Transportation Systems in a Changing World." The complex transportation system of transit and infrastructure, and the rapidly changing environment impacts the nation's largest city and metropolitan area. The New York/New Jersey Metropolitan has over 19 million people, 600,000 businesses and 9 million workers. The Region's intermodal and multimodal systems must serve all customers and stakeholders within the region and globally.Under the current grant, the new research projects and the ongoing research projects concentrate the program efforts on the categories of Transportation Systems Performance and Information Infrastructure to provide needed services to the New Jersey Department of Transportation, New York City Department of Transportation, New York Metropolitan Transportation Council , New York State Department of Transportation, and the New York State Energy and Research Development Authorityand others, all while enhancing the center's theme.

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The modern professional must combine the technical skills of engineering and planning with knowledge of economics, environmental science, management, finance, and law as well as negotiation skills, psychology and sociology. And, she/he must be computer literate, wired to the web, and knowledgeable about advances in information technology. UTRC's education and training efforts provide a multidisciplinary program of course work and experiential learning to train students and provide advanced training or retraining of practitioners to plan and manage regional transportation systems. UTRC must meet the need to educate the undergraduate and graduate student with a foundation of transportation fundamentals that allows for solving complex problems in a world much more dynamic than even a decade ago. Simultaneously, the demand for continuing education is growing – either because of professional license requirements or because the workplace demands it – and provides the opportunity to combine State of Practice education with tailored ways of delivering content.

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UTRC's Technology Transfer Program goes beyond what might be considered "traditional" technology transfer activities. Its main objectives are (1) to increase the awareness and level of information concerning transportation issues facing Region 2; (2) to improve the knowledge base and approach to problem solving of the region's transportation workforce, from those operating the systems to those at the most senior level of managing the system; and by doing so, to improve the overall professional capability of the transportation workforce; (3) to stimulate discussion and debate concerning the integration of new technologies into our culture, our work and our transportation systems; (4) to provide the more traditional but extremely important job of disseminating research and project reports, studies, analysis and use of tools to the education, research and practicing community both nationally and internationally; and (5) to provide unbiased information and testimony to decision-makers concerning regional transportation issues consistent with the UTRC theme.

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16. Abstract

We examine why American driving fell between 2004 and 2014, and consider how planners should respond. We weigh two competing explanations: that the driving downturn was caused by "Peak Car"— a voluntary shift away from driving, and that it was caused by economic hardship. We analyze an array of aggregate data on travel, incomes, debt, public opinion and Internet access. These data are imperfect, as they lack the precision of microdata, but they are available annually for the years before during, and after driving's decline. We find little evidence supporting Peak Car. If Americans voluntarily drove less, they should have used other modes more. However, even as the US dramatically expanded its supply of public transportation and bicycle infrastructure in the 2000s, demand for these modes remained flat or declined while driving fell. Our evidence is consistent, in contrast, with the economic explanation. During the downturn the costs of driving rose while median incomes fell. Gas prices increased at a record rate, and while the economy grew overall, it did so unequally. Mass driving requires a mass middle class, but economic gains accrued almost entirely to the top one percent.

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Do Consumer Expenditures Affect the Demand for Driving?

Final Report

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The driving downturn: a preliminary assessment

Problem statement, research strategy and findings

We examine why American driving fell between 2004 and 2014, and consider how planners should respond. We weigh two competing explanations: that the driving downturn was caused by "Peak Car"— a voluntary shift away from driving, and that it was caused by economic hardship. We analyze an array of aggregate data on travel, incomes, debt, public opinion and Internet access. These data are imperfect, as they lack the precision of microdata, but they are available annually for the years before during, and after driving's decline. We find little evidence supporting Peak Car. If Americans voluntarily drove less, they should have used other modes more. However, even as the US dramatically expanded its supply of public transportation and bicycle infrastructure in the 2000s, demand for these modes remained flat or declined while driving fell. Our evidence is consistent, in contrast, with the economic explanation. During the downturn the costs of driving rose while median incomes fell. Gas prices increased at a record rate, and while the economy grew overall, it did so unequally. Mass driving requires a mass middle class, but economic gains accrued almost entirely to the top one percent.

Takeaway for practice

Were Americans voluntarily abandoning automobiles for other modes, planners could simply reduce investments in automobile infrastructure and increase investment in alternative modes. Yet little evidence supports this view. Driving's decline was not accompanied by transit's rise. The lesson of the driving downturn, instead, is that people drive less when the price of driving rises. Planners should obviously not seek to create income insecurity of the 2000s, but they should consider policies that increase driving's price. Planners should also rethink the current direction of US transit; even when driving fell at an unprecedented pace, transit use did not rise.

INTRODUCTION

For decades, one of the most reliable predictions in transportation planning was that Americans would drive more. In 2004, however, US driving began to decline. Over the next nine years, American vehicle miles travelled (VMT) fell both absolutely and per capita. It fell in 44 states and Washington DC. Depending on the source, between 2004 and 2012 annual per capita VMT fell 8 or 9 percent, between 650 and 840 miles (U.S. Department of Transportation, various; U.S. Department of Energy, 2014). In 2014, per capita VMT began rising, but remained below its historic highs. The decline was notable not just because driving fell, but because it fell even as the economy grew. The Great Recession occurred from 2008-2009, but driving started to fall before the recession began and continued to fall after it ended.

Why did driving decline? This article weighs two competing, though not mutually exclusive, explanations. The first explanation, sometimes called "Peak Car", sees the driving downturn as part of a larger shift in American attitudes toward transportation, away from "car culture" and toward other modes (Lyons 2014; Van Wee 2015). Peak Car suggests that as Americans become more concerned about the environment, more open to urban living and transit, and better able to substitute technology for travel (via online shopping or social media), they will find automobiles less desirable or necesssary.

The second explanation for driving's decline is economic, not attitudinal. The driving downturn coincided with sharp gas prices increases, dramatic escalations in household debt, and steep losses of income and employment. Lost jobs meant lost commutes—often the longest-distance daily trips—and less of the discretionary travel that occurs when people have discretionary income.

Less VMT is not intrinsically beneficial, so the extent to which we should celebrate driving's decline hinges on the relative validity of these explanations. If Peak Car is correct, and Americans willingly drove less, the driving downturn implies a large social gain. The reduced VMT would benefit people who chose not to drive (they satisfied their preferences), people who continued to drive (they faced less congestion) and the environment (emissions fell). Most important, Peak Car suggests a longstanding problem solving itself. Planners have struggled for decades to wean Americans off automobiles; suddenly, the tide of that battle has turned. Planners needn't fight to change American preferences, only deliver more of the transportation alternatives, such as transit, that citizens now appear to want.

If the economic explanation is correct, however, the driving downturn holds different lessons. Less VMT in this case would suggest decreased, not increased, social welfare. The economic explanation also suggests that as the economy recovers, driving will increase, as indeed it has. This in turn suggests that planners' longstanding battle against the social costs of driving is not over, and that in fact we may be waging it inefficiently. If driving fell because it became more expensive, and not because Americans turned to other modes, then perhaps planners' efforts to reduce VMT's harmful effects of VMT should focus more on increasing driving's price—via gas taxes and congestion tolls—and less on increasing the supply of transit and other alternatives.

As we will discuss, the data available to evaluate these arguments are imperfect. Nevertheless, we find more evidence for the economic explanation than for Peak Car. While the drop in VMT was unprecedented, so too were the economic conditions accompanying it. Evidence that people changed modes or willingly drove less, in contrast, is hard to find.

THE PUZZLE OF THE DRIVING DOWNTURN

One of the great stylized facts of US surface transportation is that American driving moves in lockstep with economic growth. Growth and driving probably feed each other. As the economy grows and incomes rise, more people drive further. As more driving connects people and firms, the economy grows.

Figure 1 plots this relationship, using VMT per capita and Gross Domestic Product (GDP) per capita from 1936 to 2013. The figure suggests that, in the big picture, the driving downturn was relatively small (it is the far right tail of the graph), but also that it was both unprecedented and puzzling. Although driving has declined before, it has generally done so in sync with GDP. The last time driving fell while GDP rose was 1940, when the country emerged from a depression by mobilizing for war. GDP increased as the government rationed gasoline, rubber and steel, and as it nationalized automobile factories for conversion to military production. No such policies existed in 2004, leaving us no obvious answer for why driving fell while the economy grew.

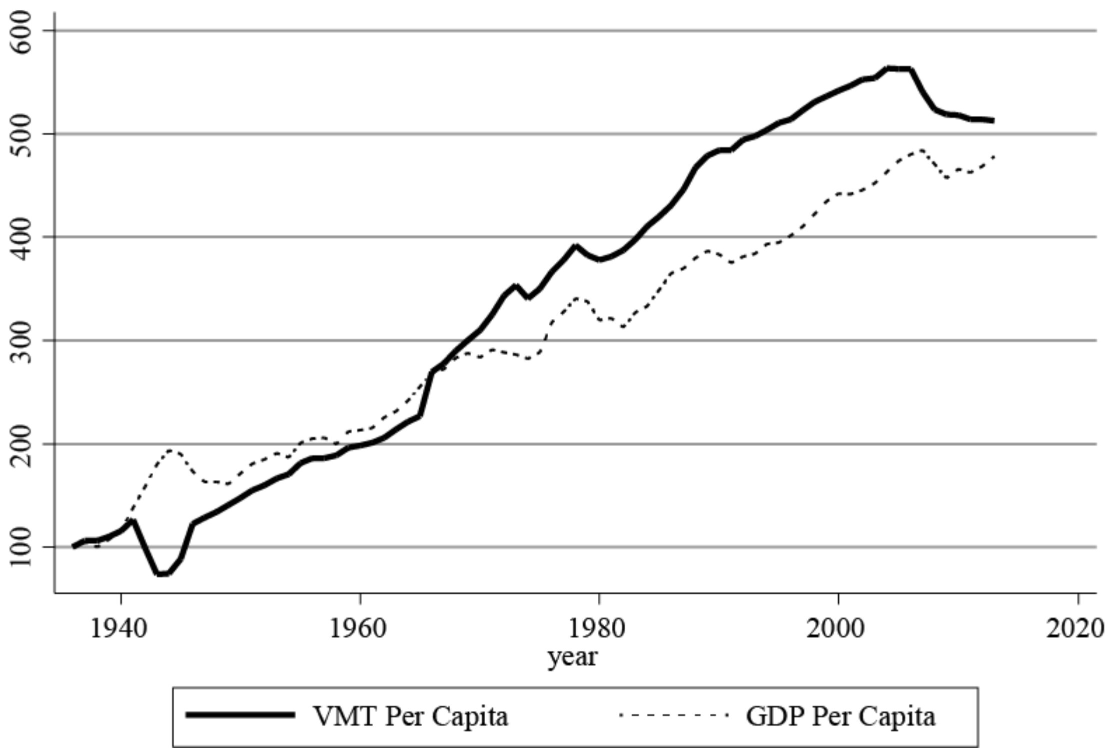

FIGURE 1 Per Capita GDP, VMT, and Vehicle Ownership (1936=100), United States, 1936-2013, Sources: (U.S. Department of Transportation various)

Peak Car explains this puzzle by emphasizing demographic and attitudinal shifts. The large baby boom generation might drive less as it leaves the workforce, but more important is that the even-larger Millennial generation (people born between 1980 and 2000) seems to drive less still. Millennials drive less than both other age cohorts today and earlier cohorts of young adults (McDonald 2015). They also may be more concerned about the environment, and more willing to ride transit and live in cities (Koch, 2014). And they are “digital natives”—the first generation raised on the Internet and social media, who might be likely to replace traditional travel with new technology (Van Wee 2015). If Millennials in fact prefer not to drive, and maintain that preference, then in the future driving stay low or fall again (Davis and Druzik, 2012).

Economic factors, however, could also explain Millennial behavior. While it is possible that Millennials do not want to drive, it is also possible they can't afford to, because they carry large financial burdens. Millennial VMT may not be a cause of driving's decline but a symptom of its true cause, which is economic insecurity.

We do not examine Millennials per se, as other researchers have done so (McDonald 2015, Blumenberg et al 2012). But the questions that surround Millennial driving apply to driving more generally: did it fall because of new attitudes, or new hardship?

Ideally, answering this question would involve examining person-level data that covered the years before, during and after driving's decline. These data would track not just travel behavior but factors that might influence it: attitudes toward driving, demographics Internet and social media use, household expenditures and debt, and so on.

Unfortunately, no such data exist. The main source of American travel microdata is the National Household Travel Surveys (NHTS), which are carried out infrequently and irregularly. The government conducted one NHTS in 2001, a few years before driving fell, and another in 2009, which was both midway through the downturn and in the absolute trough of the recession. No NHTS was conducted between 2009 and 2014. If a primary puzzle of the driving downturn is that it started before the recession and ended after it, then the NHTS—whose only data point from during the downturn ocurred during the recession itself—may offer little insight into the solution.

The NHTS also lacks some explanatory variables needed to examine the economic and Peak Car explanations. It contains no information on attitudes toward driving or transit, nor on household expenditures or debt. While the NHTS includes a measure of Internet use, its ability measure the Internet's influence on VMT is limited, because the survey only measures household

VMT. E-commerce might reduce household driving, but might increase commercial driving (goods ordered online need to be delivered). Commercial driving accounts for about 12 percent of American VMT, but is not in the NHTS (US Department of Transportation various).

Lastly, the NHTS may have coverage bias. NHTS surveyors only call landline phones (US Department of Transportation 2011). As mobile phone use has risen, this approach has become less defensible. In 2002 over 90 percent of US households had a landline, but in 2009 fewer than 75 percent did (Blumberg and Luke 2015). Nor are wireless-only households evenly distributed across the population. Both low-income people and Millennials are less likely to have landlines (Blumberg and Luke 2015).[i] While we cannot be certain that excluding mobile phones biased the NHTS, researchers examining other landline-only surveys have found substantial coverage bias, particularly in estimates of young adults and low-income people (Keeter et al. 2007, Blumberg and Luke 2007, 2009). Sampling weights cannot fully correct for this bias, and sometimes even exacerbate it (Peytchev et al 2010).

In sum, the NHTS offers no data from when driving was falling but the economy was growing, and in 2009 it excluded a nonrandom 25 percent of US households. In doing so it may have particularly under-represented two groups—the economically vulnerable and the young tech-savvy—hypothesized to have contributed to the driving downturn. These factors make the survey an imperfect tool for analyzing driving's decline.

The NHTS is not, of course, the only source of travel microdata. Metropolitan Planning Organizations also conduct travel surveys. However, these surveys are not national, not annual, and do not include commercial travel. Thus regular and complete microdata from during the driving downturn remain unavailable. Metropolitan travel surveys also often neglect rural areas, which contribute disproportionately to American driving. In 2012 rural residents were 19 percent of the population, but rural roads held 31 percent of the VMT (U.S. Department of Transportation various).

Indirect Testing

In this article we rely less on the NHTS and more on administrative data. Our administrative data include counts of VMT reported by the Federal Highway Administration (FHWA), transit ridership counts from the National Transit Database (NTD), and gasoline price records from the Department of Energy. We supplement these data from surveys carried out more frequently than the NHTS (such as the General Social Survey, conducted every two years), and surveys that suffer less nonresponse and coverage bias (such as the U.S. Census's American Community Survey, which people are legally compelled to complete).

Administrative data offer a number of advantages. First, they are available annually, allowing us to track patterns before and throughout driving's decline. Administrative data are also available on a wide array of topics, letting us examine trends in variables the NHTS does not cover. Finally, administrative VMT data are not restricted to households, letting us account for commercial travel.

Naturally, administrative data may contain errors of their own. For example, the FHWA estimates VMT data from hourly traffic counts conducted at 4,000 locations nationwide (FHWA n.d.). These counts could err, particularly if traffic shifts toward or away from roads with counting equipment. On the other hand, doubts about these VMT data are doubts about the driving downturn itself: FHWA data are how we know driving fell to begin with.

Another problem with administrative data is that they are collected for administrative, not research, purposes. They thus often lack detailed demographic information (e.g, Johnson and Moore 2005). These aggregate data can show us that miles were driven or transit trips taken, but not who took them or how those people traveled before. They thus preclude direct tests of the Peak Car or economic explanations—we cannot, for instance, see if people who lost jobs or income drove less while others did not.

Our approach instead is one of testing-by-proxy: we generate implications of each explanation, then look for evidence that those implications are valid. We consider this approach a complement, rather than a corrective, to research using the NHTS.

Our starting proposition is that the economic explanation is more likely. Little prior evidence suggests that attitudes influence VMT, while substantial evidence suggests that economic factors do. In general, for instance, a ten percent decline in per capita income is associated with a 5 percent reduction in VMT over five years (Goodwin *et al*. 2004).

The economic explanation, however, must confront the fact that during the driving downturn, both the economy and personal income grew overall. Per capita GDP was higher in 2012 ($53,000) than it was in 2004 ($52,300), and per capita income grew 5 percent over the same time (US BEA various). The Great Recession was severe, but a recession from 2008-2009 cannot explain a driving downturn from 2004-2013.The economic explanation thus implies economic hardship during a period of economic growth. We test this implication.

Economic factors can reduce VMT in two ways: driving's private costs can rise (owning or operating a vehicle becomes more expensive), and/or people's ability to pay those costs can fall. We measure driving's costs with data on vehicle and gasoline prices. Measuring ability to pay is less straightforward. The standard measure of ability to pay in travel behavior studies is per capita income (e.g., Small and Van Dender 2007), but for two reasons we think this metric may be inadequeate. First that ability to pay can fall even when income rises, if income growth is outpaced by growing expenses. We thus examine data on debt and expenditures as well.

Second and more important, VMT could fall as income rises, if the rising income is unequally distributed. Mass driving might require mass prosperity. Large amounts of VMT are easier when many people have many places to go; four median-income households gaining an additional $25,000 probably yields more VMT than one affluent household gaining $100,000. As income grows, the benefits of convesting additional income into driving fall, and the opportunity costs of doing so rise. Rich households have fewer unmet travel demands than poorer households, and driving if nothing else takes time. Even the rich have only 24 hours in a day. Because income per capita says nothing about income distribution, it may be a poor measure of income's influence on VMT, particularly places (like the US) that are becoming increasingly unequal. We therefore examine median household income, which better measures the typical American's financial well-being. Finding evidence of hardship before and after the recession would be evidence for the economic explanation.

The best evidence for Peak Car would be an *absence* of evidence for the economic explanation. Without economic hardship, changing attitudes are a plausible explanation for falling VMT. With economic hardship, however, the two explanations become difficult to separate. Suppose we find that Americans drove less without travelling less: they walked, biked or rode transit instead. This finding would not by itself be evidence for Peak Car, because peeople could switch modes for attitudinal reasons (they prefer not to drive) or economic reasons (they switched to other modes to save money). Adjudicating between the two explanations would require knowing people's motivations for changing modes, and such data do not exist.

Conversely, we might find that as driving fell Americans did *not* use other modes more: they just traveled less. This finding too could support both the Peak Car and economic explanations. People might be traveling less because they have less income, or (less plausible but not impossible) because they have lost some desire to move around.

A first step in any weighing any of these scenarios is determining if other modes rise while driving fell. Answering this question is relatively easy for transit, but harder for walking and biking. The NTD provides reliable annual transit data, and given the distances of many vehicle trips—the average commute is 12 miles, the average shopping trip seven—transit is the mode most likely to replace VMT.

Walking and biking data are scarcer. The US Census tracks bicycle and pedestrian commutes, but commutes are small fractions of total biking and walking. The NHTS measures total cycling and walking, but NHTS data, again, are available only for 2001 and 2009, and may undercount bikers and walkers if they are less likely to own landline phones, or overcount them if these modes spiked during the recession. We measure walking and biking with the NHTS, the 2002 and 2012 federal surveys of Bicyclist and Pedestrian Attitudes and Behavior, and data from the bicycle industry.

In the next section we first look for evidence that economic factors grew during the driving downturn, and then look for evidence that other modes increased as driving fell.

RESULTS

ECONOMIC FACTORS: RISING FUEL COSTS, FALLING INCOMES

Driving became more expensive pre-recession

Owning a vehicle did not become more expensive during the driving downturn. While vehicle prices fluctuated from 2004 to 2013, they did not substantially rise. The Consumer Price Index for new vehicles rose from 100 in 1983 to 144 in 1997, then fell to 134 in 2008, after which it climbed to 146 in 2014 (Federal Reserve Bank of St. Louis, 2015). Used vehicle prices followed a similar pattern, falling until 2009 and then rising.

Operating a vehicle, in contrast, became much more expensive. Between 1998 and 2012, real gas prices rose from their lowest point in history to their highest since 1918. Further, gas prices rose before the recession began (Figure 3). In 1998, the real average gasoline price was $1.54 per gallon (2013 dollars). By 2004, when VMT began falling, it was $2.35. By 2006 it was over $3, by 2008 it was $3.59 (marking the largest recorded ten-year increase), and in 2012—after a steep plunge and subsequent rise—it was $3.75. Gas prices remained high through 2013, at over $3.50, then fell. When they fell driving began to rise.

This unprecedented spike in gas prices could account for much of the unprecedented fall in VMT. Estimates of driving's sensitivity to fuel prices vary, but generally suggest that a 10 percent increase in gas prices is associated with a 1 to 3 percent decline in VMT over 5 years (Goodwin et al. 2004; Hymel et al. 2010; Circella et al. 2014). From 2004 to 2012, gas prices rose 60 percent. From 1998 to 2012, they rose 143 percent. By these metrics, gas prices could more than account for the driving downturn; these price increases might have created a *larger* decline in driving. Better fuel economy, which increased xx percent from 2004 to 2013, may have mitigated the impact of rising gas prices (cite).

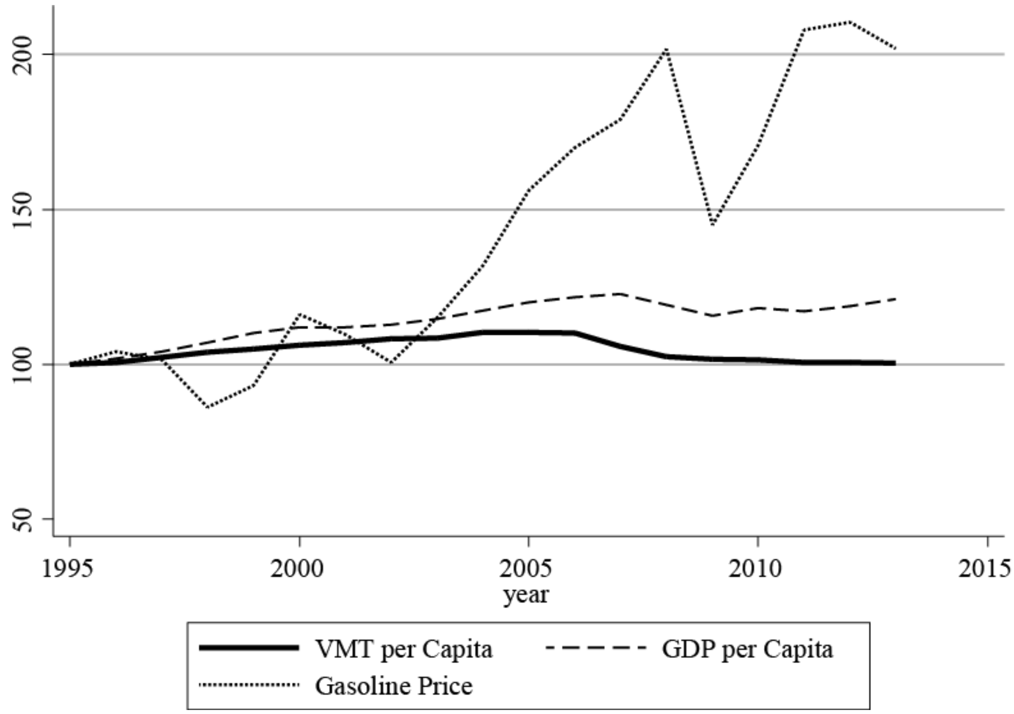

FIGURE 2 Trends in Real Average Gas Prices, VMT per Capita, and GDP per Capita, 1995-2013, (1995=100), sources: (U.S. Department of Transportation, various; Bureau of Economic Analysis, various; U.S. Department of Energy, 2014)

The Economy Grew, But Unequally

Examining median incomes shows that for many Americans, financial trouble began well before the recession and persisted after it. Income growth slowed while expenses rose. Between 2004 and 2008, median household income grew 1.5 percent, while median expenditures grew almost 11 percent (Pew Charitable Trusts 2016). Median income fell during the recession, but expenditures kept rising. (These expenditures included, but were not limited to, the gas prices discussed above). The recession ended in 2010 but the subsequent recovery was deeply unequal. The top 1 percent captured 95 percent of the economic growth that occurred between 2010 and 2012 (Saez 2013). Even this figure understates the recovery's lopsided nature, since most of the top 1 percent's gains went to the top 0.01 percent (Dungan 2015). Thus while per capita income grew 5 percent from 2004 to 2013, median household income contracted, median household expenditures rose 13 percent, and the poverty rate grew 23 percent (Pew Charitable Trusts 2016; Bishaw 2013). The economy grew, but the typical household lost ground.

Rising spending and falling income combined to increase debt, and this debt landed heavily on Millennials. Per capita household debt rose 22 percent between 2004 and 2013, from $37,300 to $45,700. Student debt, which almost tripled per capita between 2004 and 2013, accounted for much of this increase (Federal Reserve Bank of New York 2016). In 1995, ten percent of households held student debt, only a quarter of those were headed by people under 35, and the average real debt burden was about $12,000. By 2010, 20 percent of households had student debt, 35 percent of those were headed by people under 35, and average debt had reached $27,000 (Fry 2012). The share of 25 year olds carrying student debt increased from 25 to 43 percent between 2003 and 2012, and their average debt rose from $13,000 to over $20,000 (Federal Reserve Bank of New York, 2013).

Growing inequality will affect VMT if richer households are less likely to convert income into driving. What evidence we have suggests this is so. The 2009 NHTS shows that households earning $40,000- $50,000 annually made almost twice as many trips as households earning under $10,000 (3,900 trips compared to 2,046). Households earning over $80,000, however, made only 25 percent more trips (4,900) than those earning $40,000-$50,000 (Santos et al. 2011). Figure 3, also from the NHTS, shows this relationship in per capita terms, making the nonlinearity more stark. For both vehicle travel and travel overall, the largest differences are between low- and middle-income households, suggesting that income accruing to the top 1 percent (in 2012, households with over $400,000 in earnings) or the 0.01 percent (households earning over $12 million) was unlikely to be than turned into driving.[ii]

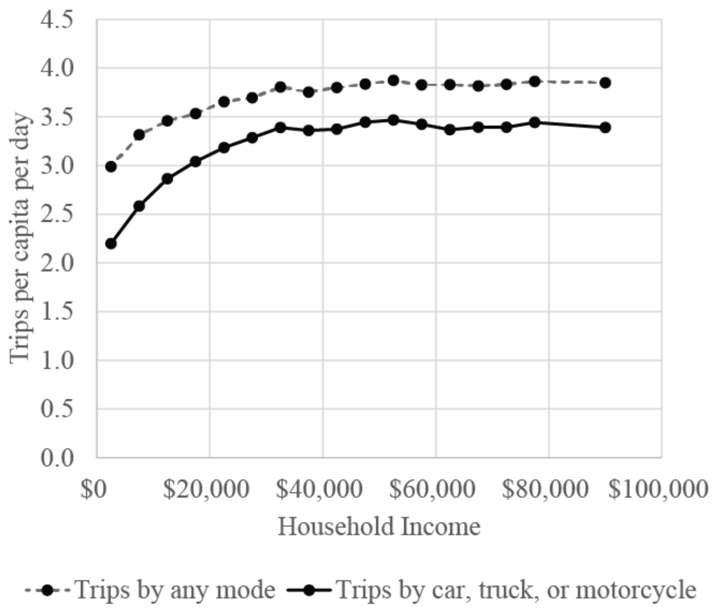

FIGURE 3 Per capita tripmaking by income, for all modes and for car, truck, and motorcycle, United States, 2009 Source: (NHTS 2009)

The reasoning above suggests that as inequality grows, VMT should track median income more than per capita income. And indeed that occurs. From 1970 to 1999, the simple correlation between GDP per capita and VMT per capita was 0.98, and the correlation between per capita income and per capita VMT was 0.99. The correlation between median household income and per capita VMT was much weaker (0.58). After 1999, however, these relationships reversed. From 2000 to 2013, the correlation between median household income and VMT per capita swelled to 0.80, while per capita VMT's correlations with income and GDP became negative (-0.66 and -0.12).

Figure 4 shows this relationship, using trends in per capita GDP, per capita VMT, median household income, and the share of national income going to the top 1 percent. Initially these variables move in sync. Gradually, however, GDP diverges from median household income, and after the recession two separate trajectories emerge: GDP rises with the top 1 percent income share, while VMT continues to falls with median household income. The economy trended up with the rich, while driving trended down with the middle.

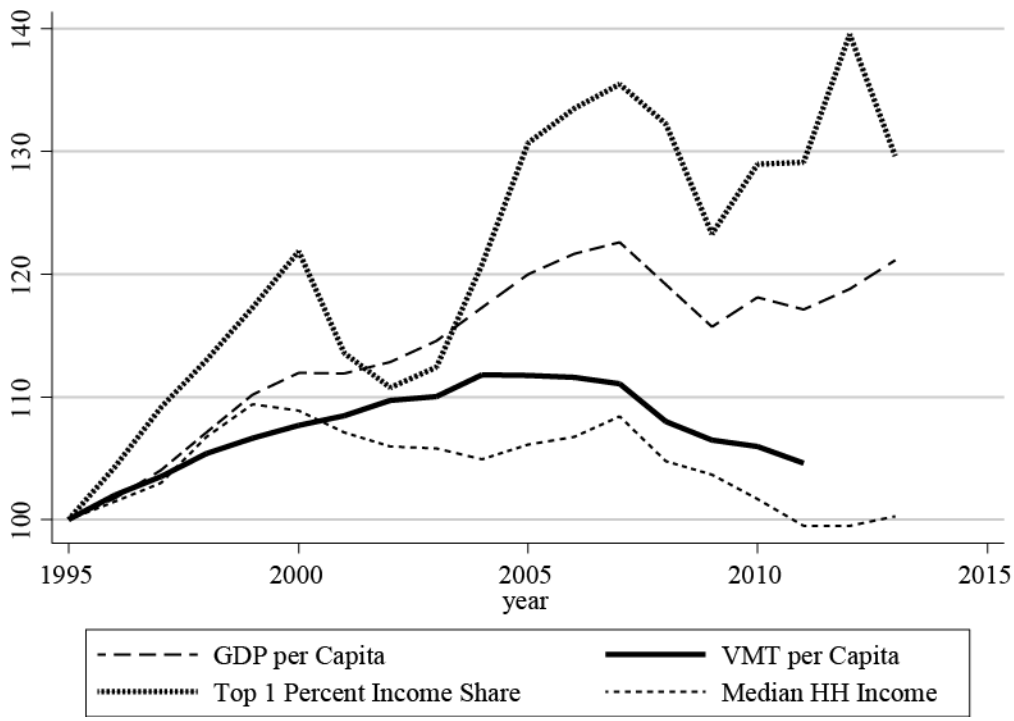

FIGURE 4 Trends in VMT, GDP per Capita, Median Household Income, and Top 1 Percent Income Share, 1995-2013, (1995=100), sources (U.S. Department of Transportation, various; U.S. Census Bureau, various; Alvaredo, 2015)

PEAK CAR : LITTLE EVIDENCE OF MODE SHIFT

Walking and Biking Did Not Rise

The share of Americans who walk regularly did not change between 2002 and 2012, although regular walkers reported walking more frequently.[iii] Over 60 percent of walking trips were for exercise, recreation, or dog-walking, making them unlikely to replace driving (Schroeder and Wilbur 2013). The remaining walks may have replaced driving, but many walking trips are short and many vehicle trips are long. Walk trips could replace short vehicle trips, but this might do little to reduce VMT. For walking to substantially reduce VMT, many people would need to change their destinations as well as their modes—not just replace driving with walking, but also (by necessity) replace further-away driving destinations with much closer walking destinations. This outcome is possible, but may be improbable. With the caveat that walking data are spotty, they offer little evidence walking grew, or that walking increases reduced VMT.

Bicycling, which offers more range than walking, can better replace driving. During the 2000s, numerous cities have made substantial and highly visible investments in bike infrastructure. Where in 2004 US cities had fewer than 40 protected bicycle lanes, by 2014 over 140 lanes existed in 80 cities (People for Bikes 2016). In some of these cities the new bike translated undeniably into more biking (Pucher et al. 2011).

This new biking, however, does not appear to help explain driving's decline. Driving fell nationwide, but both new cycling new infrastructure and new cycling gains were concentrated in a few places (Pucher et al. 2011). New York City holds 8 percent of the US population, but fully 25 percent of its bike-lane centerline miles. Biking rose dramatically in New York during the 2000s (NYC DOT 2016), but since few New Yorkers drove beforehand, these new bike trips may not have replaced VMT.

Nationally, biking did not rise. The bicycle industry struggled as driving declined. In 2014 Americans bought 57 bicycles per 1,000 people (39 bikes per 1,000 excluding children's bicycles), down from 67 per 1,000 in 2005 (NBDA 2014, 2015). Nor does every new sale indicate a new rider: a few dedicated riders often account for a large share of purchases. The number of bike shops fell 19 percent from 2004 to 2014 (38 percent from 2000 to 2014), and total sales floor area was stagnant (NBDA 2015, Angell 2015).

People can, of couse, switch to biking without buying new bikes. But both industry and government surveys suggest that biking fell during the driving downturn. Bike trips per capita peaked in the 1970s, and biking's share of all trips rose only imperceptibly between 2001 and 2009, from 0.9 percent to 1 percent (Pucher et al 2011). The share of adults biking six or more days per year fell from 15 percent in 2005 and to 11 percent in 2014 (NBDA 2014, 2015). The share of Americans who never bike in the summer (the only time many people ride) grew from 57 percent in 2002 to 61 percent in 2012 (Schroeder and Wilbur 2013).

As with walking, the typical bike trip is unlikely to replace a vehicle trip. Most bike trips are short (60 percent are a mile or less), and almost half are for recreation or exercise (Santos et al. 2011; Pucher et al. 2011). Finally, biking, like walking, is easier in urban areas where travel distances are shorter and not-auto travel more common. As Table 1 shows, however, driving declined much more in rural areas. Per capita rural VMT fell over twice as much as urban. In absolute terms, rural VMT fell 12 percent, while in urban areas it grew.

Table 1: US Urban and Rural VMT, 2004 and 2012

	2004	2012	Percent Change
Total VMT (millions)	2,727,054	2,664,060	-2.3
Urban	1,788,030	1,837,223	2.8
Rural	939,024	826,837	-11.9
VMT Per Capita (thousands)	9.3	8.5	-8.6
Rural	15.8	13.9	-12.0
Urban	7.6	7.2	-5.3
Population (thousands)	293,389	314,402	7.2
Rural	59,273	59,342	0.1
Urban	234,116	255,060	8.9

Sources: *US Highway Statistics,* US Census

Transit Investment vs Transit Use

Transit is the most plausible substitute for most American vehicle travel. Politically and fiscally, public transportation surged while driving fell. American transit supply, measured by vehicle hours of service, has more than tripled since 1970. Throughout the driving downturn, Americans in unprecedented numbers demonstrated a willingness to finance and build transit. Almost 20 cities introduced or expanded rail between 2000 and 2013. Light rail revenue miles rose 90 percent, and heavy rail 14 percent (US Federal Transit Administration various). Surveys showed that Americans, and young Americans in particular, strongly supported transit and urban living (USPIRG Education Fund 2014; Zipcar Inc 2015; TransitCenter 2014). Most impressively, since 2000 over 200 localities have voted to raise their own taxes to finance billions of dollars of transit improvements (ARTBA n.d.; Center for Transportation Excellence n.d.). The success rate of these transportation tax ballots exceeds 70 percent, far above the rate for tax referenda overall (APTA 2015; Center for Transportation Excellence n.d.).

These political successes were highly visible, as were the new service openings that followed them. The media began reporting a transit boom (e.g. Berman 2014; Hurdle 2014; Xie 2014, Hamilton 2014). But the transit comeback is in many ways a renaissance without ridership. During the driving downturn the national transit habit stayed essentially flat. In 2004 Americans took 0.64 transit trips per per person per week. In 2012 they took 0.65. These numbers are little changed from 2000 (0.64 trips), 1990 (0.68), 1980 (0.72) and 1970 (0.68) (Federal Transit Administration various).

Per capita transit trips did rise in some urban areas (UAs), but it isn't obvious that these increases caused or even coincided with reduced VMT. The geography of falling VMT is poorly aligned with the geography of transit. Between 2004 and 2013, 77 of the 101 largest UAs saw per capita VMT decline. Per capita transit trips, however, increased in less than half (36) of these UAs. Further, transit trips also increased, and by a greater amount, in 13 additional UAs where VMT rose.[iv] Across these 101 UAs from 2004 to 2013, changes in per capita VMT and per capita transit use were positively, not negatively, correlated (r=0.2).

If we examined Person Miles Travelled (PMT), an alternative measure of travel demand, transit looks somewhat better. Total highway PMT fell 10 percent from 2004-2013, while total transit PMT rose 22 percent. Per capita PMT rose xx percent. Yet it is not clear that PMT is a better metric of demand than trips. When trips are flat, rising PMT suggests longer distances for each transit trip, not more people using transit. And the geography of transit PMT, like that of transit trips, aligns poorly with that of falling VMT. PMT per capita rose in 40 of the 77 UAs where VMT per capita fell, and rose in another 20 UAs where VMT per capita rose as well. Like trips per capita, PMT per capita grew more (by 38 percent) in places where VMT rose, than where it fell (17 percent). Across the largest UAs, changes in per capita PMT and per capita VMT were positively correlated.

To be clear: transit use can be measured in different ways, and transit *did* grow in some places, as would be expected with many new service openings. Futher, transit ridership may well increase in the future. But even interpreted in the most favorable light, changes in transit use cannot explain the driving downturn. Driving per capita declined nationwide, and most heavily in rural places. Transit use is heavily concentrated in five “legacy” urban areas: New York, San Francisco, Boston, Philadelphia and Chicago. These UAs account for over 60 percent of US transit trips, and New York alone accounts for over a third. Transit PMT is even more concentrated. PMT rises with trip length, and long transit trips are taken by rail. Rail creates 55 percent of American transit PMT, despite accounting for only xx percent of transit vehicle-hours and xx percent of trips (APTA 2015b). The five legacy UAs, which contain most US rail ridership, account for two-thirds of total transit PMT in the 100 largest urban areas. Transit use rose in these in five UAs from 2004-2013, but per capita VMT fell in only three.

Because driving is far more common than transit use, even small shifts from driving to transit should generate extremely large gains for transit. Transit PMT rose by 10.6 billion during the driving downturn. This number seems impressive, but highway PMT fell by 562 billion. Transit's increase cannot explain such a large drop, particularly since over 4 billion of the increased transit PMT occured in New York. Similarly, American households take, on average, about 2,900 automobile trips per year, compared to about 66 transit trips (Santos et al. 2011). Shifting even one percent of car trips to transit would result in 29 more transit trips per household, a 44 percent increase. Nowhere in the data is there evidence of such a comeback.

What happened? Such surveys can be misleading, of course: responses can be sensitive to how questions are asked, their answers can be interpreted in multiple ways, and what people say is not always what they do. Thus while some surveys report that Millennials want to live in cities and drive less (Global Strategy Group 2014), others arrive at the opposite conclusion (Lachmann and Brett 2015; Demand Institute 2014), and Census data suggest that regardless of what they say, Millennials tend to live in suburbs (Kolko 2015).Even in many places that voted to finance new transit, transit commuting did not increase, and many voters who express support for transit also report little desire to use it more, or drive less (Manville and Cummins 2015).

Transit's resurgence appears to be more one of supply and support, not demand and use. Figure 5 plots VMT per capita, transit supply (measured as vehicle hours of service), transit demand (per capita weekly transit trips) and the share of Americans who want to spend more on transit but not on roads (from the GSS). The graph is standardized to show percent changes since 1985.

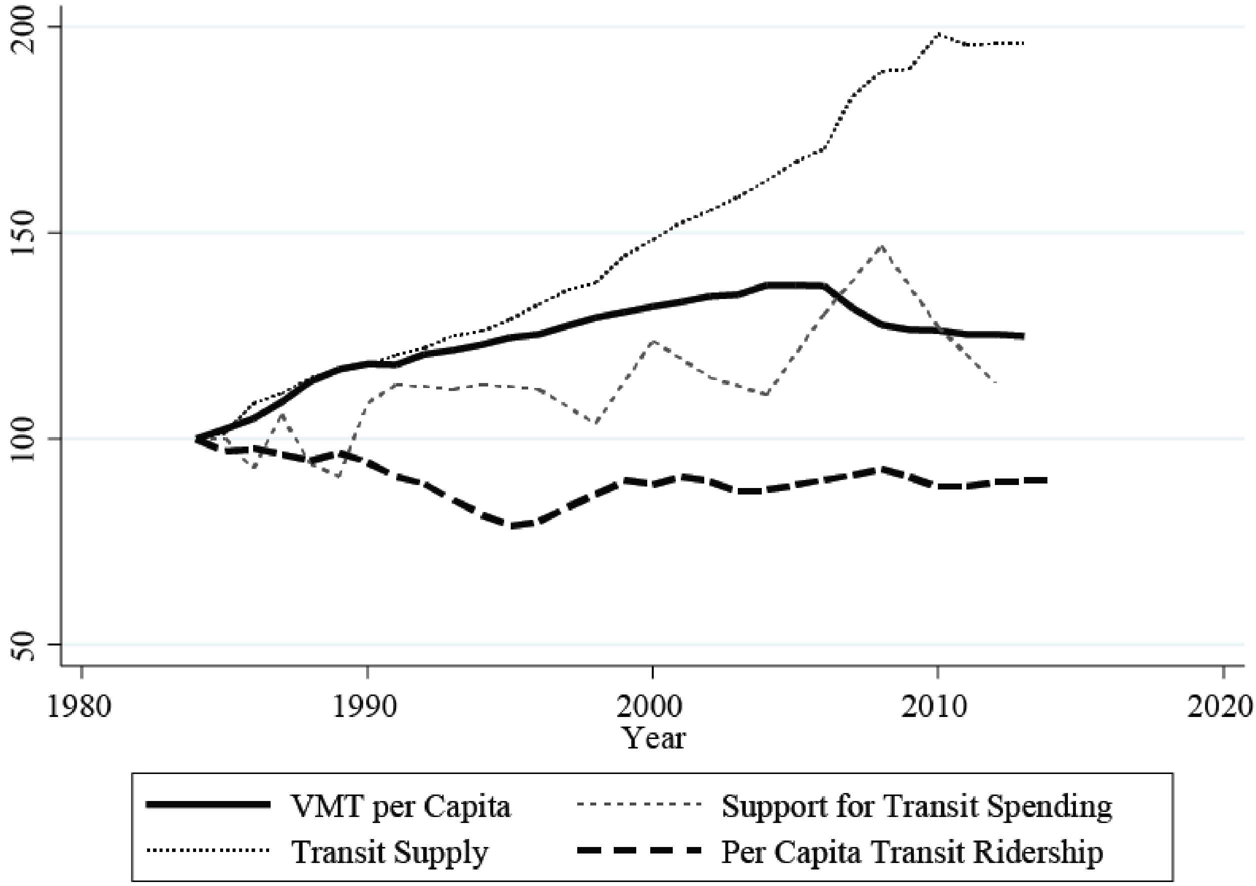

FIGURE 5 VMT, Transit Ridership, Transit Supply and Attitudes Toward Transit Funding, (1985=100), United States, 1985-2013, sources: (U.S. Department of Transportation various; National Data Program for the Sciences 2011; APTA 2015}

The figure shows, first, that as VMT fell, transit trips did not rise. Transit finished 2013 below its 1985 level, and roughly equal to its 2004 level. Second, even as transit use remained flat or fell, support for transit spending rose. From 1985 to 2013, the simple correlation between transit trips per capita and support for more transit spending is actually negative (-0.35). [v] Third, the supply of transit marches steadily upward, regardless of changes in VMT, transit support, or transit demand. These general patterns are not sensitive to choosing different base years.[vi] Over the last two decades driving has risen and fallen, transit supply has steadily increased, and transit demand has stayed largely unchanged.

Are People Just Traveling Less?

Just as mode shift's presence does not automatically validate Peak Car, neither does its absence automatically preclude it. Peak Car may actually be Peak Travel. Americans may have chosen to not just drive less but travel less overall. If so, total trips would decline with VMT. NHTS data do show a slight reduction in trips between 2001 and 2009. Per capita tripmaking fell less than VMT (5 percent compared to 8 or 9 percent), but fell nonetheless.

Falling overall travel, however, is consistent with both attitudinal and economic explanations for driving's decline. People might travel less because they can't afford to, they don't want to, or both. No easy method exists to separate these motivations.

Arguing that Americans voluntarily decided to travel less requires explaining why that would occur, since for centuries Americans have steadily traveled more. One potential answer is new Information and Communication Technology (ICT). Perhaps the Internet and social media replaced travel through e-commerce, online interaction, and the like (Van Wee 2015). Empirical tests of this idea have reached conflicting results. McDonald (2015) examined the NHTS and concluded that ICT explained some declines in household VMT. Blumenberg et al. (2012) also examined the NHTS but found the opposite: Internet use was, if anything, correlated with more travel.

While this question demands further attention, little history or theory suggests that ICT will reduce travel. A substantial literature in transportation, urban economics, and economic geography shows that travel and telecommunications are as much complements as substitutes. In general falling communication costs do not eliminate travel, but create communication. This increased communication, in turn, increases the demand for for face-to-face interaction, and creates more travel (Leamer and Storper 2001; Mokhtarian, 2002; Mokhtarian 2009, Andreev 2010).

New ICT might be different, but it is not obviously so. New ICT has enabled e-commerce, which could reduce household driving, but (again) might increase commercial driving. New ICT has also made cars smarter and safer, and in revolutionizing logistics it has enabled the rise of auto-oriented big box stores (Basker 2007). Mobile phones could make driving less necessary and transit more productive, but they also let people summon vehicles-for-hire, and safety statistics suggest (distressingly) that many people use mobile phones without giving up their cars (Insurance Institute for Highway Safety 2015).

STATISTICAL EVIDENCE ON DRIVING'S DECLINE

We ran statistical models measuring the association between state-level VMT per capita and the various socioeconomic factors that might influence it. Full details are in the Technical Appendix, but we estimated fixed-effect panel regressions where the unit of analysis was the 50 states and Washington, DC, from 1980 to 2012. Analyzing state-level data is not ideal, since people, not states, choose to drive. State data, however, offer the only annual measures of VMT and its potential determinants: income, unemployment, poverty, gas prices, the share of each state living in rural areas, the share aged 65 or older, and the share aged 20-35. For some number of years, we also measure per capita household debt and the share of households with Internet access.

Our goal was to determine if economic factors alone could account for most or all of the changes in per-capita state-level VMT. We did this first by interpreting the regression coefficients: asking if the models suggested that changes in income, gas prices and unemployment could account for the bulk of lost VMT. We also used a year-specific intercept to capture the underlying trend in VMT that remained after controlling for the independent variables. If this trend was negative during the driving downturn, it would suggest that factors beyond those in the regressions were associated with driving's decline. If it was positive or flat trend, it would suggest that the statistically and substantially significant variables in our model explained most of the VMT differences within and between states.

Given the limits of state data, we emphasize that our results are more suggestive than dispositive. Nevertheless, the results suggest that economic factors can on their own explain most differences in state level per-capita VMT. The models suggest that the observed changes in state per capita income, unemployment, debt, poverty, and gas prices would together be associated with a roughly 9 percent decline in per capita VMT—virtually all the decline that occurred over this time.

The demographic variables, in contrast, are less consistent. The share of people aged 65 or older is associated with lower per capita VMT, though the size of this relationship varies considerably across models. The share of the population aged 20 to 34 is associated with less VMT in two models but more VMT in two others. The association between VMT per capita and Internet connectivity is ambiguous at best (sometimes positive and sometimes negative) and always small.

In every model but one the year-intercept trend is largely positive, and in a majority of models it is statistically significant. This result suggests that after accounting for economic and demographic factors, per capita VMT was trending up, not down, during the driving downturn. Figure 3 compares the actual trend in VMT per capita across states from 1980-2012 with the underlying VMT trend captured by the year-specific intercept. Driving only trends downward during the recession of the early 1980s (when actual VMT rose) and the Great Recession (when actual VMT fell). Compared to the mid-to-late 1980s, controlling for economic and demographic factors, the trend has been for more VMT. The only exception is a sharp downturn between 2008 and 2009, after which driving rose again. Outside of recessions, state per capita VMT has been on a nearly unrelenting upward trend. Even in 2009, the year-specific intercept, though trending down, remains 40 percent higher than in 1980.

This finding is commensurate with a point we made earlier, that by conventional estimates the spike in gas prices should have resulted in a larger VMT drop than actually occurred.

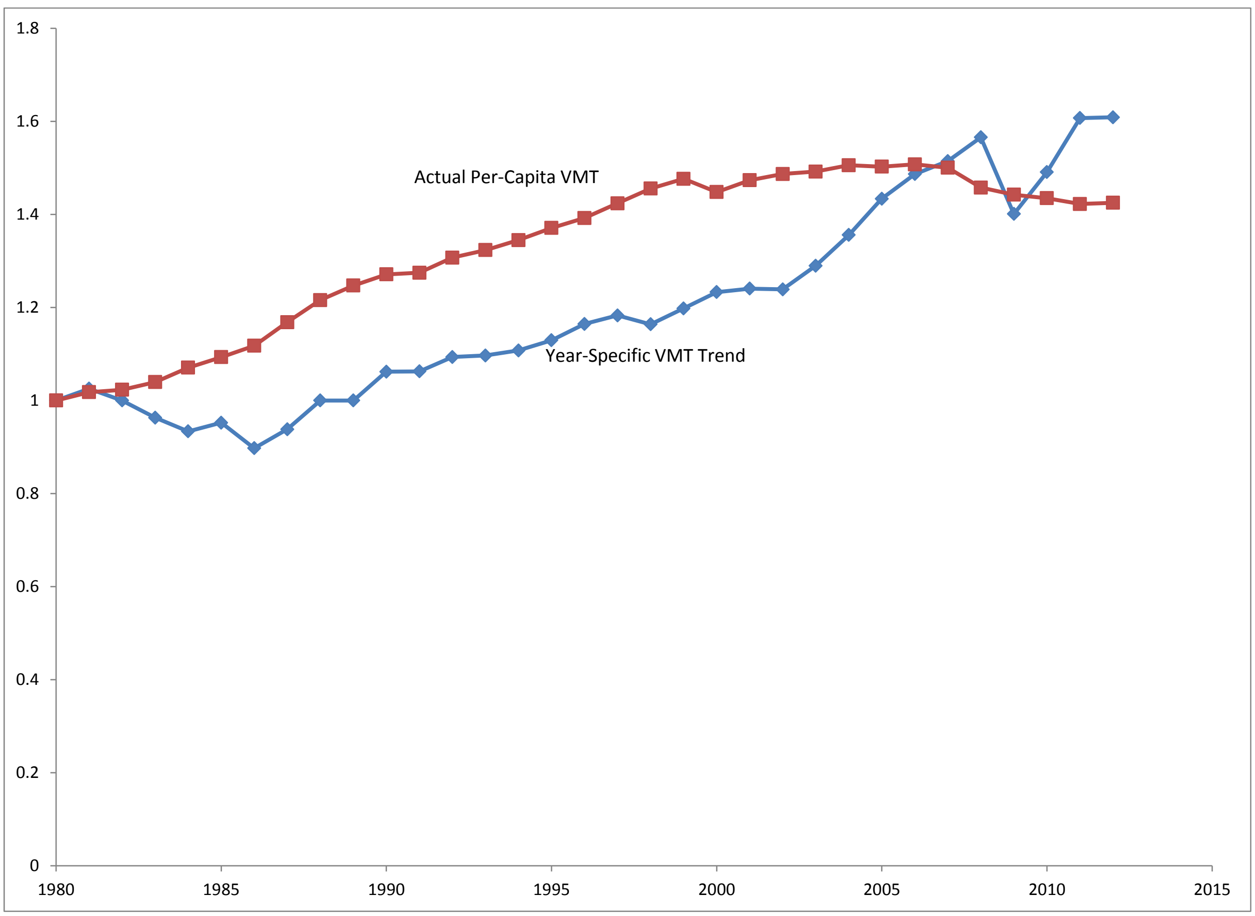

Figure 6: Actual VMT Per Capita and Underlying VMT Time-Trend, 1980-2012-

CONCLUSION

Our analysis suggests that driving fell between 2004 and 2013 because for many Americans it became harder to afford. The price of gasoline rose, and while America's economy grew, it grew unequally, and the typical American household lost financial ground. Little evidence suggests that Americans drove less because they chose other modes.

These findings cast the driving downturn in a somber light. Economic insecurity is a high price to pay for less VMT. The driving downturn exposes a quiet but profound contradiction in American transportation planning, and suggests a new path forward. For decades, despite rising concern about driving's social costs, planners and policymakers have subsidized automobile travel. Planners have forced developers to widen roads and provide parking. Lawmakers have kept gas taxes low, and kept most roads and parking spaces free. All these actions are intended make driving easier and less expensive. Even transit investments have been often justified on grounds that they would reduce congestion: a benefit for drives. Almost no evidence suggests these policies reduce VMT, and ample evidence suggests they increase it (Shoup 2011, Duranton and Turner 2011). Transit's role—or lack thereof—in the driving downturn illustrates this problem. Despite decades of investment, even when driving fell by an unprecedented amount, transit use at best rose slightly, and arguably did not rise at all.

This approach needn't imply imposing hardship on many people. Planners can accomplish, by intent and with minimal damage, what rising gas prices and falling incomes did by accident and with great harm. Economic insecurity reduces driving at high cost, because the lost VMT is often a byproduct of lost work or schooling or medical care. Targeted interventions that make driving more expensive, independent of income, let people economize on VMT in the way that works best for them: e.g. continuing to drive to work but letting children walk to school.

Planners can make driving more expensive both by raising prices (gas taxes, congestion tolls, parking charges), and removing subsidies (parking requirements and road widenings). Mass driving might require mass prosperity, but mass prosperity needn't be accompanied mass driving. It is possible to have a country where incomes are high but driving's price is neither unpredictable nor artificially low, and where economically secure people can travel in ways that are more environmentally sustainable. This outcome, however, requires that planners confront driving's low price.

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TECHNICAL APPENDIX

Data and Method

Our regression analysis uses several data sets. Our dependent variable, per capita VMT, comes from the FHWA's *Highway Statistics* series, which tracks VMT for every state from 1980-2012. *Highway Statistics* are also compiled for the nation as a whole, and for urbanized areas, but for practical and conceptual reasons we choose to analyze states. National-level VMT offers fewer observations and little variance (only one unit of analysis, observed once per year). UA data, meanwhile, offer more observations and more variance, but exclude rural VMT, which fell the most in per capita terms. Analyzing UAs also reduces our available control variables, because little economic data (e.g. on income, or gas prices) are compiled at the UA level.

The FHWA estimates annual VMT using automated traffic counts over thousands of roadways in all fifty states and the District of Columbia. While this method is probably robust, it can be prone to error. For example, if driving in a state rises or falls more rapidly on local roads (which are largely not included in automated traffic count locations) then the method might under- or over-count VMT for that state in that year. We expect such errors to be small, they are undoubtedly present.

We match our VMT data with data on per capita incomes from the US Bureau of Economic Analysis, and unemployment data from the US Bureau of Labor Statistics. From the US Census, we use annual estimates of poverty and the age distribution (the share of people between 18 and 34 years of age, and the share aged 65 or older). Census data also give us the share of each state's population living in rural areas, although we needed to linearly interpolate these create values intercensus years. From the US Energy Information Agency, we include each state's annual average real gasoline price.

Finally, we include two additional variables not available for the entire 1980-2012 period. First is household debt per capita from 2002-2012, from the US Federal Reserve. Second is the share of the population living in Internet-connected households, which the Census collected periodically in the 1990s and then consistently from 2005-2013. This latter variable is, an admittedly imperfect proxy for ICT. The Internet is only one form of ICT, and Internet access is not equivalent to Internet use. Some households with Internet use it far more than others. Nevertheless, to our knowledge this variable is the only state-level measure of ICT available annually for most years of the driving downturn.

Our data yield a balanced panel of 51 units of geography (50 states plus Washington, DC). For our first model, covering 1980 to 2012, this gives us 1,683 state-years of data. In our more restricted models, where we use data unavailable in earlier years, we have 306 or 561 observations, depending on the specification.

Table A-1 shows summary statistics. Our dependent variable, VMT per capita, varies considerably across states and over time. The dataset's observation where VMT per capita is lowest is New York in 1980 (4,421 VMT per capita). The highest, Wyoming in 2003, is nearly four times as large (18,296 VMT per capita). The data's standard deviation ranges from 1,000 to 2,000 VMT per capita across years, or about one fifth the mean in each year. Overall, state per capita VMT fell by 5.4 percent between 2004 and 2012, with the largest decline in Georgia (-16 percent), and the largest gain in North Dakota (+22 percent). In only six states did per capita VMT rise (North Dakota, Nevada, Louisiana, Alabama, Indiana, and Ohio).

Table A-1: Summary Statistics, State=Level VMT and Socioeconomic Charactersistics

	All years (1980-2012)				Later Years (2006-2012)			
	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
VMT Per Capita	9,337	1,988	4,421	18,296	10,236	1,929	5,625	18,296
Per Capita Income	$36,952	$8,080	$20,435	$78,229	$43,609	$7,635	$30,975	$78,229
Percent Unemployed	6.1%	2.1%	2.3%	17.8%	7.1%	2.3%	2.6%	13.8%
Percent in Poverty	13%	4%	3%	27%	13%	3%	6%	23%
Real Average Gas Price	$2.40	$0.66	$1.25	$4.42	$2.95	$0.59	$1.73	$4.42
Rural Population Share	29%	15%	0%	68%	26%	15%	0%	62%
Percent Age 20-34	23%	3%	17%	34%	20%	2%	17%	32%
Percent Age 65+	12%	2%	3%	19%	13%	2%	6%	18%
Percent of Households with Internet					72%	9%	42%	88%
Household Debt Per Capita					$47,962	$14,176	$22,575	$97,972
N(State-Years)	1,683				306			

All dollars 2012

An important point, and important limitation to our regressions, is that variance in per capita VMT between states (and within them over time) is much smaller than the variance in *personal* VMT in any *given* state. Within any state in any year, some people don’t drive at all and some drive over 60,000 miles. As such, our regression results cannot be interpreted as associations between VMT and the attributes of individual people. For example, finding state per capita income is statistically associated with state per capita VMT is not the same as finding that lower income people are driving less, only that people in states with lower average incomes do less total driving. While this finding is consistent with the hypothesis that lower-income people drive less, it is not hard evidence for it.

This problem, called ecological inference, limits but does not nullify the utility of our regressions. We are interested in why US driving fell over time, so examining how American driving varied across the US’s component parts can be useful. In this instance, as is often the case, regressions of aggregate data are an imperfect approach, but also the most feasible. Not uncommon Small and Van Dender…

We estimate fixed-effect panel regressions where the dependent variable is the natural log of per capita VMT. In our preferred specifications, we also take the natural log of our independent variables, mostly for ease of interpretation. Log-log regression coefficients can be interpreted as elasticities—the dependent variable's response to a one percent change in the independent variable. Each regression also includes a year-specific intercept, to track the underlying trend in per capita VMT over time.

Results

Table A-2 shows our results. Model 1 uses the full 1980-2012 dataset, and thus excludes the Internet and debt variables. We introduce these variables in subsequent models, at the cost of data from earlier years. Overall, the models fit the data reasonably well, with r-square values of 0.31 and 0.59.

Three independent variables show consistent associations with VMT. Per capita income is consistently associated with more per capita VMT. This variable's coefficients suggest that a ten percent increase in per capita income is associated with a two to four percent increase in VMT per capita (consistent with previous research). Gasoline prices are also strongly associated with less driving, albeit in only three of our four models; a ten percent increase in fuel prices is associated with a two percent decline in driving (again consistent with previous research). Three of our four models also suggest that states with a larger share aged 65 or older have less per capita VMT, controlling for other variables in the model. A ten percent increase in the older population is associated with a one to two percent decline in driving.

Our other variables are less consistent across models. Unemployment and poverty rates have little association with VMT, controlling for other variables in the model. This finding is unsurprising, since we also include income in the models, and unemployment and poverty would mostly impact VMT by reducing income.

The Internet access variable is positive and statistically significant in one model, and positive but insignificant in another. In both cases the coefficient itself is very small, suggesting virtually no association between state-level Internet connectivity and state-level VMT.

Similarly, the percent of the population aged 20 to 35 is only statistically significant in one of our four models, although in that model its magnitude is meaningful. In model 2, which controls for internet access but not debt, a ten percent increase in the younger adult population is associated with a two percent decline in driving. Once we control for household debt, however, in model 3, this young adult coefficient becomes statistically insignificant. One interpretation of this result is that some of the "Millennial Effect" on VMT reflects the higher rates of debt these young adults carry.

In two ways, the regressions suggest that economic factors can account for much of the state-level driving decline. First, if we use the regression output to simulate the changes in VMT that result from the observed changes in income, unemployment, gas prices poverty and debt that took place between 2004 and 2012, and hold all other variables at their means, the output in every model predicts a 9 to 10 percent reduction in per capita VMT across and between states.

Second, the year-specific intercepts are generally positive and statistically significant. The trend lines suggest that, controlling for the statistically significant variables in our model (most of which are economic), VMT has increased almost monotonically since 1988. This result suggests that is surprising state-level per capita VMT did not fall more during the driving downturn, given the economic conditions and aging of the population. Fuel economy rose…

Alternative specifications

We experimented with a variety of other variables and functional forms, but the overall results remained consistent. We substituted median for per capita income, included the freeway lane-miles per capita in each state, and also included the share of state gas tax revenues spent on public transportation. In each case the results were substantially the same as those reported above. Similarly, we estimated the model log-linearly, and with all variables unlogged, and the results were essentially unchanged.

Table A-2. Log-Log Panel Model of VMT by State, 1980-2012; Dollar amounts in $2012

	Model 1			**Model 2**			**Model 3**			**Model 4**		
Variable	Coeff.	t	Prob.	Coeff.	t	Prob.	Coeff.	t	Prob.	Coeff.	t	Prob.
Log (Income in thousands)	0.218	6.12	***	0.236	4.11	***	0.395	3.99	***	0.406	6.130	***
Log (Percent unemployment)	-0.040	-4.16	***	-0.013	-0.88		0.013	0.58		0.016	1.050	
Log (Percent in poverty)	-0.010	-0.88		0.012	0.80		-0.002	-0.11		0.004	0.280	
Log (Real average gas price)	-0.198	-5.23	***	-0.032	-0.59		-0.200	-2.29	**	-0.224	-3.340	***
Log (Rural population share)	0.240	14.88	***	0.138	4.07	***	-0.106	-1.30		-0.088	-1.410	
Log (Percent age 20-34)	-0.035	-1.00		-0.181	-3.89	***	-0.141	-1.39		-0.140	-1.950	*
Log (Percent age 65+)	-0.184	-8.02	***	-0.079	-2.12	**	-0.112	-1.84	*	-0.074	-1.680	*
Log (Percent of individuals with internet)				0.037	4.14	***	0.077	1.41				
Log (Real total debt per capita)							-0.176	-3.83	***	-0.145	-4.670	***
Year (base for each model: 1980, 2002, 2007, 2003)												
1981	0.023	2.23	**									
1982	0.026	2.22	**									
1983	0.011	0.72										
1984	0.010	0.58										
1985	0.023	1.31										
1986	-0.018	-0.68										
1987	0.025	0.98										
1988	0.054	2.01	**									
1989	0.085	3.31	***									
1990	0.125	5.27	***									
1991	0.128	4.96	***									
1992	0.148	5.40	***									
1993	0.150	5.15	***									
1994	0.158	5.38	***									
1995	0.173	5.75	***									
1996	0.192	6.57	***									
1997	0.203	6.63	***									
1998	0.183	5.01	***									
1999	0.208	5.96	***									
2000	0.225	7.76	***									
2001	0.232	7.44	***									
2002	0.234	7.00	***									
2003	0.264	8.64	***	-0.021	-1.32							
2004	0.295	10.72	***	0.032	2.35	**				0.042	3.790	***
2005	0.325	13.17	***	0.018	1.25					0.078	3.630	***
2006	0.339	13.98	***	-0.014	-0.74					0.101	3.620	***
2007	0.344	14.05	***	0.000	0.02					0.111	3.470	***
2008	0.348	14.37	***	0.000	0.00		0.100	2.35	**	0.103	2.660	***
2009	0.303	10.92	***	-0.032	-1.01		0.010	0.35		0.020	1.010	
2010	0.333	12.91	***	-0.033	-0.87		0.024	0.59		0.041	1.400	
2011	0.362	14.37	***	-0.037	-0.81		0.047	0.84		0.069	1.670	*
2012	0.365	14.05	***	-0.039	-0.82		0.039	0.67		0.064	1.520	
Constant	7.217	43.39	***	7.356	30.14	***	10.481	17.15	***	9.282	22.980	***
Sigma (u)	0.137			0.146			0.260			0.248		
Sigma (e)	0.053			0.036			0.029			0.027		
Rho	0.871			0.943			0.988			0.988		
N(State-Years)	1,683			561			306			306		
N(States)	51			51			51			51		
N(Years)	33			11			6			6		
R-square (within states)	0.87			0.47			0.49			0.52		

R-square (between states)	0.41	0.35	0.44	0.40
R-square (overall)	0.59	0.36	0.35	0.31

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[i] Like many telephone surveys, the NHTS also has a low response rate (US Department of Transportation 2011, Meyer et al 2015).

[ii] The Consumer Expenditure Survey provides further evidence on this nonlinearity. In 2012 households earning over $150,000 per year spent over three times as much on transportation ($19,000) as households earning under $70,000 ($6,100). Little of this difference, however, stemmed from expenses relating to miles driven. Rather the affluent households spent three times as much buying and maintaining vehicles (i.e., they bought nicer cars), and over seven times as much on air travel. The affluent spent only twice as much on gas, the factor that most closely reflects distances driven (US BLS 2014).

[iii] If anything, the walk share fell slightly, from 71 to 70 percent (Schroeder and Wilbur 2013).

[iv] Calculated from HPMS data via the Texas Transportation Institute, and from the NTD.

[v] Smart (2014) suggests that increased support for transit stemmed partly from gas price volatility.

[vi] Transit ridership does outpace population growth if the trend starts in 1996. This starting point is somewhat misleading, however, since the early 1990s saw inordinately low transit ridership. Starting a trend in 1990 or 2000 shows per capita ridership as unchanged.

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ABSTRACT
This paper documents the declining socioeconomic status of American households without vehicles. Carless households have lost income in absolute terms since the mid-20th century, and the income gap between households with and without cars is now larger than that between college graduates and non-graduates, and homeowners and renters. We tie this falling socioeconomic status to the increasing auto-orientation of America's built environment, and show that in New York City, where the built environment largely has not changed to favor the car, the correlation between vehicles and socioeconomic status essentially vanishes.

INTRODUCTON
In the 20th century the cost of moving goods fell dramatically, while the money spent to move people rose. Today goods movement accounts for a far smaller share of the national economy than it did in 1900 or even 1950 (Glaeser and Kohlhase, 2004), but personal mobility is a much larger share of household income and expenditures. Motor vehicles explain this increased spending. In 2015 transportation accounted for over 17 percent of household expenditures, and 93 percent of those expenditures went toward purchasing, operating or repairing personal vehicles (Bureau of Labor Statistics, 2016a). Automobiles increased personal mobility but also redefined it. The car allows many people to cover vast distances, on their own, at high speeds.

But the price of entry into this new transportation system, which in many ways became the price of entry into its economic system, is ownership of a personal vehicle.

Widespread personal vehicle ownership has of course had many consequences. This article focuses on the consequences for people *without* vehicles. We start from the premise that personal vehicles have network externalities (Webber, 1992). Vehicles become more valuable when more people own them, because as vehicle ownership increases, so too do the public and private investments that complement it, and these investments lower the price—in time, money and convenience—of vehicle use. These investments include lower-density land use patterns, more and wider roads, an abundance of service stations, parking lots, and so on.

The network externality cuts two ways, however. As society becomes more organized around vehicles, people without vehicles risk being left out of society. This exclusion occurs not just because those with cars can cover more ground more quickly than those without, but because changes made to accommodate people with cars can affirmatively disadvantage people without them. Physical changes that enable high speed automobile travel can penalize lower-speed modes by pushing destinations apart, and by making walking or cycling less comfortable or safe.

This process should yield a strong selection effect in vehicle ownership. As vehicle ownership becomes more necessary, most people who can acquire a vehicle will, even if doing so is a large financial burden. In turn, the population without vehicles should over time become increasingly disadvantaged. More poor people will acquire automobiles, and people without automobiles will be increasingly poor.

In what follows we document this declining socioeconomic status of carless households. We draw on secondary qualitative sources, as well as multiple quantitative data sets whose information spans from 1900 to 2013, although our analysis emphasizes the 1980s forward. We first review the rise of American automobility, the changes in the built environment that it wrought, and the disadvantage these changes imposed on lower-income Americans. We then show that while vehicle ownership has grown for over a century, the share of carless households stopped falling in the late 1970s or early 1980s (the precise date depends on the data used). Since that time, the household vehicle stock has grown largely because households with vehicles have added more, not because households without vehicles have acquiring their first. And while there is substantial churn in this zero-automobile cohort—households at the bottom of the income ladder frequently climb into and fall out of vehicle ownership frequently (Klein and Smart, 2017)—the socioeconomic gap between carless households and others has widened over time. The income gap between households with and without vehicles is now larger than that between households with and without college educated adults, and larger than that homeowners and renters. Perhaps most strikingly, vehicle-free households are poorer in absolute terms today than they were 60 years ago.

The causality here is almost certainly two-way. Lack of vehicles can make some households poorer, but many households lack vehicles because they are poor. A number of studies have tried to sort out this endogeneity, by controlling for selection and isolating the independent effect of vehicle ownership on income (Gurley and Bruce, 2005; Pendall et al., 2015; Raphael et al., 2001). Our goal here is to highlight selection effects rather than control them away—to emphasize the built environment's underlying role in the vehicle-poverty relationship. To that end, the article's final section examines New York City, which is the American city that changed its built environment least to accommodate automobiles. In New York, vehicle ownership has almost no correlation with socioeconomic status.

THE CHANGING COSTS OF MOBILITY AND AUTOMOBILITY

Cars converted personal transportation from something that cost time into something that cost money. Figure 1 plots a 100-year trend in household transportation expenditures, using data from the Bureau of Labor Statistics. Transportation's share of household spending rose sevenfold from 1917 to 2015, and more than doubled from 1934 to 1985, when it peaked at 20 percent. After 1985 transportation's share plateaued, and hovered between 18 and 19 percent into the 21st century. Only housing, during this time, grew faster than transportation as a share of household expenditures (BLS 2006; 2016).

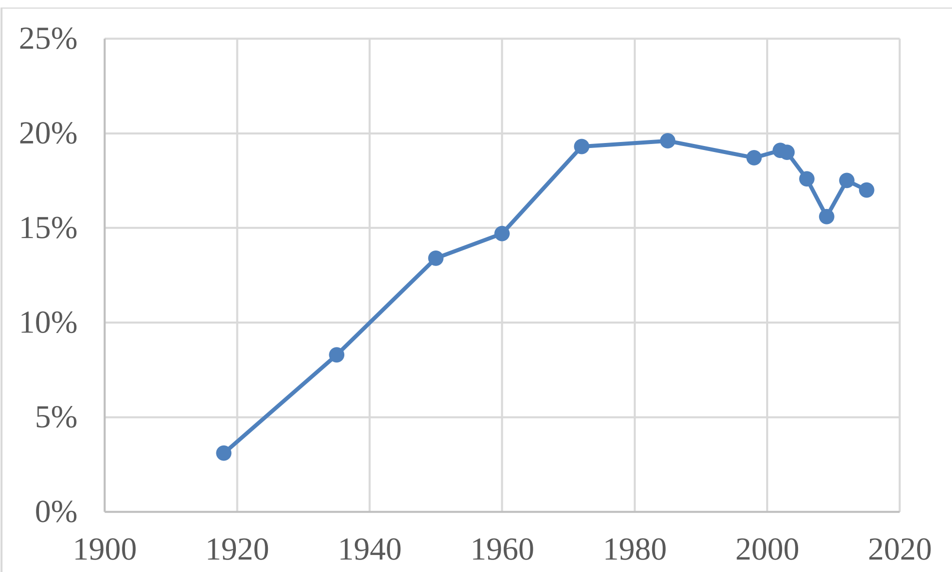


FIGURE 1. Share of household expenditures on transportation, 1918-2015, Sources: BLS (2006) and US Consumer Expenditure Surveys 2007-2016

This increased spending was a product of Americans buying cars. From 1906-1940 the quality adjusted price of automobiles fell 85 percent, and stayed low through the 1980s (Raff and Trajtenburg 1996). The simple correlation between vehicles per capita and transportation's share of household expenditures from 1935-2013 is 0.8. Consumer Expenditure Survey data shows that in most years, and certainly from 1972 forward, over 90 percent and often over 95 percent of household transportation spending was devoted to cars (BLS various). The relationship this implies is somewhat paradoxical: households spent more on transportation because cars became *less* expensive. The falling real price of automobiles let more households buy them, and in buying cars these households went from spending almost nothing on transportation to spending 15-20 percent of their budget on it.

The mass auto ownership that resulted transformed America's landscape, and the landscape's transformation further enabled mass auto ownership. Vehicles spurred profound changes in public investment, public regulation, and private entrepreneurship. Most obviously, governments improved and expanded roads, changed road designs to support high-speed auto travel, and changed the mix of uses allowed on roads. These steps in turn increased the value f private vehicles. All these developments have been ably documented elsewhere; we discuss them only briefly here.

Within cities, planners improved streets, widened them to accommodate cars, and regulated them in new ways to give cars primacy—for instance, inventing and then prohibiting jaywalking (Norton, 2011). Street configurations also changed. The American street networks of the early 20th century, with their short blocks, narrow widths, and frequent intersections, gave way to wider roads with more curves and fewer interruptions (Barrington-Leigh and Millard-Ball, 2015). From 1920 to 1990, street connectivity steadily fell: the share of cul-de-sacs and dead ends rose, while the share of intersections with four or more connected edges declined, as cities abandoned gridlike patterns in favor of loops and whorls that gave drivers long sightlines, enabled consistent fast driving, and accommodated large fire trucks and other emergency equipment (Barrington-Leigh and Millard-Ball, 2015).

These interventions enabled speed, and speed let people abandon dense areas without losing access to them, thereby opening up outlying areas with lower per-square-foot land and housing costs. Purchasing speed thus let people purchase more space, and more space encouraged automobile travel by enabling and requiring higher speed.

Fischel (2004) goes so far as to contend that automobiles spawned modern zoning. Motor vehicles liberated industrial uses and worker housing from the need to be near ports or rail lines. In doing so they created the prospect of footloose “undesirables”, which prompted stricter controls on the type and location of building. Minimum lot sizes, in this telling, were both symptom and source of mass automobility.

Regardless of whether one accepts this particular narrative, lot sizes did grow, and as they grew homes became larger and farther apart. Residential lots for new construction expanded from an average of 6,000 square feet in the 1930s to more than 18,000 square feet in 2008 (Hirt, 2015). Residential floorspace per capita doubled between 1890-2010, even as average household sizes fell (Moura et al., 2015). The average new house was 1,660 square feet in 1973, but 2,392 square feet in 2010 (U.S. Bureau of the Census, n.d.). Some this new floorspace owed to the demands of vehicle storage: garages and off-street parking became more common, partly in response to market demand and mostly in response to parking requirements in zoning codes (Jakle and Sculle, 2008; Shoup, 2011). Between 1950 and 1980, for example, Los Angeles County added about 310,000 parking spaces per year, and by 2015 over one-third of the county’s land area was parking (Chester et al., 2015).

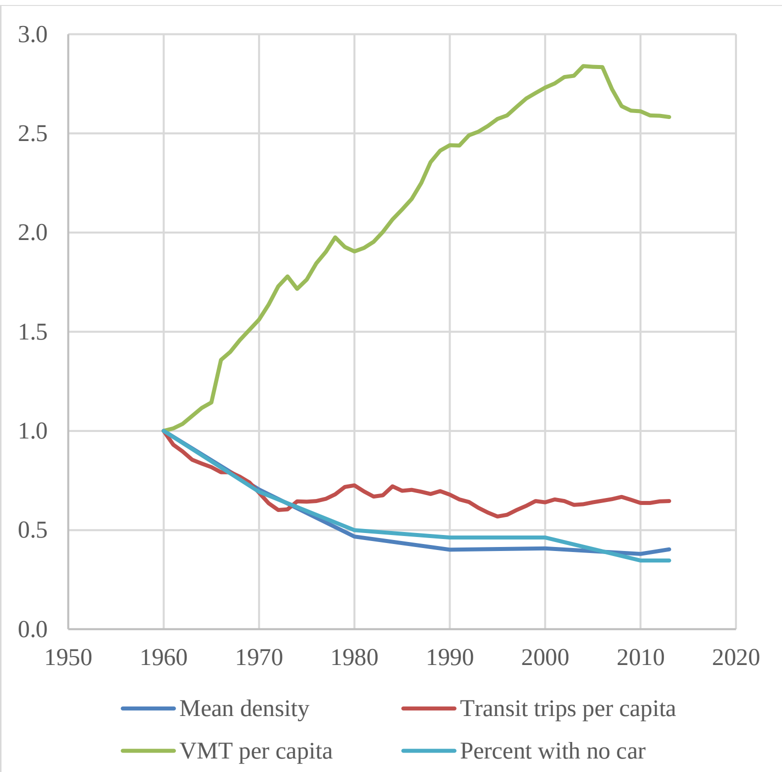
Retail followed population, and soon shopping—once an activity conducted in dense downtowns—was also suburbanized. The proportion of all retail sales occurring in malls and shopping centers rose from 14 percent in 1960 to over 50 percent by 1990 (Feinberg and Meoli, 1991). A hallmark of malls, of course, was their relative inaccessibility to anyone without a car; the typical mall was in an outlying area and surrounded by parking.

As activities dispersed, density fell. From 1960 to 2015, mean residential census tract density fell from 14,000 people per square mile to under 6,000, and median density declined by two-thirds, from 6,000 to 2,000 people per square mile. By 2015 half the US population lived in neighborhoods of less than 2,000 people per square mile, and 25 percent lived in neighborhoods under 1,000 people per square mile.

Falling density, combined with other changes to the landscape, made automobiles the default mode of travel for more trips. The national transportation surveys show that from 1969 to 2009, average household vehicles and average household Vehicles Miles Travelled (VMT) grew 60 percent, even as average household size fell. Over this same time the average length of vehicle trips grew only modestly, by 9 percent—largely because employment and shopping followed housing out to the periphery. But the average number of household vehicle trips grew by 50 percent. Thus in the average household fewer people used more vehicles to drive more places, although the places they drove to were not on average much farther away (Santos, et al., 2011). Put another way, the average distance between driving destinations did not grow. What grew was the number of destinations that required driving.

The same falling density that made driving more useful made transit less so. Figure 2 plots trends in residential density, VMT per capita, transit trips per capita, and the share of households without vehicles, from 1960-2013 (1960=1.0). VMT per capita rises steadily for most of this time, nearly tripling by the mid-2000s, while density and transit use both fall sharply and then plateau. Transit actually stops falling before density, stabilizing in the early 1970s at just over half 1960's level, while density declines into the 1980s.

FIGURE 2. Changes in density, transit use, driving, road capacity, and carlessness, 1960-2013



Why did transit use stop falling before density? Transit was helped when ,unicipal governments began taking over and investing in struggling private systems in the 1960s (Jones, 2010), and also helped because a core group of central cities that retained prewar built environments saw less conversion to automobiles. These cities—New York, Boston, Chicago, Philadelphia and San Francisco—then and now provided a core population of transit riders. But perhaps the more important takeaway from the graph is that density varies less with transit use than with the share of households without vehicles. Density fell along with the share of carless households, and stopped falling when the share of carless holds also stabilized. The low-density landscape is associated more strongly with the prevalence of vehicles than the absence of transit.

THE BURDEN OF OWNING, AND NOT OWNING, AN AUTOMOBILE

American automobility let drivers move more quickly, with fewer stops, to more destinations. But it also disadvantaged other modes of travel. Cul-de-sacs and circuitous street layouts made driving easier but walking and biking less so. Low-density zoning and abundant parking pushed buildings apart from each other and back from the street. Off-street parking placed asphalt between pedestrians and storefronts, and it required curb cuts that let vehicles intrude into sidewalks.

As early as the 1960s, researchers began recognizing that automobility's landscape was penalizing people who could not afford to drive (Kain 1968; Wachs and Kumagai (1973; Blumenberg and Manville, 2004). To a great extent these problems arose because the auto-centric landscape made public transportation, the main mobility option of the poor, less useful. As Myers observed in 1970, transit "does not start where [the poor] want it to start, and it often does not go where they want it to go" (1970:192). Over time the number of places in the United States where people could live easily without an automobile dwindled. People unable to afford cars had to locate in these places or lose mobility. Some evidence suggests that the poor concentrate in cities in part because cities tend to have better transit (Glaeser *et al*. 2008), but the quality of transit service varies across and even within center cities. Voulgaris *et al.* (2016) examined 30,000 2010 Census tracts, categorized them by their built environments and transit supply, and then measured the association between those categories and different travel modes. They found that one neighborhood type, which they called "Old Urban" (essentially a prewar built environment), accounted for a strongly disproportionate share of America's non-auto travel. But these neighborhoods were scarce. They were only 5 percent of US Census tracts, and half were in the New York metropolitan area.

Outside such areas, transit faced large obstacles. As it became less useful fewer people used it, and as fewer people used it bcame it less useful. Transit needs scale to be effective; the more it becomes an option primarily for the poor, the less effective it becomes, because most of the US does not have enough low-income people to support a transit system large enough to take the poor everywhere they need to go. This in turn makes automobiles still more attractive to low-income people (Myers 1968).

Figure 3 illustrates transit's declining utility to the poor. Using data from the Panel Study of Income Dynamics (PSID) and the US Census, the figure plots the diminishing correlation between individuals' income and the use of public transportation in their home census tract. The correlation is moderately strong and negative in the 1970s, suggesting that poor households located near, and used, transit. But it weakens considerably over time, and by 2010 is essentially zero.

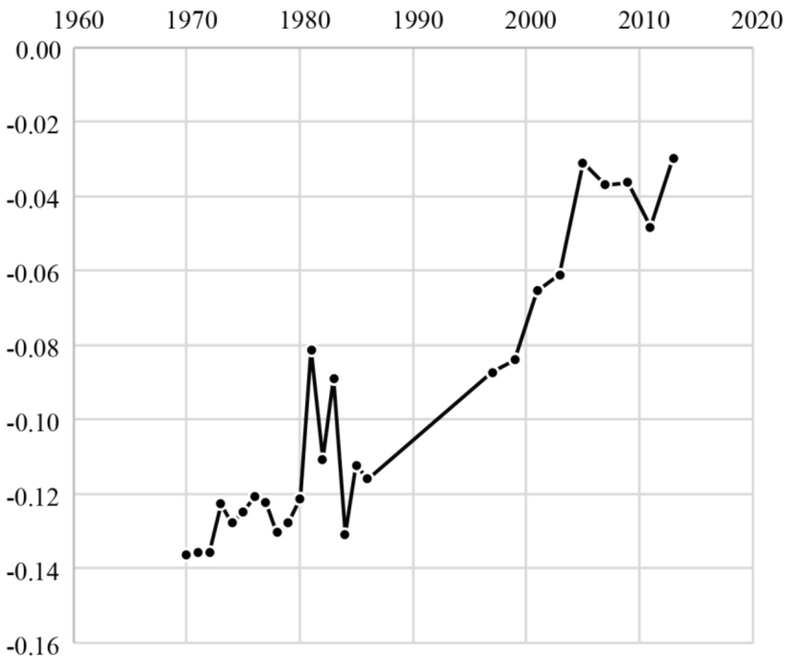
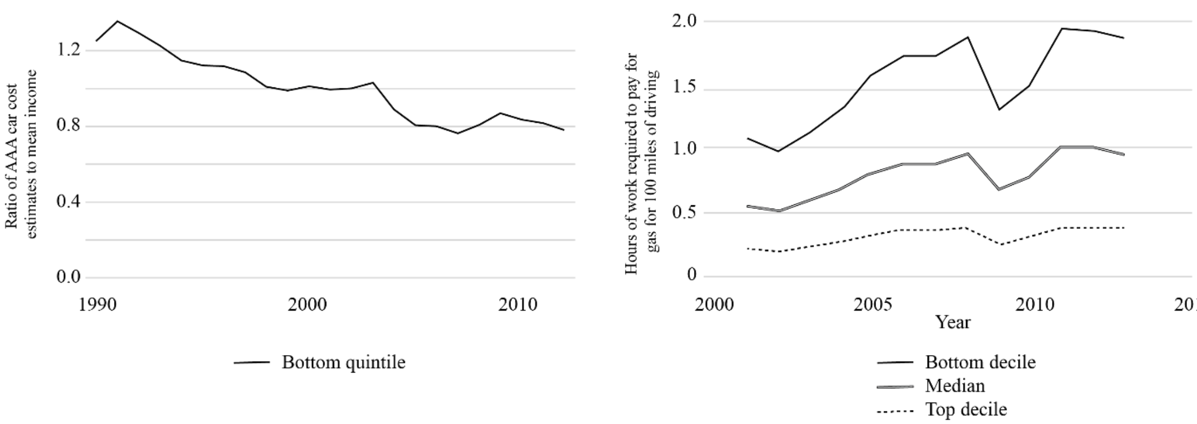


FIGURE 3. Correlation between income and transit commuting, PSID 1968-2013 and Census 1970-2010, ACS 2011-13

The increasing difficulty of using non-auto modes makes driving more important. Considerable evidence now suggests that automobile access improves outcomes for the poor (Cervero et al., 2002; Lichtenwalter et al., 2006; Pendall et al., 2015). But driving is also burdensome, because automobility is not just transformative but regressive. Accessing its advantages hinges on acquiring vehicles, insurance, and gasoline, the prices of which are set by markets rather than ability to pay.

Driving's regressivity is easier to conceptualize than to precisely measure, but all estimates of driving costs suggest that they disproportionately burden the poor (Rice, 2004; Smart and Klein, in press; Thakuriah and Liao, 2005). The best-known driving cost data come from the American Automobile Association (AAA), which has estimated driving costs annually since 1990. Panel 1 of Figure 4 shows the ratio of these annual costs to the mean income of households in the bottom income quintile. The ratio has fallen steadily, largely because driving costs have declined, but even at their lowest driving costs were 80 percent of mean income for households in the bottom quintile. For households in the top income quintile (not shown), in contast, driving costs are never more than 6 percent of average income.

FIGURE 4. (left panel): Ratio of AAA Annual Driving Costs to Bottom Quintile Mean Income; (right panel): Hours of Work Required at Median Income to Purchase Gasoline to Cover 100 Miles of Driving at Average Fuel Economy



Source: BTS, http://www.taxpolicycenter.org/statistics/household-income

One problem with such calculations is that driving costs are endogenous to income. Richer households drive more expensive cars further distances, and replace their cars more often. AAA assumes that households drive 15,000 miles annually, and purchase new vehicles every five years. Lower-income households almost certainly buy used vehicles, drive them less, and keep them longer. Rice (2004) accounts for some of this endogeneity, and calculates that in 2000 poor, low-income and higher-income families spent about $2,800, $3,600, and $7,100, respectively on vehicles; contemporary AAA estimates suggested an average cost of $5,500 (American Automobile Association, 2000).[vi]

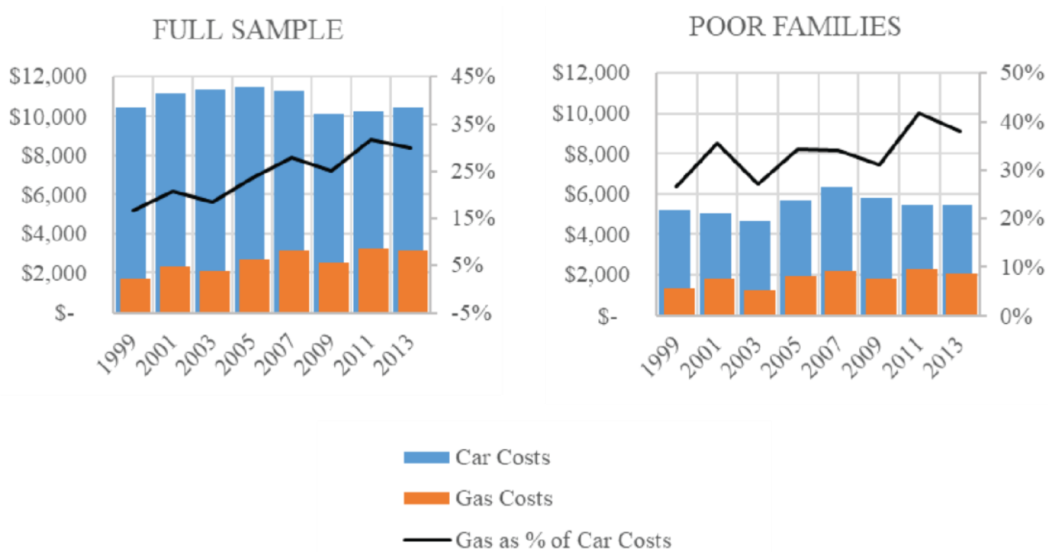
Per-gallon gasoline prices might provide a better window into driving's relative economic burden. Gas is a small part of total driving costs, but per gallon gas prices are largely immune to income-endogeneity. Most vehicles won't run without gas, and it is hard to save money by buying cheaper gas. Most vehicles take the same fuel, and the price difference between premium gas and regular (usually about ten percent) is far smaller than, for instance, the variance in vehicle prices or driving distances across households of different incomes.

Panel 2 of Figure 4 shows, for 2000-2015 and for three different points in the wage distribution (the top 10 percent, the median, and the bottom ten percent), the hours of work needed to buy enough gas to drive 100 miles in a vehicle of average fuel economy. The fuel burden is a function of both gas price volatility and the ability of wages to keep pace with that volatility. Workers in the top wage decile have high earnings that have kept pace with fuel prices, so their trend line is low and flat: over the course of 15 years they never have to work more than 27 minutes to earn the money necessary to drive 100 miles.

Workers in the bottom decile, in contrast, have lower and more stagnant wages, making them more vulnerable to fluctuations in fuel prices. Over these 15 years a bottom decile worker needed to work between 1-2 hours to afford 100 miles of gas. A median-wage earner needed to work between 30 minutes and an hour.

Figure 5, drawn from the PSID, shows that car-owning households economize more on vehicles overall than gasoline, reinforcing the difficulty of avoiding fuel costs. Among auto-owning families, poor families spend about half as much on cars than families overall, but gasoline is a larger share of costs for the poor. In 2013, for example, families overall averaged more than $10,000 in vehicle costs, and about $3,000 in gasoline. Poor families spent less than $5,000 overall, but almost $2,000 in gas, making gasoline almost 35 percent of total car costs.

FIGURE 5. Spending on cars for full sample and sample in poverty, PSID 1999-2013



THE DECLINING FORTUNES OF ZERO-VEHICLE HOUSEHOLDS

Table 1 uses data from the Survey of Consumer Finances, for select years from 1955-2013, to demonstrate the downward socioeconomic trajectory of households without vehicles. Vehicle ownership grew steadily over this time. Among households with automobiles, the ratio of vehicles to people almost quadrupled, from 0.21 in 1955 to 0.75 in 2013.

In real terms, the average value of a household vehicle (aggregate vehicle value divided by number of vehicles) vehicle grew relatively little over this time, from just under $9,000 in

1955 to just over $11,000 in 2013. Vehicles values grew most for households in the top income decile, and least for households in the bottom decile. The burden of vehicle ownership (expressed here as vehicle value's share of income)[vi] fell for all households, but most sharply for the highest-income households. The burden was also always highest for households in the bottom decile. Despite driving the lowest-valued cars, the ratio of vehicle value to income for bottom decile households was consistent 4-5 times the size of the ratio for car-owning households overall.

While the number of household vehicles grew steadily over this time, the share of households with at least one vehicle did not. The proportion of carless households fell from 29 percent to 13 percent between 1955 and 1977, but then plateaued. From 1977 forward it never exceeded 16 percent and never dipped below 12 percent.

This plateau occurred largely at the bottom of the income distribution. Even in 1955, over 90 percent of households in the top income decile had automobiles, as did 75 percent of households overall. Over three quarters of households in the bottom decile, however, did not. In the next 60 years, the middle three income deciles essentially converged with the top decile, as carlessness fell by 80 percent for the middle class. Carless fell among bottom decile households as well, but by 2013 45 percent of the bottom decile still had no vehicle. As a result, carlessness became more concentrated at the bottom of the income distribution. In 1955, the 75 percent of the bottom income decile households without an automobile accounted for 26 percent of the carless households in the nation. By 2013 the 45 percent of bottom decile households without an automobile—who were under 5 percent of US households—accounted for 41 percent of all zero-vehicle households in the country.

Household Vehicle Ownership By Income Bracket Over Time, Select Years					
Year	HHs	Vehicles Per Person (HHs with Vehicles)	Avg Value Per HH Vehicle	Ratio of Avg Vehicle Value to HH Income	Percent of HHs W/out Vehicles
1955	All	0.21	8,921	0.17	29
	Top Income Decile		13,855	0.09	6
	Middle 3 Deciles		7,585	0.25	25
	Bottom Income Decile		5,805	0.95	74
1961	All	0.19	nd		26
	Top Income Decile		nd		7
	Middle 3 Deciles		nd		17
	Bottom Income Decile		nd		77
1970	All	0.44	nd		18
	Top Income Decile		nd		5
	Middle 3 Deciles		nd		10
	Bottom Income Decile		nd		56
1983	All	0.63	11,185	0.09	14
	Top Income Decile		16,443	0.02	7
	Middle 3 Deciles		6,428	0.14	17
	Bottom Income Decile		6,764	0.78	56
1989	All	0.67	9,239	0.11	16
	Top Income Decile		30,000	0.01	6
	Middle 3 Deciles		8,674	0.14	5
	Bottom Income Decile		4,439	0.49	54
1998	All	0.72	10,915	0.13	14
	Top Income Decile		51,236	0.03	4
	Middle 3 Deciles		10,306	0.17	7
	Bottom Income Decile		5,873	0.66	47
2007	All	0.76	12,248	0.12	11
	Top Income Decile		47,469	0.03	2
	Middle 3 Deciles		11,784	0.19	4
	Bottom Income Decile		6,525	0.62	43
2013	All	0.75	11,359	0.12	12
	Top Income Decile		36,289	0.02	5
	Middle 3 Deciles		10,943	0.18	4
	Bottom Income Decile		7,074	0.71	45

Source: Survey of Consumer Finances. All dollars 2013

nd= no data (SCF did not collect vehicle value data)

While having a vehicle is no longer a sign of affluence, lacking one is an increasingly reliable sign of poverty. Households at the bottom of the income distribution became more likely to have cars, and households without cars became more likely to occupy the bottom of the income distribution.

As a consequence, the economic gap between households with and without vehicles has widened over time. Table 2, also drawn from the SCF, shows that in 1955, the median income of households with cars was just over twice that of households without them. By 1989, this ratio had doubled. Between 1989 and 2013 it shrank, but by 2013 households with vehicles had 3 times the median income of households without. Gaps in household net worth, meanwhile, were even larger. Households without vehicles generally do not carry debt (auto debt or any other kind), which in earlier years made gaps in net worth smaller (it also explains why median net worth in 1970 is zero for households with vehicles, as many were also carrying housing debt). But from 1955 to 2013 the median net worth of car-owning households grew over 5,300 percent, while growing 130 percent for those without.

The income gap between vehicle owners and household vehicles has grown more than the gap between homeowners and renters, or between households with and without college-educated adults. In 1955, homeowners had 1.2 times the income of median renters, while vehicle owners had twice the income of non-owners. In 2013 the ratio between owners and renters had grown to 2.3, meaning it had grown faster than the gap between households with and without cars, but it remained smaller proportionally. Similarly, in 2013 households where the householder had a BA or higher had 2.3 times the median income of other households, still smaller than the gap between vehicle-owning and zero-vehicle households (3.1 times).

The gap between households with and without vehicles is notable not just for being large, but for being driven by falling income at the bottom, not rising income at the top. The college-educated have diverged from the less-educated because even though both made gains, the gains of the educated were larger. In contrast, the median income of households without vehicles fell *absolutely* between 1955 and 2013. While households with vehicles saw their median incomes rise 36 percent over this period, households without vehicles saw it fall by 8 percent. Renters also saw their incomes fall absolutely (by 6 percent), but the gap between homeowners and renters grew primarily because homeowner median income grew by 80 percent.

TABLE 2.

Household Income and Net Worth by Vehicle Ownership, Selected Years

	HHs with Vehicles		HHs Without Vehicles		*Ratio*	
Year	Income	Net Worth	Income	Net Worth	*Income*	*Net Worth*
1955	38,721	1,960	18,759	313	*2.1*	*6.3*
1970	59,950	0	20,288	420	*3.0*	*0.0*
1989	54,681	113,190	13,198	904	*4.1*	*125.2*
2013	52,755	106,000	17,247	720	*3.1*	*147.2*
Pct Chg	*36%*	*5308%*	*-8%*	*130%*	*48%*	*2251%*

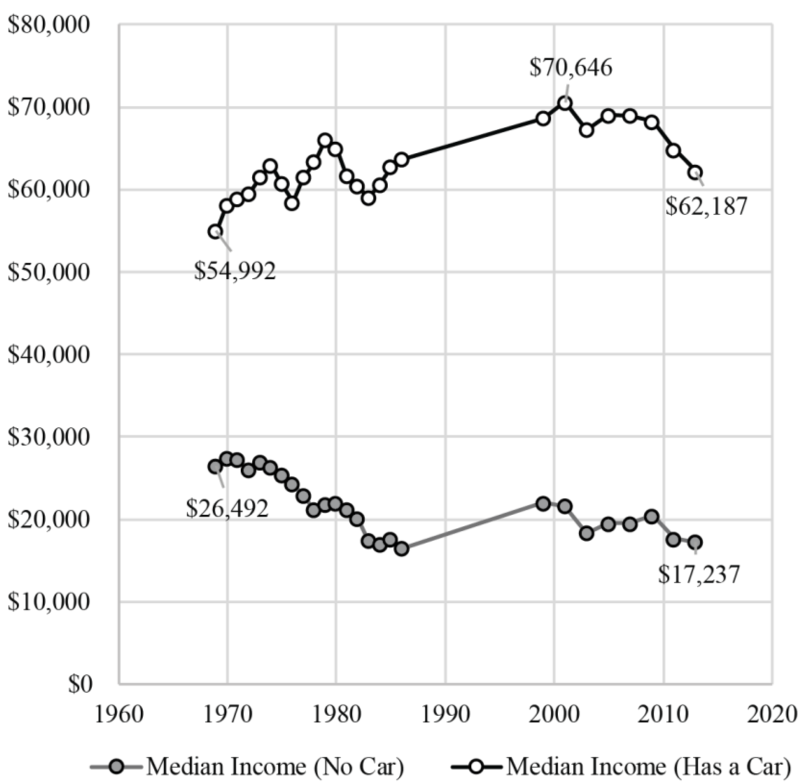
Income by Tenure and Educational Attainment

Year	Homeowners	Renters	BA	No BA	*Tenure Ratio*	*BA Ratio*
1955	35,414	29,112	55,091	31,047	*1.8*	*1.2*
1970	60,640	38,527	84,807	48,872	*1.7*	*1.6*
1989	60,337	24,512	75,422	37,711	*2.0*	*2.5*
2013	63,915	27,392	80,148	35,508	*2.3*	*2.3*
Pct Chg	*80%*	*-6%*	*45%*	*14%*	*27%*	*92%*

Source: Survey of Consumer Finance. All dollars 2013. Values are medians.

The falling real income of the carless is not an artifact of our starting point or our data set. If anything the SCF might understate the loss. Figure 6, from the PSID, shows that the median income of households with vehicles increased steadily through the mid-2000s, then declined with the recession. But households without vehicles saw their incomes steadily decline incomes from the late 1960s through the late 1980s. Incomes climbed in then 1990s, but never reached their pre-1970 levels, and then fell again. From the late 1960s to 2013 the income of the carless fell almost a third in constant dollars, to just over $17,000.

FIGURE 6. Median Income in 2013 Dollars of Families with and without Cars, 1969-2013 PSID



VEHICLES AND SOCIOECONOMIC STATUS IN AN OLDER BUILT ENVIRONMENT

If the falling socio-economic status (SES) of car-free households reflects selection pressure brought about largely by an auto-oriented built environment, then the fortunes of carless households should not have declined as much in places that did not adopt auto-oriented built environments. We can test this idea by examining New York City, which changed relatively little to accommodate automobiles. New York's population density was over 25,000 in 1950, over 28,000 in 2014, and in the intervening years its density never dipped below 23,500. Its streets are narrow, and both because of its old housing (even today almost one third of its housing stock was built before 1940) and its low minimum *and* maximum parking requirements, parking is scarce and expensive. Only 30 percent of New York's housing units include a parking space, compared to over 90 percent of US housing units overall (Manville et al., 2013). For an American city, in sum, New York has long been an extraordinarily difficult place to own an automobile.

Table 3 uses Census data from the Integrated Public Use Microdata (IPUMS – Ruggles et al 2017) to compare households without vehicles in the US, New York City, and the USA's second-largest city, Los Angeles. We use data from 1960-2014, but exclude 1970 because the IPUMS database does not provide city-specific data for that year.

The table shows, first, that carlessness is and has been more common in New York than elsewhere. While carlessness is rare in the US and LA, in every decade since 1960 over half of New York households have been vehicle-free. The table also confirms that since 1960 in the US the median household income of zero-vehicle households has fallen absolutely. (Since 1980, however, it has grown modestly). The same is true in LA. In New York, however, the median household income of the carless has *risen,* and is much larger absolutely ($36,600) than that of the carless in Los Angeles ($15,400) or the US ($17,900 – and if New York households are removed, the US median falls to $16,000).

TABLE 3.

Prevalence and Income of Zero-Vehicle Households, NY, LA and USA

	% HHs W/Out Vehicles			Median HH Income, Zero-Vehicle HHs ($2014)		
	NY	LA	USA	NY	LA	USA
1960	58	16	22	$32,760	$17,960	$17,995
1980	59	17	13	$25,859	$15,089	$14,952
1990	56	15	12	$34,209	$19,910	$16,290
2000	56	16	10	$35,620	$19,728	$20,284
2010	56	13	9	$35,738	$16,884	$17,976
2014	55	13	9	$36,600	$15,400	$17,900
	-0.07	*-0.24*	*-0.30*	*0.12*	*-0.14*	*-0.01*

Sources: American Community Survey and Decennial Census, IPUMS

Carlessness has a different character in New York, because driving is so expensive there. Compared to LA and the US, the poor in New York are *more* likely to be carless, but so too are the rich. Table 4 shows the relationship between zero-vehicle households and income distribution in these three places over time.

Zero-Vehicle Households and Income Distribution, 1980-2014

	Share of Households with Zero Vehicles in:					
	Top Ten Percent			Bottom Ten Percent		
	USA	LA	NY	USA	LA	NY
1980	1	0.3	4	44	35	17
1990	2	1	5	44	33	19
2000	3	2	6	37	27	17
2010	2	1	7	41	34	18
2014	2	1	7	41	37	18

	Top Decile HHs with Zero Vehicles			Bottom Decile HHs With Zero Vehicles		
Year	USA	LA	NY	USA	LA	NY
1980	1	0.4	20	38	47	85
1990	2	1.4	24	38	42	86
2000	3	4	30	31	42	80
2010	2	1.2	34	26	35	80
2014	2	1	35	26	36	80

Source: IPUMS

Compared to vehicle-free households in Los Angeles and the US, zero-vehicle households in New York are less likely to be in the bottom income decile and more likely to be in the top decile. Carless households in New York are 7 times as likely as those in LA to be in the top income decile, and less than half as likely to be in the bottom.

If we instead ask what share of the bottom income decile is carless, we see that carlessness is far more common among New York's poor: 80 percent of New York's bottom decile is vehicle-free, compared to 36 percent of LA's and 26 percent in the US overall. But carlessness is also more common among New York's rich: the city's top decile households are 35 times more likely than those in LA to be vehicle-free, and 17 times more likely than those in the US. Thus relative to the US and LA, New Yorkers are more likely to be carless if they are disadvantaged, but less likely to be disadvantaged if they are carless.

Is this really the result of New York's built environment? New York differs from the rest of the US in many ways, so the question is hard to answer. One clue, however, comes from Staten Island, the borough of New York that looks less like the rest of the city and more like a typical American place. Although Staten Island shares a government and labor market with the rest of New York, it has no subway connection, has much lower levels of density, and higher levels of vehicle ownership. Indeed, as Table 5 suggests, over the last 35 years Staten Island, in the level and trend of its density, car ownership, and share of people living in single family homes,. resembles Los Angeles more than the rest of New York.

TABLE 6.

Characteristics of the Built Environment , New York, LA, Manhattan and Staten Island, 1980-2014

	Population Density (Per/Sq Mi)			Share Detached SF Homes			Share HHs Without Vehicles		
	NYC	LA	Staten Island	NYC	LA	Staten Island	NYC	LA	Staten Island
1980	23,705	7,427	6,446	8%	39%	34%	56%	15%	18%
1990	26,403	7,877	7,588	10%	39%	34%	56%	16%	18%
2000	27,012	8,092	8,041	9%	39%	37%	56%	13%	18%
2010	28,056	8,383	8,108	9%	39%	34%	55%	13%	16%
2014	28,056	8,383	8,108	9%	39%	34%	55%	13%	16%

Source: US Census

By our logic, the fortunes of the carless on Staten Island should have declined more dramatically than those in New York as a whole. Table 6 shows that indeed they have, by comparing median household incomes by vehicle ownership on Staten Island to those on Manhattan, the New York borough least hospitable to automobiles. Recall in New York overall, the median income of the carless grew 12 percent from 1960-2014. On Manhattan, they more than doubled. This growth was slower than for Manhattan households with automobiles, but the key point is that zero-vehicle households improved in absolute terms, and since 1980 their income as a share of vehicle-owning households' income has not much changed, always hovering near half.

Median Household Income by Vehicle Ownership, Manhattan and Staten Island, 1960-2014						
	Manhattan			Staten Island		
Year	Vehicles	No Vehicles	*Ratio*	Vehicles	No Vehicles	*Ratio*
1960	37,760	31,760	*1.19*	48,680	32,040	*1.52*
1980	73,701	33,234	*2.22*	69,203	19,846	*3.49*
1990	108,600	47,241	*2.30*	86,430	26,498	*3.26*
2000	114,052	53,430	*2.13*	84,324	23,838	*3.54*
2010	117,379	56,924	*2.06*	87,526	21,186	*4.13*
2014	124,600	65,000	*1.92*	80,000	19,000	*4.21*
Pct Chng	*230.0%*	*104.7%*	*61.2%*	*64.3%*	*-40.7%*	*177.1%*

Source: US Decennial Census and 1-Year ACS Summary Files, IPUMS

On Staten Island, in contrast, we see a divergence between vehicle-owning and zero-vehicle households that more closely resembles the USA. Overall. Where vehicle-owning households saw their median incomes rise by 64 percent, the income of vehicle-free households fell by almost 41 percent. In 1960 households with vehicles had, on average, 1.5 times the median income of households without. By 2014 they had over four times the median income. Unlike the rest of New York, on Staten Island the fortunes of the carless fell both relatively and absolutely.

CONCLUSION

The same changes to America's society and landscape that have made driving easier have made *not* driving harder. Today lower income people must economize on transportation by traveling less frequently, less often, at lower speeds over shorter distances, or in lower quality vehicles. In a country organized around high-speed travel to spread-out destinations, any of these choices will create disadvantage.

A simple prediction from these facts is that over time households without vehicles will filter further down the income ladder. The increasing poverty of car-free households will be a both a result of their carelessness (they will not be able to participate fully in a society organized around private vehicles) and a cause of it (the income threshold at which people can afford automobiles will steadily fall, making the carless steadily poorer).

We ascertain that this pattern holds, and we provide strong albeit suggestive evidence that the built environment is a main factor in this filtering. The striking declines in SES that we see among the American carless as a whole are not evident in New York City, except in that part of New York City that looks most like the rest of America. Our findings reinforce the importance of the built environment as mediator between transportation and well-being. When the built environment is designed for cars, carlessness will be concentrated economically, and is a sign of disadvantage. When the built environment fosters multiple modes of travel, carlessness can concentrate geographically, and within those geographies the presence of an automobile might indicate affluence, its absence needn't indicate poverty.

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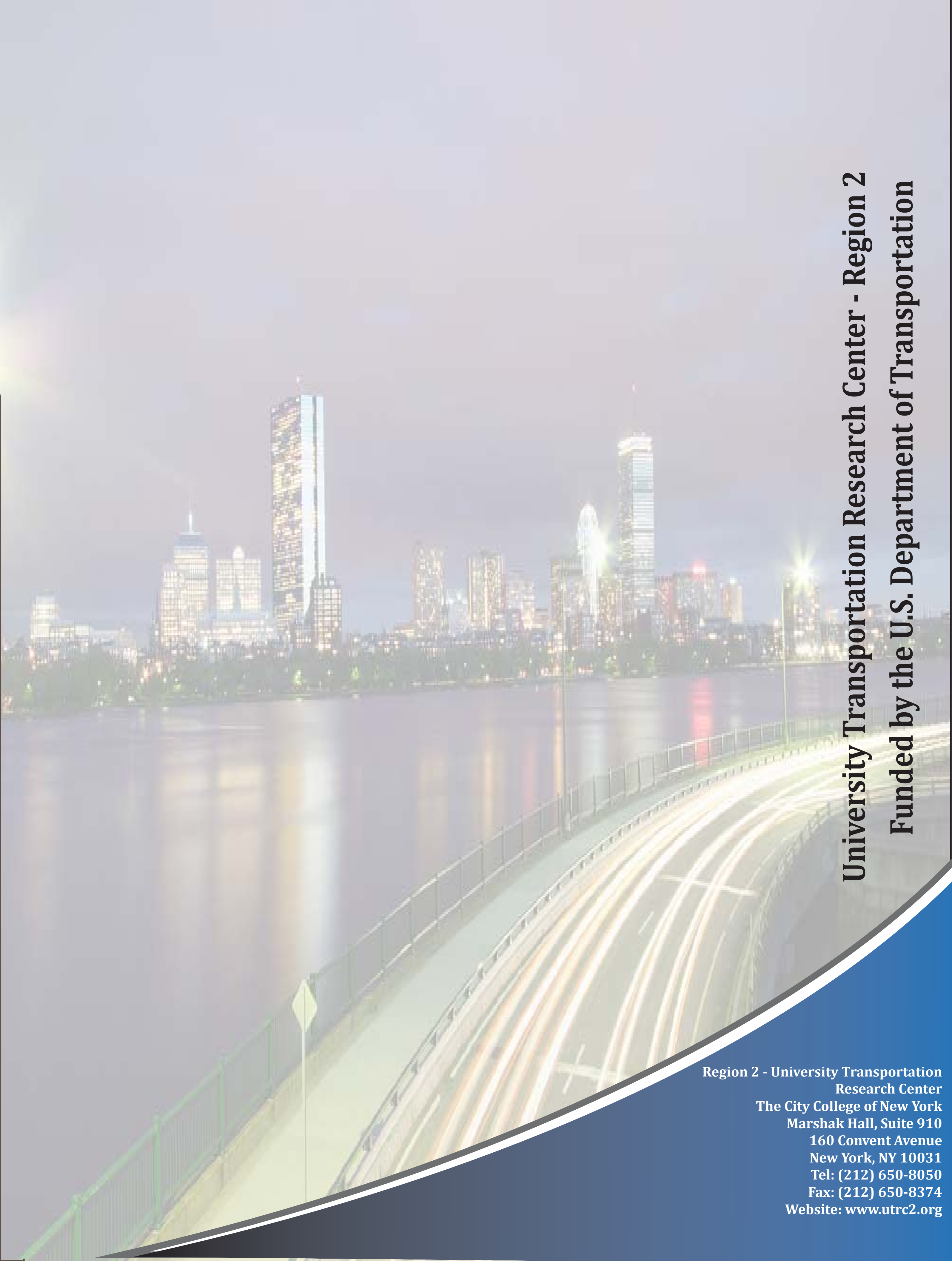

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