POLICY PROPOSAL 2019-03 | JANUARY 2019

THE HAMILTON PROJECT

Local Transportation Policy and Economic Opportunity

Matthew A. Turner

MISSION STATEMENT

The Hamilton Project seeks to advance America's promise of opportunity, prosperity, and growth.

We believe that today's increasingly competitive global economy demands public policy ideas commensurate with the challenges of the 21st Century. The Project's economic strategy reflects a judgment that long-term prosperity is best achieved by fostering economic growth and broad participation in that growth, by enhancing individual economic security, and by embracing a role for effective government in making needed public investments.

Our strategy calls for combining public investment, a secure social safety net, and fiscal discipline. In that framework, the Project puts forward innovative proposals from leading economic thinkers — based on credible evidence and experience, not ideology or doctrine — to introduce new and effective policy options into the national debate.

The Project is named after Alexander Hamilton, the nation's first Treasury Secretary, who laid the foundation for the modern American economy. Hamilton stood for sound fiscal policy, believed that broad-based opportunity for advancement would drive American economic growth, and recognized that "prudent aids and encouragements on the part of government" are necessary to enhance and guide market forces. The guiding principles of the Project remain consistent with these views.

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This policy proposal is a proposal from the author(s). As emphasized in The Hamilton Project's original strategy paper, the Project was designed in part to provide a forum for leading thinkers across the nation to put forward innovative and potentially important economic policy ideas that share the Project's broad goals of promoting economic growth, broad-based participation in growth, and economic security. The author(s) are invited to express their own ideas in policy papers, whether or not the Project's staff or advisory council agrees with the specific proposals. This policy paper is offered in that spirit.

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Abstract

This paper seeks to provide a solid empirical foundation for the policy debate surrounding transportation infrastructure funding. First, it provides a short description of the current condition and utilization of U.S. interstate highways, public transit buses, and urban rail cars. Second, it surveys what we know about how highway and transit usage responds to changes in infrastructure capacity or condition. Third, it describes what is known about how investments in highways and public transportation affect the organization, location, and level of economic activity in our urban and rural areas, and in particular, how these investments affect employment opportunities for the poor. Finally, it describes policies to improve mobility and reduce transportation costs that are suggested by this evidence.

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Introduction

There is broad agreement about the importance of transportation infrastructure, but disagreement about the goals of transportation policy and the appropriate means to achieve these goals. For example, the 2016 Democratic Party platform stated, "We need major federal investments to rebuild our crumbling infrastructure and put millions of Americans back to work in decent paying jobs in both the public and private sectors" (Democratic Party, 7). On the other hand, the Republican Party platform pilloried the Democrats for subordinating "civil engineering to social engineering as it pursues an exclusively urban vision of dense housing and government transit," while calling for a reduction in federal support for public transit (Republican Party, 5). This paper seeks to provide a solid empirical foundation for this policy debate.

First, this paper provides a short description of the current condition and utilization of U.S. highways, public transit buses, and urban rail cars. Second, it surveys what we know about how highway and transit usage responds to changes in infrastructure capacity or condition. Third, it describes what is known about how investments in highways and public transportation affect the organization, location, and level of economic activity in our urban and rural areas, and in particular, how these investments affect employment opportunities for the poor. Finally, it discusses transit policy reform options that are rooted in this analysis. The highway and bus transit systems are a particular focus, with congestion fees being one important mechanism for improving the performance of those systems.

While there may be partisan disagreement over whether U.S. transportation policy should favor rural automobiles or urban rails, there should be no disagreement over the desirability of infrastructure that people actually use and that reduces the cost of mobility. With this in mind, the evidence described here suggests the following conclusions about transportation policy.

1. Claims about the dilapidation of U.S. transportation infrastructure should be regarded with a critical eye. On average, the Interstate Highway System allowed for a smoother average ride in every successive year from 1993 until 2015 (the most recent available year of data), with rural interstates much better maintained than their urban counterparts. Similarly, the average age of the U.S. fleet of buses and urban rail cars was approximately constant from 1992 onward, although an average urban rail car is 22 years old.

This does not suggest a pervasive maintenance deficit. On the contrary, it suggests that current levels of investment approximately offset deterioration of transit vehicles and steadily improve the interstates. Blanket increases in infrastructure maintenance are probably not warranted. On the other hand, urban rail cars are old and heavily used, while the rural interstate is lightly used and is becoming progressively smoother over time. This suggests a decrease in spending on the rural interstate and an increase in spending on urban rail. As noted below, this analysis does not preclude the possibility of acute needs in particular areas or problems with specific bridges.

2. Claims about the ability of highways or transit to promote economic growth or economic opportunity for the poor should also be regarded skeptically. Highways and transit play an important role in determining where people live and work but probably do not much affect how productive they are or the probability that they are employed. Therefore, simply spending more on transportation infrastructure to increase economic opportunity, particularly for the poor, is unlikely to be cost effective. In particular, the available evidence suggests that the annual investment in subways required to cause a single low-educated worker to enter the workforce is at least equal to the income such a worker could earn and could be much larger.[1] However, transit policy reform could allow for more-efficient use of existing infrastructure, with potential benefits for low-wage workers.

3. Miles driven on the interstate have more than doubled since 1980. This has come with a corresponding increase in congestion. Available evidence strongly suggests that expansions of highway capacity lead to proportional increases in driving and do not reduce congestion, except over the very short term.

On the other hand, almost all segments of the interstate have excess capacity at off-peak times. Given that congested speed of travel is highly sensitive to the flow of vehicles, policies that reduce peak load slightly have large effects on the speed of travel. Experience with time-of-day pricing or congestion pricing suggests that such policies are promising ways to shift demand to less-congested times, thereby improving the overall performance of the transportation system. Further experimentation with these schemes is warranted.

4. Riders served by the U.S. fleet of motor buses stayed about constant between 1992 and 2017. During this same period the number of passengers served by urban rail networks and the Interstate Highway System both increased dramatically. Thus, buses are becoming relatively less able to attract riders over time. Policy should encourage experimentation with ways to administer bus-based public transit more effectively.

5. While the exact nature of our investments in transportation infrastructure should be subject to debate, the fact that current expenditures are considerably larger than gas tax and toll revenue means that much highway expenditure is financed with taxes on labor and capital rather than user fees. Covering a larger share of highway expenditure with the gas tax would reduce disincentives for work and thrift in the tax code while simultaneously reducing the implicit subsidy for driving.

The remainder of this paper is largely devoted to investigating the evidence for these five conclusions about transportation policy, followed by a summary of potential directions for reform, including bus transit reform, changes in highway funding, and congestion pricing. As policymakers consider these options, priority should be placed on experimentation and rigorous evaluation in order to generate evidence that can lead to better policy in the future.

Before we turn to this investigation, however, a few comments are in order. First, Conclusions 1 and 2 above are not arguments for any particular policy, but are primarily arguments against large classes of policies. If our object is to spend our transportation budget on infrastructure that people actually use and that reduces the cost of mobility, then blanket spending increases and policies based on unrealistic expectations about the effects of infrastructure are mistakes to avoid.

Second, experimentation with congestion pricing and with changes to the management of bus-based transit are complementary for three reasons: (1) The revenue from congestion pricing of busy urban roads is a natural source of funding for public transit. (2) By reducing peak-hour congestion, congestion pricing schemes speed the travel of buses, making them a more-attractive option. (3) By increasing the cost of peak-hour driving, congestion pricing will make it easier for transit to attract riders. Thus, congestion pricing should lead to an allocation of transportation resources in which drivers more nearly pay the congestion costs they impose on each other and more heavily used public transit can more nearly cover its operating costs.

Background: The Current Condition and Use of U.S. Interstate Highways, Public Transit Buses, and Urban Rail Cars

U.S. INTERSTATE HIGHWAYS

The Federal Highway Administration (FHA) keeps a careful annual inventory of the National Highway System (NHS) and records the resulting data in the Highway Performance Monitoring System (HPMS). These data provide a detailed description of the condition and utilization of the NHS each year from 1980 to the present, and are reasonably consistent over time, facilitating an assessment of highway infrastructure conditions.

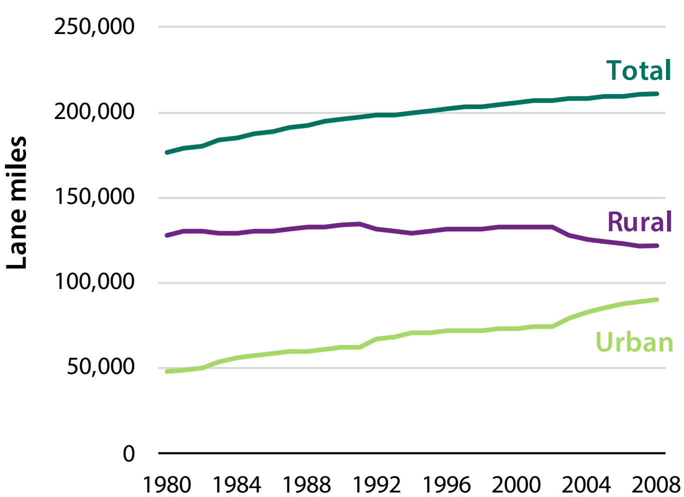
The NHS consists of roads that are important to the nation and are eligible for subsidies from the federal government. The set of roads in this class sometimes varies year-over-year as eligibility criteria are revised. The Interstate Highway System, however, is at the center of the NHS. It consists entirely of limited-access highways, built to similar specifications over time, that are always eligible for federal subsidies for construction and maintenance. This makes the system a preferred subject for analysis over time.[2]

Figure 1a reports total lane-miles of interstate highway—as well as urban and rural lane-miles separately—from 1980 until 2008. Although the Interstate Highway System was substantially complete by 1970, construction is ongoing and the extent of the network increased by about 15 percent from 1980 to 2008.[3] These plots show that urban portions of the interstate have become increasingly important over time, and that this is where the bulk of the new miles are located. This partly reflects the reclassification of previously rural segments as the boundaries of urbanized areas expand.

The HPMS requires that states measure and report the International Roughness Index (IRI) for each interstate segment. While the details of this index are complicated, it is intended to measure the inches of suspension travel an average automobile would experience while driving over a one-mile segment of roadway. Loosely, this is a census of potholes, and it provides a summary measure of highway infrastructure conditions.

FIGURE 1A.

Lane-Miles of the Interstate Highway System, 1980–2008

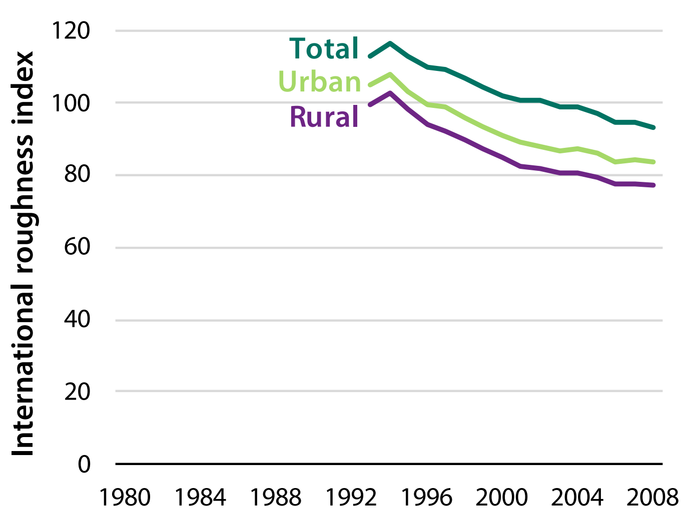


Source: Federal Highway Administration (FHA) 1980–2008; author's calculations.

Note: Data for 2009 are omitted due to issues with urban–rural classification.

FIGURE 1B.

Average Roughness of the Interstate Highway System, 1993–2008



Source: FHA 1980–2008; author's calculations.

Note: Data for 2009 are omitted due to issues with urban–rural classification. The series represent lane mile–weighted averages of the International Roughness Index (IRI).

Figure 1b reports (lane mile–weighted) average roughness for the whole interstate system, and for the rural and urban subsets.[4] That these plots decline over time indicates that the Interstate Highway System is getting smoother. This is true for both the rural- and urban-designated portions of the network, although rural highways are smoother than their urban counterparts. That is, maintenance of the Interstate Highway System is more than keeping up with depreciation, at least according to the main indicator that the FHA uses to measure its state of repair. This is a surprising finding, and so it is important to note that it describes only the interstate highways and not other roads or bridges.[5]

Whereas figure 1 reports on the extent and condition of the Interstate Highway System, figure 2 reports on its use. Figure 2a reports the lane mile–weighted average number of vehicles traversing a segment of the interstate on an average day, a measure known as average annual daily travel (AADT). This is a standard measure of the traffic volume experienced by the interstate system. Unsurprisingly, AADT shows a steady increase and about doubles between 1980 and 2008. Rural and urban traffic increases at about the same rate, but urban highways carry about twice as many vehicles per lane as rural highways.

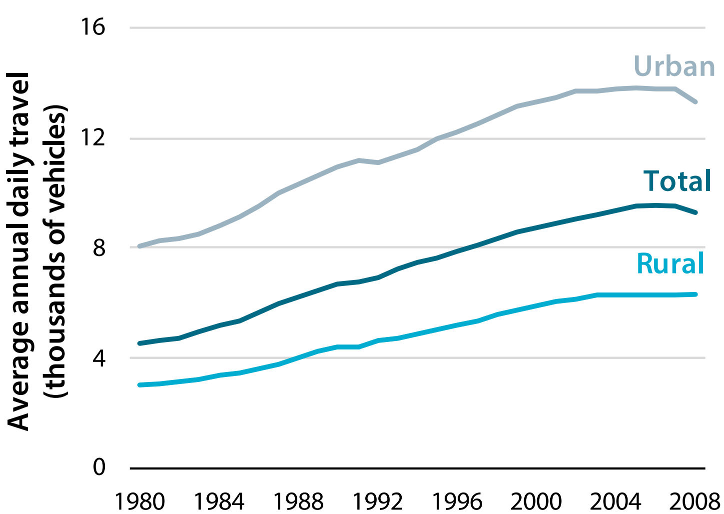
Figure 2b shows total vehicle miles traveled (VMT) on the interstate system and on its rural and urban components. This panel also shows a steady increase for both rural and urban highways. Changes in VMT reflect both changes in the number of vehicles carried by an average segment and changes in the extent of the network. Thus, VMT increases more rapidly than AADT. Note that the shorter urban interstate network carries a larger share of traffic than the longer rural interstate network.

At its maximum capacity, an interstate highway lane can carry about 2,200 vehicles per hour (Small and Verhoef 2007). Even if we restrict attention to the period from 5:00 AM to midnight, this means that each interstate highway lane can carry about 37,000 vehicles per day. By comparison, urban interstates near the end of our sample period reach AADT levels of about 13,000. Even this high level is less than 40 percent of the daily maximum capacity of these lanes during waking hours. In contrast, with an AADT of about 7,000, an average rural interstate lane-mile is operating at about 18 percent of its capacity of 37,000 vehicles per day.

As severe as highway traffic congestion may be, it is not strictly a problem of highway capacity: Daily rates of travel are well below the physical capacity of the interstate. Highway congestion is a problem of having sufficient capacity at peak times. Nearly all interstate highways have surplus, unused capacity at off-peak hours. Obviously, capacity at midnight is not a perfect substitute for capacity at 6:00 P.M. However, capacity at 7:00 P.M. is not so different from capacity at 6:00 P.M., and capacity at 8:00 P.M. is not so different from capacity at 7:00 P.M. Together with the fact that travel speed on a congested highway is highly sensitive to the number

FIGURE 2A.

Average Annual Daily Travel on the Interstate Highway System, 1980–2008

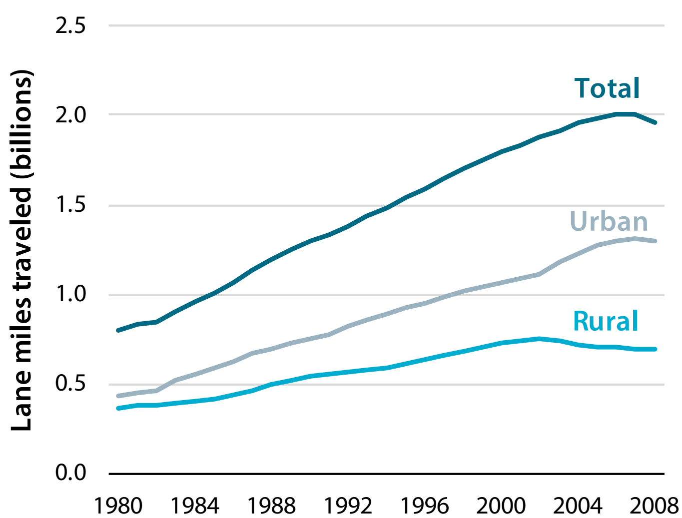


Source: FHA 1980–2008; author's calculations.

Note: Data for 2009 are omitted due to issues with urban–rural classification. The series represent lane mile–weighted estimates of average annual daily travel (AADT).

FIGURE 2B.

Vehicle Miles Traveled on the Interstate Highway System, 1980–2008



Source: FHA 1980–2008; author's calculations.

Note: Data for 2009 are omitted due to issues with urban–rural classification.

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of drivers using the road, this means that policies to spread travel out over the day, even slightly, can have large effects on congestion. Thus, policies to exploit slack, off-peak capacity deserve serious attention.

To sum up, maintenance of the Interstate Highway System seems to be keeping up with and exceeding depreciation, at least on average. Second, rural highways are in better condition than more heavily used urban highways. Third, the interstate is carrying much more traffic over time. Fourth, while peak-hour capacity may be congested, there remains much unused off-peak highway capacity, and diverting even a small fraction of peak-hour trips to off-peak times—or eliminating a small fraction of peak-hour trips altogether—would likely result in dramatic reductions in peak-hour travel time.

PUBLIC TRANSIT BUSES AND URBAN RAIL CARS

As the HPMS is the federal government's annual inventory of subsidized roads, so the National Transit Database (NTD) is the federal government's annual inventory of subsidized public transit. The NTD provides a detailed description of the operation of all large transit districts, and, in particular, of the number, age, and utilization of operational buses, light rail, and subway cars. This permits an analysis in the same spirit as was just provided for highways. In each year, we can calculate the size of the public transit vehicle fleet and its average age. We can also calculate measures of total ridership and utilization rates analogous to VMT and AADT for highways.

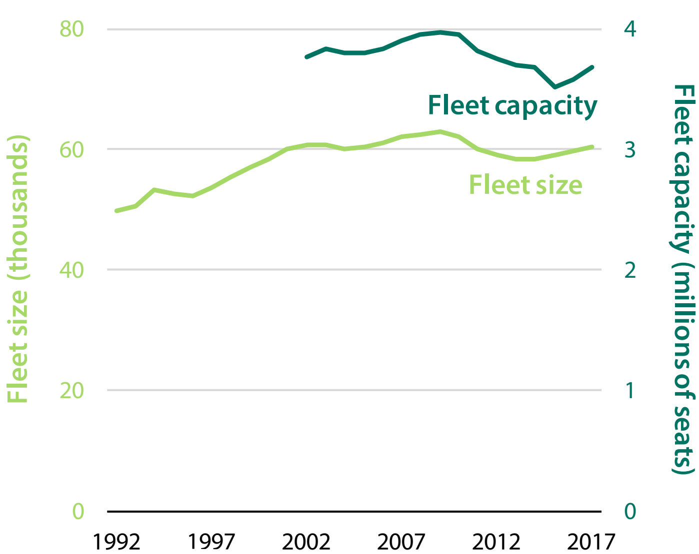
Figure 3a reports the number of operational motor buses in the U.S. by year in all full reporter transit districts.[6] The figure shows a uniform increase in the number of buses from year to year. Ultimately, the number of buses in service in 2017 is about 20 percent larger than the number in 1992. In principle, the capacity of the buses in operation in 2017 could be different from the capacity of buses in operation in 1992, so that simply counting buses may not be an accurate measure of capacity. To address this problem, figure 3a also shows the number of passengers that could simultaneously fit on the bus fleet in each year. That this line follows about the same path as the count of buses indicates that the capacity of an average bus in the U.S. fleet does not change dramatically over this period.

Figure 3b reports on the average age of a bus in the U.S. fleet each year. We see that the average age of buses in the U.S. fleet varies within narrow bands over the period 1992–2017, and decreases slightly over this period. While age is an imperfect measure of the condition of the fleet, this result does not suggest that the U.S. fleet of buses has deteriorated dramatically over this period. That is, investment in buses seems to be more or less keeping up with depreciation.

As with the highway system, it is helpful to examine how utilization has changed over time (figure 4). In figure 4a we see that total trips and total passenger miles provided are about the same in 2017 as they were in 1992, although they were somewhat higher in the middle of this period.

FIGURE 3A.

Size of Public Transit Bus Fleet, 1992–2017

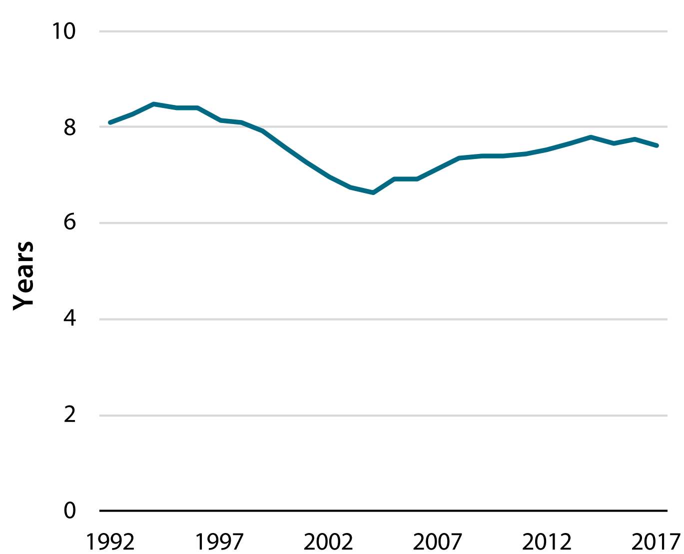


Source: Federal Transit Administration (FTA) 1992–2017; author's calculations.

Note: Data are restricted to full reporter districts. Fleet size is the aggregate count of buses. Fleet capacity is the total number of passengers that the total bus fleet can hold at once.

FIGURE 3B.

Average Age of Public Transit Bus Fleet, 1992–2017



Source: FTA 1992–2017; author's calculations.Note: Data are restricted to full reporter districts. Average age is fleet size–weighted.

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Figure 4b presents two measures of utilization. The first is the total number of riders served in a year divided by the total number of buses in service. This measure is approximately constant over the 1992–2017 period and indicates that an average bus provided about 80,000 rides per year, or 220 per day. The second measure of utilization, realized capacity, is an attempt to measure how much of bus capacity is actually used. It results from the following calculation: First, calculate the total number of passenger miles that the bus fleet could provide if all service miles operated at full capacity. Second, divide passenger miles traveled by this number. If the length of a typical passenger trip is constant over our study period, we expect the realized capacity share to track riders per bus closely. The fact that realized capacity is in the neighborhood of 0.2 indicates that for an average service mile, a bus in the U.S. fleet is at about 15 to 20 percent of capacity. Therefore, a typical 60-passenger bus carries just 12 people on an average service mile.

The NTD also reports on the U.S. stock of light and heavy rail cars, where heavy rail cars are typically subway cars. We consolidate these two classes into the term "urban rail." The NTD reports much the same information for urban rail cars as it does for motor buses. Figures 5 and 6 present information for the urban rail fleet analogous to what we see for buses in figures 3 and 4.

In figure 5a we see that the nation's stock of urban rail cars has increased by about a quarter over the period from 1992 to 2017, with total capacity tracking fleet size closely. The mean age of the urban rail fleet has fluctuated over this period, and is now, at 22 years old, near the top of its historical range (see figure 5b).

Figure 6 reports on utilization of the urban rail fleet. In figure 6a we see that ridership (i.e., average trips) and passenger miles track each other closely, and that both nearly doubled between 1992 and 2017. In figure 6b we see that utilization rates also increased over this period, and that an average urban rail car provided about 300,000 passenger trips in 2017 versus about 200,000 in 1992. Given this increase in ridership, that realized capacity rates stay about constant indicates that each urban rail car traveled further or that each rider traveled less far over time. As for buses, realized capacity is a bit below 20 percent.

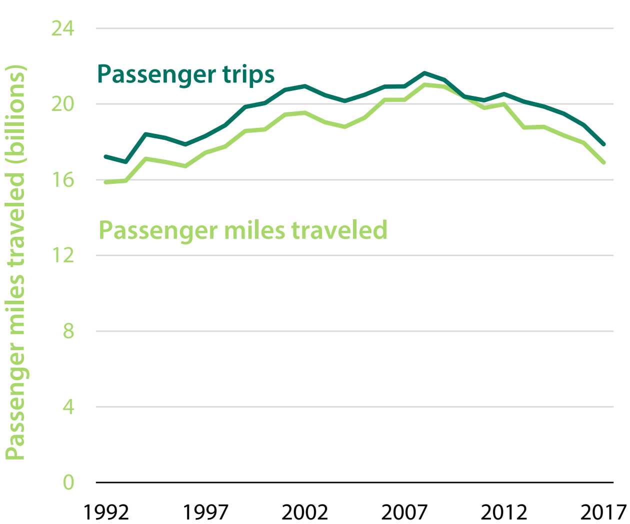
SUMMARY

Highways, Buses, and Urban Rail Cars per Person

Between 1990 and 2015, the population of the U.S. increased from about 250 million to about 320 million, or about 28 percent. During this same period, lane-miles of interstate and the bus and urban rail fleet increased modestly but did not keep up with the growth of population, and we now have somewhat less transportation infrastructure per person than we did in 1990. With this said, note that this analysis is narrowly concerned with the interstate, buses, and urban rail cars. Duranton and Turner (2011), for example, suggest that

FIGURE 4A.

Aggregate Service by the Public Transit Bus Fleet, 1992–2017

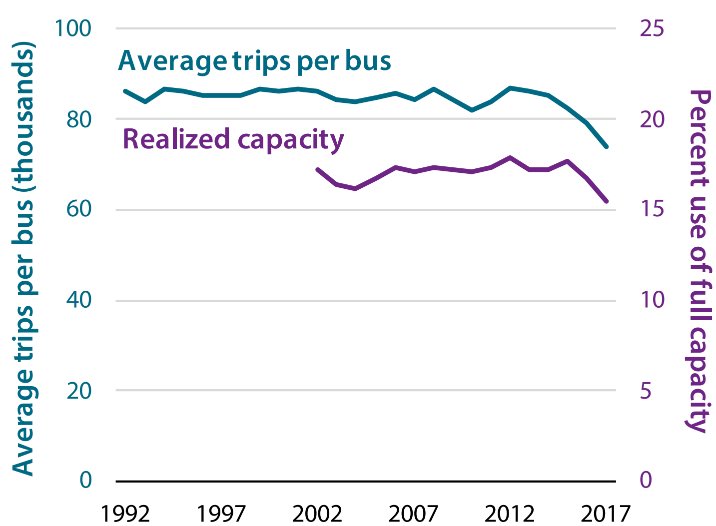


Source: FTA 1992–2017; author's calculations.

Note: Data are restricted to full reporter districts. Passenger trips represent unlinked passenger trips.

FIGURE 4B.

Utilization Rates of the Public Transit Bus Fleet, 1992–2017



Source: FTA 1992–2017; author's calculations.

Note: Data are restricted to full reporter districts. Realized capacity is calculated by dividing total passenger miles traveled by the potential total passenger miles traveled if all service miles are operated at full capacity.

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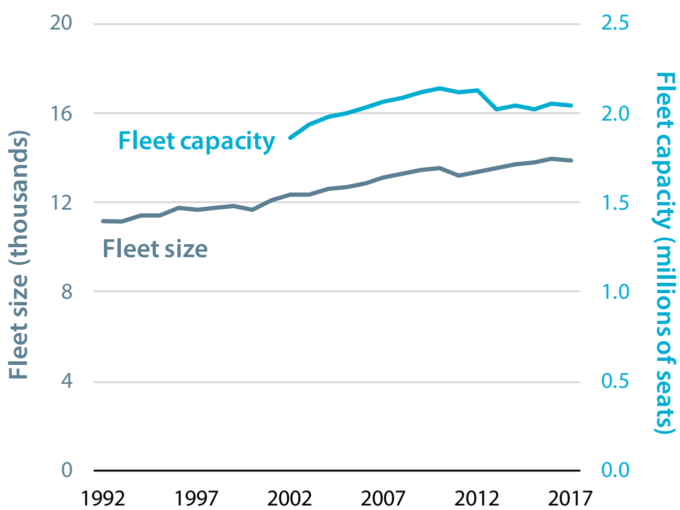
FIGURE 5A.

Size of the Urban Rail Fleet, 1992–2017

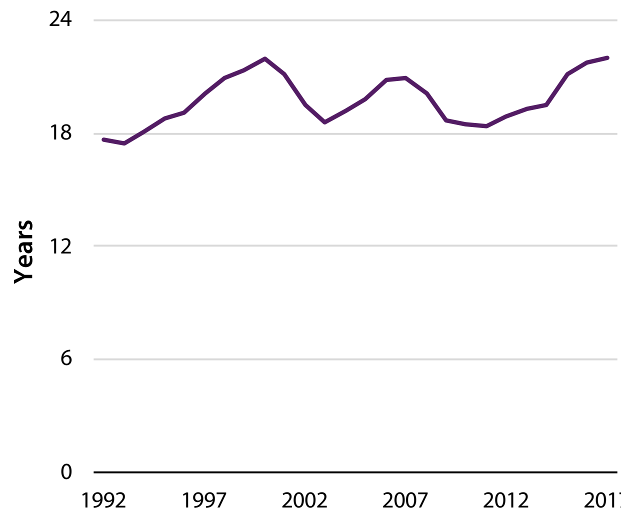


Source: FTA 1992–2017; author's calculations.

Note: Data are restricted to full reporter districts. Fleet size is the aggregate count of rail cars. Fleet capacity is the total number of passengers that the total urban rail fleet can hold at once.

FIGURE 5B.

Average Age of the Urban Rail Fleet, 1992–2017



Source: FTA 1992–2017; author's calculations.

Note: Data are restricted to full reporter districts. Average age is fleet size–weighted.

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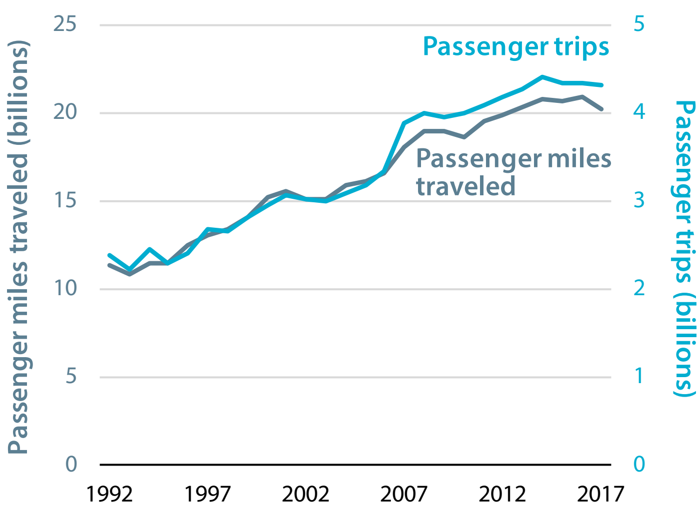
FIGURE 6A.

Aggregate Service by the Urban Rail Fleet

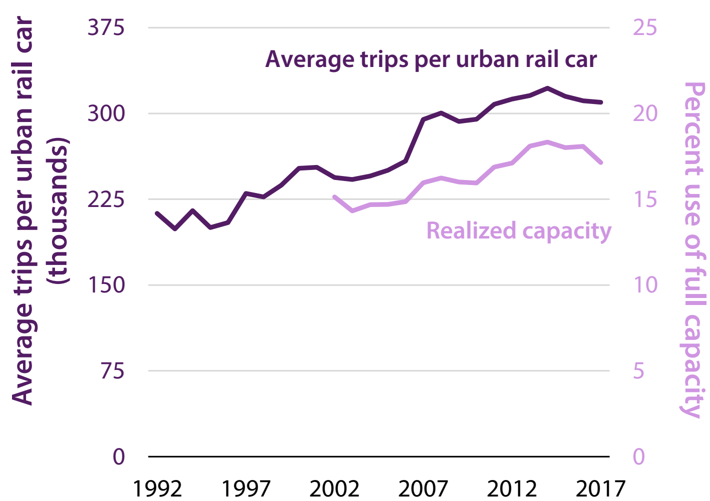


Source: FTA 1992–2017; author's calculations.

Note: Data are restricted to full reporter districts. Passenger trips represent unlinked passenger trips.

FIGURE 6B.

Utilization Rates of the Urban Rail Fleet, 1992–2017



Source: FTA 1992–2017; author's calculations.

Note: Data are restricted to full reporter districts. Realized capacity is calculated by dividing total passenger miles traveled by the potential total passenger miles traveled if all service miles are operated at full capacity.

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arterial roads and state highway mileage grew much faster over this period than did the interstate.

Condition of Highways, Buses, and Urban Rail

The Interstate Highway System became smoother over the period from 1993 to 2008 and appears to have become smoother still since 2008. On average, rural sections of the interstate are better maintained than urban sections. The average age of the bus and urban rail fleet has stayed about the same over the period from 1992 to 2017. On the basis of easily available indicators, there does not seem to be a crisis of maintenance for the interstate or of the national fleet of buses and urban rail cars. With this said, the average age of an urban rail car is 22 years and at least some subway systems suffer from a backlog of deferred maintenance.

Utilization Rates

The Interstate Highway System has carried more traffic each year since 1980 and an average lane-mile of highway now serves almost twice as many vehicles per day as it did in 1980. Throughout this period, the rural interstate carried about half as much traffic per lane-mile as did the urban interstate. Buses carry about the same number of passengers per day as they did in 1992 while the urban rail fleet in 2017 served nearly twice as many passengers as it did in 1992.

Wasted Capacity

Average annual daily travel (AADT) for the interstate has grown rapidly over the past generation. Even these high rates of use, however, are less than 40 percent of a plausible maximum for urban sections, and 18 percent for an average rural section. Unlike utilization rates for highways, utilization rates for buses have stayed about constant since 1992 at around 20 percent. For an average service mile, a typical 60-person bus carries about 12 passengers. Utilization rates for urban rail cars are now roughly at the same 15 to 20 percent rate seen for buses. An average urban rail car serves about 300,000 passengers per year, up from 200,000 in 1992.

The Challenge

Fundamentally, transportation projects—whether a highway, a subway, or a bus system—serve to reduce the cost of moving people and goods. Transportation policy and infrastructure investment can in particular shape where people live, where they choose to go to work, and across which locations trade occurs. This suggests the possibility of constructing transportation infrastructure to accomplish societal goals only indirectly related to mobility (e.g., fostering economic development or increasing economic opportunities for the poor). In the following pages we survey what is known about the consequences of transportation infrastructure on a number of important outcomes.

TRANSPORTATION INFRASTRUCTURE AND TRAVEL BEHAVIOR

Duranton and Turner (2011) find evidence for a fundamental law of road congestion. That is, interstate VMT in a city increase in direct proportion to increases in interstate lane-miles. Thus, a 1 percent increase in lane-miles causes a 1 percent increase in interstate driving over a time horizon of less than five years.[7] The authors are able to identify the causal impact of additional lane-miles by comparing places that were originally slated in the 19th century for more rail and highway infrastructure to those places that were not. In this way, Duranton and Turner avoid concerns that contemporary traffic congestion may lead to additional construction, thereby biasing estimates of the effects of construction.

In a related exercise, Couture, Duranton, and Turner (2018) explicitly address the extent to which increases in a city's stock of highways reduce travel times and find that the effect is small. Los Angeles illustrates this principle: It has been expanding its highway network in response to traffic congestion for many years with little effect on congestion.

Duranton and Turner (2011) also estimate the sources of the additional VMT. They find that about half of the extra driving results from changes in household driving behavior. As the highway network expands, people drive more. The remaining increase reflects increases in truck traffic, a small amount reflects travel by people drawn to a city because of the new highways (more on this below), and the rest reflects the diversion of traffic to the expanded highway network from other roads. Thus, while we can be confident that new highway infrastructure will be used, we can be almost equally confident that it will primarily serve vehicles that are not currently on the road. Thus, expansions of the road network should be expected to add to capacity (and to unused capacity) but not to reduce congestion.

This finding has an important implication for transportation policy. We should not expect that adding capacity to the road network will provide more than short-run relief from traffic congestion.

This is not to say that adding capacity to the road network does not have important and possibly beneficial effects on a city or region. The evidence for and against such effects is enumerated in the pages below.

Related to the evidence on effects of new road lane-miles, the evidence for the effect of public transit capacity on highway congestion is mixed. Duranton and Turner (2011) find that changes to a city's stock of buses or urban rail do not affect VMT over a five- to ten-year horizon. On the other hand, Anderson (2014) finds a large, if very short-run, effect of subway strikes on Los Angeles traffic. Subway construction should be regarded as a risky prescription for reducing traffic congestion.

Baum-Snow and Kahn (2005) examine how the share of commuters using public transit changed in 16 U.S. cities that added to their light rail or subway networks between 1970 and 2000. They document declines in the fraction of commuters using public transit over this period, even as the fraction of workers living within two miles of a subway line increased.

In contrast, in a sample of 77 cities from all over the world, Gonzalez-Navarro and Turner (2018) found that a 10 percent increase in the number of subway stations in a city resulted in about a 6 percent increase in ridership.

To reconcile the Baum-Snow and Kahn (2005) and Gonzalez-Navarro and Turner (2018) results, we note that urban populations in the U.S. increased dramatically over the 1970–2000 study period for Baum-Snow and Kahn. Thus, commute share using public transit could have decreased, even as ridership increased in a way consistent with Gonzalez-Navarro and Turner.

When considering new investments in rail transit, it is worth comparing the ridership response to subways to the driving response to roads. On the basis of Duranton and Turner (2011) we expect a 10 percent increase in metropolitan lane-miles of highways to cause about a 10 percent increase in VMT on these roads. On the other hand, on the basis of Gonzalez-Navarro and Turner (2018), we expect a 10 percent increase in subway system extent to cause about a 6 percent increase in ridership.

The relationship between expansions of bus service and ridership does not appear to have been documented, although Gonzalez-Navarro and Turner (2018) find that additional subway capacity has only tiny effects on bus ridership in cities that add to their subway networks.

TRANSPORTATION INFRASTRUCTURE AND ECONOMIC GEOGRAPHY

One of the most fundamental predictions of economic models of cities is that reductions in transportation costs spread people out across space. Given this prediction, we should expect that transportation infrastructure leads to cities that are less dense, even if metropolitan area population increases.

There is compelling evidence that this is the case. Baum-Snow (2007) examines the effect of the Interstate Highway System on the organization of U.S. cities between 1950 and 1990. During the period from 1950 to 1990, the aggregate population of central cities (holding constant their boundaries) declined by about 17 percent even as total metropolitan area population grew by about 72 percent. Taken together, these two statistics mean that the share of the urban population living in the old central cities declined from 48 percent in 1950 to about 23 percent in 1990. This was a time of rapid and fundamental change in the way that American cities were organized. Cities grew rapidly, even as their centers shrank.

The period from 1950 to 1990 coincides with the construction of the Interstate Highway System, which began in the late 1950s and was substantially complete by 1990. During this time, an average U.S. metropolitan area saw the construction of 2.6 interstate highways that traveled radially from the old center. While there are obvious questions about the extent to which cities would have decentralized in the absence of the highways, Baum-Snow (2007) finds that each radial interstate highway was responsible for about a 10 percent decrease in central city population. In a statistical sense, the Interstate Highway System is able to explain almost the entire decline in the population of an average metropolitan area's old center from 1950 to 1990.

This finding does not seem to be unique to the United States. Using a similar methodology, Baum-Snow et al. (2017) find that radial highways constructed in China between 1990 and 2010 played a similarly important role in the decentralization of China's cities during this time. Garcia-López, Holl, and Viladecans-Marsal (2015) find a similar effect for highways in Spain. Unlike Baum-Snow (2007), Baum-Snow et al. (2017) are able to track the decentralization of people and jobs separately. They find that the relationship between radial highways and manufacturing jobs was even stronger than the relationship between highways and residential location.

Indeed, Baum-Snow (2017) documents a similar pattern in the U.S. between 1960 and 2000. Not only did the Interstate Highway System cause a dramatic suburbanization of population, but it also led to a suburbanization of manufacturing jobs. In short, the Interstate Highway System appears to have played an important role in the suburbanization of U.S. cities. These findings highlight that these roads did not necessarily increase growth or activity, but rather moved population and activity to different areas.

The effects of subways on the spatial organization of cities is qualitatively similar to that of highways. Gonzalez-Navarro and Turner (2018) construct panel data describing all subway systems in the world, together with "lights at night data," to measure the location of population and economic activity within cities. They find that lights decentralize as subway systems expand, although the effect seems to be smaller than one would expect from radial highways with similar capacity.[8]

Finally, we note that transportation infrastructure also has important implications for how rural communities are organized. Chandra and Thompson (2000) consider two sets of rural counties in the U.S.: (1) those that received an interstate highway between 1969 and 1994 and (2) the neighboring counties. Chandra and Thompson examine the way that industry earnings in these counties varies during the approximately 25 years after highway construction. They find that rural counties that receive an interstate highway see a decrease in farm and retail earnings during the years after highway construction, but also see increases in manufacturing, retail, services, and government. Total economic activity in these counties increased. Neighboring counties experienced approximately opposite effects, and the aggregate effect on the set of highway counties and their neighbors is approximately zero. Thus, the Interstate Highway System led to a modest restructuring of rural America as well, shifting it toward the interstate.

TRANSPORTATION INFRASTRUCTURE AND INTERREGIONAL TRADE

While the ability of highways to decentralize cities is probably the best-documented effect of transportation infrastructure on economic geography, we can also be reasonably confident of a number of other effects.

Michaels (2008) conducts a similar exercise to Chandra and Thompson (2000), comparing counties that received interstate highway connections to adjacent counties that did not. However, instead of looking for changes in the level of economic activity, he looks for changes in the extent to which connected counties specialize in employing high-skilled or low-skilled labor. He finds that counties that initially had relatively high shares of high-skilled labor saw increases in the demand for high-skilled labor, with the converse true for counties that had high initial shares of low-skilled labor.

This result suggests that transportation infrastructure can facilitate greater specialization. To the extent that such specialization is regarded as one of the mechanisms behind economic growth, the result raises the possibility that transportation infrastructure could also facilitate growth. It indicates that the effects of transportation infrastructure on the organization of economic activity may be far-reaching, subtle, and difficult to value. Should we prefer a rural America drawn more closely to the interstate highways and with more-specialized rural labor markets?

Finally, two other papers point to the ability of highways to affect patterns of trade in subtle ways. In particular, on the basis of Chinese data, Baum-Snow et al. (2017) find that the construction of the Chinese highway network led to a concentration of people and economic activity in a small number of regional centers, at the expense of smaller satellite cities. That is, at the regional level, highways served to concentrate people rather than disperse them. Second, Duranton, Morrow, and Turner (2014) examine the effect of the interstate highways on trade between large U.S. cities. Interestingly, they find no effect on the level of trade, but do find an effect on its composition. Cities with more highways become relatively more specialized in manufactured goods with a low price per pound. This suggests that as a city improves its ability to move trucks around, it becomes more specialized in goods that rely more heavily on trucks to get to market.

On the basis of the literature discussed above, we expect cities to decentralize with more highways, rural economic activity to move closer to highways, and poor people to concentrate near urban bus or rail transit. Beyond this, there is evidence that highways have complicated implications for patterns of activity and specialization. This raises the possibility that transportation infrastructure can contribute to the level or growth of economic activity.

TRANSPORTATION INFRASTRUCTURE AND ECONOMIC GROWTH

While it is common for the proponents of particular infrastructure projects to claims they will create jobs and increase economic activity, the results described above should cause us to regard such claims with skepticism. Highways and other transportation infrastructure clearly have the ability to create economic activity in one place at the expense of some other place. It is less clear that this infrastructure increases overall economic activity.

A large literature addresses this issue. Duranton and Turner (2012) examine the relationship between the stock of interstate highways within a metropolitan area in 1980 and employment growth during the subsequent 20 years. They find that a 10 percent increase in lane-miles of interstate leads to a 1.5 percent increase in employment over the next 20 years. To the extent that modern econometric technique permits causal statements, this research indicates that the interstate caused employment growth.[9]

The effect sizes are relatively small in the context of cumulative employment growth, but large relative to other determinants of growth, like college attainment rates. On average, employment in a city in the Duranton and Turner (2012) sample grew by 2.8 percent per year over the course of their study period.[10] Thus, a 10 percent increase in the extent of the initial highway network is worth about six average months of employment growth over 20 years.[11]

On the other hand, highways are expensive, and we should be concerned that the benefits of highways justify their costs. Duranton and Turner (2012) attempt such an evaluation. It is well established that larger cities are more productive than smaller cities, and, after accounting for differences in worker characteristics, wages are about 3 percent higher when population is twice as large. This fact provides a basis for assessing the increase in income that results from highway construction. If a 10 percent increase in highways leads to a 1.5 percent increase in population, then this in turn leads to a 0.03 $\times$ 1.5 percent increase in average wages. Duranton and Turner (2012) show that this benefit is small compared to the cost of a 10 percent expansion of the highway network.

There is less evidence for the effect of public transit on economic development. A large literature documents that economic activity in cities shifts toward subways and light rail lines (e.g., Gibbons and Machin 2005, or Billings 2011). However, Gonzalez-Navarro and Turner (2018) is the only paper to investigate the effects of subways on urban growth in cross-city data. This paper is based on panel data describing all of the world's subway systems from 1950 to 2010, together with population data for these cities. It finds that changes in subway system extent have precisely zero effect on city population growth. Since we expect people to move to more-productive places, Gonzalez-Navarro and Turner suggest that, to the extent that subways affect the productivity of urban residents, this effect is small.[12]

BOX 1.

Transportation Infrastructure and Intercity Trade

Where Duranton and Turner (2012) considers the effects of interstate highways on the growth of cities, Allen and Arkolakis (2014) examine the value of increased intercity trade caused by the Interstate Highway System and compare this to the total cost of the interstate system. They find that the costs and benefits about match.

This is important, but comes with a number of caveats. First, and unsurprisingly, the Interstate Highway System was not constructed to connect random pairs of cities. It was constructed, in part, to construct industrial cities that wanted to trade with each other. Thus, relying on the estimates in Allen and Arkolakis (2014) to value the contribution of hypothetical expansions of the network requires that we connect pairs of cities that are similarly eager to trade. This is likely to be more difficult given the current extent of the network. Second, cost estimates in Allen and Arkolakis are dramatically lower than those developed by Duranton and Turner (2012). Third, the exercise undertaken by Allen and Arkolakis is fundamentally more difficult than that of Duranton and Turner. Where Duranton and Turner can examine patterns in the relationship between urban growth and highways from observations of many metropolitan areas, Allen and Arkolakis estimate the relationship between a national highway network and national income from a single cross-sectional description of the country's economic geography. Thus, their conclusions necessarily rely more heavily on model assumptions. With that said, the study by Allen and Arkolakis is probably the best available estimate of the value of the Interstate Highway System for intercity trade.[13]

TRANSIT AND THE POOR

Automobiles are expensive and make up a large share of income (Couture, Duranton, and Turner 2018), particularly for the poor. To the extent that proximity to transit allows poor people to forgo the purchase of an automobile, access to transit should be particularly attractive. This turns out to be true. On the basis of travel survey data for the U.S. in 1990, Baum-Snow and Kahn (2000) show that the poor are more likely to use public transit than the rich, other things held constant. Similarly, Glaeser, Kahn, and Rappaport (2008) and LeRoy and Sonstelie (1983) provide several historical examples in which the rich take advantage of a more expensive and faster mode of transit to put distance between their houses and those of the poor: Today, this faster, more-expensive technology is the automobile.

More concretely, Glaeser, Kahn, and Rappaport (2008) investigates the relationship between distance to the New York subway system (outside the borough of Manhattan) and income. They find that income in 2000 tends to be higher at greater distances from a subway line for places within two miles of a line. These results hold if one instead examines changes in subway access and changes in income. Pathak, Wyczalkowski, and Huang (2017) conduct a similar exercise around Atlanta's bus system. Like Glaeser, Kahn, and Rappaport (2008), they find that poor people in Atlanta moved to gain access to Atlanta's many bus lines. Interestingly, since many of Atlanta's bus lines traveled radially from central Atlanta, this led to a decentralization of Atlanta's poor.[14]

The evidence is clear that, holding other things constant, the poor are more likely to use transit than the rich. The evidence on the relationship between transit and residential choices is less clear. Stronger demand for transit by the poor leads them to, sometimes, but not always, outbid the rich for proximity to transit.

TRANSPORTATION INFRASTRUCTURE AND ECONOMIC OPPORTUNITIES FOR THE POOR

Understanding how public transit expansions affect low-wage workers is key to understanding whether such investments are merited. First, it is important to observe that low-income households are particularly dependent on public transit. Couture, Duranton, and Turner (2018) report that in 2008 an average U.S. household spent about $8,500 per year to buy, maintain, and operate an automobile. For an average household, this was about 18 percent of total household expenditure. In addition, as described above, poor people prefer to live in places where they are able to commute using public transit. Together, this suggests that increasing availability and reliability of public transit might significantly improve labor market outcomes for people who are poor enough that operating an automobile is prohibitively expensive. Indeed, evidence from the developing world shows that small subsidies for travel can result in large changes in labor market outcomes (Bryan, Chowdhury, and Mobarak 2014).

Pang (2017) examines the relationship between subway access and employment outcomes for low-skilled U.S. men.[15] Using these data, Pang compares changes in labor force participation (LFP) to changes in subway service. Across a variety of econometric specifications, Pang finds that a 10 percent increase in subways per 1,000 of working-age population is associated with about a 0.5 percent increase in LFP in his sample.[16]

With some care, we can use these estimates to calculate the cost of subway construction per low-skilled job created. From Pang's table 2, mean miles of subways per 1,000 working-age people is about 0.14 and mean miles of subway per city is about 130. Thus a 10 percent increase in subways involves the construction of 13 miles of subways and increases mean miles of subways per 1,000 population by $0.1 \times 0.14 = 0.014$. Pang's analysis suggests that increasing a city's stock of subways by one mile per 1,000 people increases the LFP rate for low-skilled men by 0.53. It follows that a 10 percent increase in subway miles increases the LFP rate by low-skilled men by about $0.53 \times 0.014 = 0.007$, which is just under 1 percent.

Again from Pang's table 2, with 130 miles in an average subway system and 0.14 miles of subway per 1,000 people, a sample average city must have about 1 million people.[17] In 2010, about 20 percent of the U.S. population had not completed high school. Applying this share to an average city in Pang's sample, we have that the low-skilled population of a sample average city must be about 200,000.

If a 10 percent expansion of a subway network increases the LFP for the low-skilled population by 0.007, then multiplying by the low-skilled population gives an increase in employment of about 1,400 people per city.

We have little systematic data on the costs to construct subway systems. However, Baum-Snow and Kahn (2005) provide our best evidence on this point. They find that for the U.S. between 1970 and 2000, construction costs per mile for subway systems ranged between about $45 million and $445 million (adjusted to 2018 dollars) per mile (Baum-Snow and Kahn; author's calculations). Thus, an average 10 percent subway expansion requires buying 13 miles of track at these prices, or something in the range of $580 million to $5.8 billion. If we imagine a metropolitan transit authority issuing interest-only bonds at 5 percent interest, then the annual capital cost of a 10 percent subway expansion is between $29 million and $290 million.

Dividing our estimate of annual capital costs by our estimate of increased employment, we have that subway expenditure causes low-skilled people to find jobs at a cost of between $20,700 and $207,000 per person. For reference, Pang reports that, in his sample, the average annual earnings for a low-skilled man is about $17,600 in 2018 dollars (Pang 2017; author's calculations).

That is, on the basis of the mean estimate of subway effects on employment and a low estimate of costs, the capital cost alone of a subway is about equal to the total wage bill for jobs created for low-skilled people.[18] Moreover, this calculation considers only the fixed investment associated with construction, and not operating costs or capital depreciation.

This calculation requires a number of comments. First, and as we saw above, there is evidence that poor people sort into housing with access to transit. To the extent that transit draws people who want to work, it means that poor people who do not want to work may be displaced. In this case, as LFP rises near transit, it falls elsewhere, and the calculations above overstate the effect of subways on LFP.

Second, Pang's results measure a city's stock of subways using subways per 1,000 people. This measure can increase because the city's subway network expands or, importantly, because its population decreases. Thus, it is equally fair to describe all of his results as being about cities that decrease in population. In fact, what he has shown is that cities that experience an increase in their subway network or a decrease in their population also see an increase in LFP by low-skilled workers.

In sum, Pang (2017) provides suggestive evidence that subways in U.S. cities contribute to LFP by the low-skilled population. However, the magnitude of this effect seems to be a relatively small contributor to the employment of the low-skilled population, and when measured against costs would likely not be a decisive consideration in the decision to build or extend a subway network.[19]

Pang's analysis focuses on low-skilled men. However, he also analyzes the effect of subways on LFP of low skilled women. He is not able to distinguish the effect of subways on their LFP from zero. While it is natural to speculate that subways may affect labor market outcomes for many demographic groups, there is at present, no evidence to support such speculation. Indeed, the finding in Gonzallez-Navarro and Turner (2018), that subways do not affect the growth rate of cities' population or "lights at night" suggests that, in fact, the effects of subways on total employment are also likely to be small. Focusing on only one type of benefit (employment changes) may miss the benefits of improved access or reduced travel times for those who would use the subway. Nevertheless, this calculation makes clear that new jobs or economic activity associated with low-skilled workers will probably not justify the investments on their own.

Directions for Improving Transit Policy to Enhance Access

This paper has argued that large-scale investments in transportation infrastructure have important implications for where Americans live and work. They may also be an expensive way to increase labor force participation by low-skilled men. If our goal is to increase economic opportunity, particularly for the poor, then our ability to achieve this with buses, roads, and subways is uncertain at best. However, there are other important avenues for transportation policy reform. Changes in policies related to bus transit, highway funding, and congestion pricing are all worthy of policymaker attention.

A core goal of these reforms should be to improve the reliability and effectiveness of the bus transit system, which disproportionately serves low-income workers. Proper management of congestion is complementary to this effort when it allows for a better-funded and more-reliable bus system.

BUS TRANSIT POLICY REFORM

Bus transit has lost ground as a transportation option in recent decades. Buses serve about the same number of riders today as they did in the early 1990s, while the overall population—and its use of the highway and rail systems—has grown considerably.

Moreover, buses in the U.S. are on average filling only about 20 percent of their capacity, as discussed above. There may be good reasons for this. For example, it may be that an objective of bus-based public transit is to provide coverage in particular areas whether or not riders are actually using the service in large numbers. This would tend to diminish the usage rates of bus transit. But even if coverage is a goal, transit authorities should try to fulfill such a coverage mandate in the most cost-effective way, and scope remains to improve the functioning and efficiency of bus transit.

One possibility for reform would be a requirement that all routes be reauthorized periodically (i.e., a route-by-route sunset condition) after a simple cost-benefit analysis. More generally, service levels could be subject to periodic cost-benefit auditing in order to trim lightly used routes and increase service where demand is higher. A range of transportation options may exist for people in underserved communities (e.g., rides on demand or smaller buses) that could accomplish coverage at lower cost. Another option is to restructure federal subsidies to increase the incentives for transit districts to attract riders.

In recent years bus authorities have experimented with a variety of operational reforms, from dedicated bus lanes (Basso et al. 2011), to traffic signals that adjust to accommodate buses (Schmitt 2018), to less-frequent stops (Bliss 2018). Carefully evaluating these changes would allow transit authorities to learn from each other and select improvements that can make buses more effective. This would disproportionately benefit the low-income workers who are more inclined to rely on them.

HIGHWAY FUNDING

The primary source of federal funding for the Federal-Aid Highway Program, which includes the interstate, is the Highway Trust Fund. Historically, this fund has been supported entirely by the federal gas tax and other user fees. This is no longer true. While the Highway Trust Fund continues to receive a substantial fraction of its revenue from gas taxes and user fees, it also receives income from general appropriations. Over the four-year period from 2013 to 2016, the average share of general revenue in Highway Trust Fund revenues was 39 percent (FHA 2013–16).[20]

Since general revenue largely reflects taxes on labor and capital, the current approach to funding the interstate system penalizes work and thrift in order to subsidize driving. Given that road capacity is often insufficient to meet peak-time demand, this state of affairs seems difficult to rationalize. Two natural solutions present themselves.

The first is to increase the gas tax. The federal gas tax has been constant at about 18 cents per gallon since 1997 (FHA 2013–16), and has therefore not kept up with inflation. Increasing it would provide a sufficient dedicated source of funding for the Highway Trust Fund.

A second option would be to reduce the federal subsidy to highway construction and maintenance, leaving more for the states to cover. Since states also charge taxes on gasoline, it seems likely that much of the increased share would be reflected in state gas taxes.

CONGESTION PRICING

Congestion pricing involves charging drivers for access to roads at congested times, when one individual's choice to take an additional trip imposes costs on other drivers. These schemes have been the darling of transportation economists at least since Vickrey (1963). The rationale for congestion pricing is transparent: highway capacity at peak hours is scarce while highway capacity at other times is underused. By pricing access at peak times, we provide drivers with an incentive to exploit wasted off-peak capacity, thereby improving travel times for drivers who are unable or unwilling to change their travel times.

Congestion prices have been implemented in many places, most famously in London, Singapore, and Stockholm. These programs have been carefully studied (e.g., Phang and Toh 2004; Santos and Shaffer 2004). Experience with these programs so far indicates that they are able to improve travel times, sometimes dramatically, often in response to modest time-of-day charges.

Congestion pricing and improvements to buses are complementary, particularly if the public transit system receives some or all of the revenue from congestion pricing. Among those who use private vehicles, congestion pricing is likely to fall more heavily on the poor; the poor are also more likely to use public transit. Thus, subsidies to transit would help to offset the financial burden that congestion pricing places on the poor. In addition, by speeding travel at peak hours, congestion pricing also speeds bus-based travel. Finally, by improving bus-based transit relative to automobiles, congestion pricing should lead to the greater use of buses. Greater bus ridership, in turn, can allow for a reduction in fares or in federal subsidies.

Questions and Concerns

1. How do we reconcile the recent revitalization of central cities with the decentralizing effects of highways and subways?

Evidence from the period after 2000 suggests that central cities in the U.S. are attracting college-educated young people away from the suburbs (Couture and Handbury 2017). We have less evidence for the role of the interstate on the population of central cities after 2000. This does not preclude the possibility that central cities are continuing to decline in total population and employment. It also does not contradict the finding that the Interstate Highway System was an important decentralizing force, at least through 2000.

2. Why do economists usually oppose light rail and subway construction?

Economists have long argued against subways and light rail except as a last resort. This argument follows from the high cost of building fixed-rail urban transport. The following example will illustrate this logic.[21]

In 2015 the city of Providence, Rhode Island, considered a short, light rail line. Construction of the track and purchase of the rail cars was forecast at about $100 million in all. The system was projected to carry about 2,600 riders per day. The city intended to finance the project with bonds that would pay 3.5 percent interest.

For the sake of illustration, suppose the city only paid interest on the cost of the system, and never paid down the principal. In this case, interest on the bonds would be $3.5 million per year. Now suppose that the system achieved its projected ridership and carried 2,600 riders per day for each of the approximately 250 workdays each year. In that case the system would carry about 650,000 people per year. Dividing the annual bond payments by the number of annual riders works out to about $5.40 per rider in interest—and this is before paying to operate the train or maintain the system. If the operating and maintenance costs of this system were the same as for Rhode Island's bus system, then those costs would be about $5 per rider. (The annual budget of Rhode Island's bus network is about $100 million and it carries about 20 million passengers per year.) Thus, the proposed system would likely have cost about $10 per rider. With a fare of $2 or $3, most of this cost would have come out of general revenue.

These calculations make clear why economists so often argue against light rail and subway construction projects. They are so expensive that ridership can only begin to cover construction and maintenance costs if the systems operate at close to their physical capacity most of the time; that is, if there are enough riders to fill up the cars when they run on two- to three-minute headways for many hours per day. Since most proposed projects do not meet this standard, economists generally argue against them. Buses can usually move the projected numbers of riders at a fraction of the cost.

3. Is congestion pricing regressive?

Probably, but not certainly. We know from Couture, Duranton, and Turner (2018) that when household income increases by 10 percent, total miles driven increases by about 2.5 percent. Rich people drive more than poor people, but the rate of increase in driving is about one fourth the rate of increase in income. Given this, we should expect that they will pay more in congestion tolls, but that the burden of congestion tolls will be a decreasing fraction of income. On this basis, our first guess should be that the burden of congestion pricing will fall relatively heavily on the poor.

We might expect two factors to work against this regressivity. First, we should expect that at least some of the burden of the congestion pricing scheme will be passed on to employers. If employers insist that their poor workers arrive at central locations at peak hours, then we should expect that they will ultimately need to pay these workers more than employers who do not require their workers to incur congestion tolls. Second, poor workers often have less control over their schedules than rich workers, and so have less ability to adjust their schedules in response to congestion. While congestions tolls may fall most heavily on these workers, so will the benefits of uncongested travel. Thus, the welfare implications of congestion pricing are more complicated than are questions about the incidence of the tax.

With this said, congestion pricing offers a way to reduce the amount of time Americans spend sitting in traffic as well as to reduce the need for costly peak-hour highway capacity. These are important gains, and using toll revenue to subsidize transit service should help to offset the likely regressive nature of the congestion tolls.

Conclusion

Infrastructure spending plans motivated by a desire to increase economic output or improve economic outcomes for the poor should be regarded with skepticism. There is ample evidence that highways and transit cause dramatic changes in the geography of economic activity. The evidence that it increases the overall level of economic activity is more difficult to find and suggests effects that at most offset construction costs and are likely much smaller.[22]

Moreover, interstate road surfaces are in better shape than they were a generation ago and seem to be improving steadily. Lightly used rural highways are smoother than more heavily used urban highways. Bus and urban rail fleets are no older than they were in 1992, though the urban rail fleet is quite old. Shifting expenditure from the lightly used rural interstate to more heavily used urban infrastructure should improve the infrastructure that is most in demand.

There does not seem to be a pervasive crisis in infrastructure maintenance. There are surely potholes, old buses, and decrepit rail cars, but this situation is not obviously worse than it was 20 years ago. In fact, there are fewer potholes on the interstate. At least for the three narrow categories of infrastructure examined here—highways, buses, and rail transit—investment is about matching or exceeding depreciation. Proponents of big expansions in maintenance spending should be required to show that current expenditures are not keeping up with depreciation.

However, a number of transit policies merit reform. Bus-based mass transit is one particular focus. In a period when travel on highways and urban rail both more than doubled, buses continued to serve about the same number of riders. This is not because every bus was already running at capacity. On the contrary, on a typical service mile a bus in the U.S. is only about 20 percent full. There may be good reasons for this. For example, it may be that an object of bus-based public transit is to provide coverage (i.e., access to bus transit everywhere) all the time. In that case, we would naturally expect buses to be lightly used. On the other hand, even if this is an object of policy, this should be stated explicitly, and we should expect transit districts to try to fulfill such a coverage mandate in the most cost-effective way.

In the absence of an obligation to provide coverage, we should acknowledge that bus-based mass transit has a problem and experiment with ways to fix it. Possibilities include the requirement that all routes be reauthorized periodically (i.e., a route-by-route sunset condition), that federal subsidies be restructured to increase the incentives for transit districts to attract riders, or that bus routes and service levels be subject to periodic cost-benefit auditing in order to trim lightly used routes and increase service where demand is higher.

The interstate system today carries about three times as much traffic as it did a generation ago. Given this obvious indicator of success, a natural response to traffic congestion would seem to be more construction. In fact, we have good evidence that such construction elicits more driving in equal proportion to the added capacity and hence does not relieve congestion. On the other hand, while highways are often congested at peak hours, they usually have unused capacity off peak. Congestion pricing offers a way to shift demand from congested peak hours to slack off-peak hours. While such programs remain relatively rare, they have been tried in a number of places with good results. That is, modest charges for peak-hour travel redistribute demand sufficiently to cause big improvements in peak-hour mobility without the enormous expense of capacity expansions. Experimentation with congestion pricing programs should be a policy priority.

Congestion pricing and improvements to buses are complementary. Public transit is a natural beneficiary of the revenue from congestion pricing. Congestion pricing is likely to fall more heavily on the poor, while the poor are more likely to use public transit. Thus, subsidies to transit should help to offset the financial burden that congestion pricing places on the poor. In addition, by speeding travel at peak hours, congestion pricing also speeds bus-based travel. Finally, by improving bus-based transit relative to automobiles, congestion pricing should lead to the greater use of buses. Greater ridership, in turn, can finance a reduction in fares or in federal subsidies.

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Endnotes

1. There may be additional benefits beyond increased employment, or benefits to other groups, but the available evidence on employment outcomes suggests limited tangible benefits.

2. The Interstate Highway System is also more carefully monitored by the HPMS than are less-important roads and highways. Analysis of the rest of the road and highway system should be possible, but would reflect the inferior data available for these other roads.

3. Beginning in 2011, the HPMS shifted to a geographic information system (GIS)–based database. Over the subsequent few years most states began to report, for example, mileage of on-ramps and off-ramps and interchanges that had previously been omitted. In 2009 and 2010, HPMS reporting was partially or totally incomplete. Given this, the post-2010 HPMS is not strictly comparable to earlier years. Consequently, figure 1 stops in 2008, although a plot of interstate IRI post-2010 continues to decline.

4. Note the following data limitations reflected in figure 1b and subsequent related figures. First, reporting of IRI begins in 1992 and the raw data suggest that some states took a few years to learn how to collect and report these data. The jump in IRI from 1993 to 1994 may be an artifact of these problems.

5. Note that Hartgen, Fields, and San Jose (2013) performs a similar analysis and arrives at a similar conclusion.

6. The NTD imposes different reporting requirements on transit districts according to their size. In particular, districts that operate more than 30 buses are full reporters and face more-stringent reporting requirements than do smaller districts. As a practical matter, they are also less likely to miss a year of reporting and tend to stay in the NTD system for longer. Full reporters constitute about 88 percent of the total bus fleet in 2017.

7. This finding has been replicated for Japanese cities in Hsu and Zhang (2014) and for European cities by Garcia-Lopez, Pasidis, and Viladecans-Marsal (2017).

8. It is important to note that the decentralizing effect of subways and highways should be understood as operating on the margin. In the absence of modern transportation technology, we might expect modern cities to look more like U.S. cities at the beginning of the 20th century. That is, cities would be smaller with centrally located employment surrounded by very dense housing, mostly within walking distance. Highways and subways make possible the unprecedented size of modern cities precisely because they allow people to spread out, and the data show that marginal improvements to highway and subway infrastructure facilitate this process, even though they do not seem to cause large influxes of people.

9. Duranton and Turner (2012) test whether the growth rates of cities are affected by the size or highway endowments of their neighbors. This would be the case if cities with large endowments of roads grew at the expense of other cities. They find no evidence for this effect.

10. We note that Garcia-López, Holl, and Viladecans-Marsal (2015) replicate the same basic research design as Duranton and Turner (2012) using Spanish data, and arrive at similar estimates for the effects of highways on urban growth.

11. A one standard deviation increase in metropolitan highways is about 15 percent. Such an increase leads to about a 4.2 percent increase in employment. This is a little less than two thirds of a standard deviation in the urban growth rate. Urban employment and population track each other closely in this sample, so highways cause a similar increase in urban population. In contrast, Duranton and Turner (2012) calculate that a one standard deviation–increase in the share of college graduates in a municipality contributes about one fourth of a standard deviation of population growth.

12. Gendron-Carrier et al. (2018) find that subway openings have a small, but economically important effect on air pollution in a sample of about 40 primarily Asian and European cities. Their data includes two U.S. cities, Las Vegas and Seattle. For these two cities, they are able to examine changes in particulate levels around the time of the subway opening. They find no effect on particulates in Seattle and about a 6 percent decrease for Las Vegas.

13. There is also a literature that examines the relationship between state highway spending and state GDP, e.g., Aschauer (1989) and Leduc and Wilson (2013). This literature is surveyed by Gramlich (1994). Unlike the applied micro literature described here, these papers sometimes find large effects of investment on growth, but sometimes they do not. While this macroeconometric literature is generally more favorable to the hypothesis that highway investment has large effects on growth, the results remain mixed.

14. Gordon and Wilson (1984) examine ridership on an international sample of light rail systems and find that ridership increases in density and decreases in income. However, the evidence for the relationship that poor are disproportionately attracted to public transit is subject to question. For example, Mayer and Trevien (2017) shows that it is the relatively wealthy who live near transit in Paris, while Billings (2011) shows that land prices increase near a newly constructed light rail system in Charlotte, North Carolina.

15. Pang (2017) assembles census data describing labor force participation (LFP) from 1990 to 2014 by working-age men who did not complete high school. In addition, he uses the NTD to ascertain the miles of track in each of these years, in each of the 12 U.S. cities with a subway. From Pang (2017), these cities are Los Angeles, Oakland/San Francisco, Miami, Chicago, Boston, New York, Baltimore, Jersey City, Cleveland, Philadelphia, Atlanta, and Washington, DC.

16. More specifically, for a sample of men who did not finish high school in these 12 cities, Pang conducts an individual level regression of an indicator of labor force participation (LFP) on subway miles per 1,000 of working-age population for the individual's city of residence, and 12 city fixed effects. Because this regression includes city-specific fixed effects, the estimated effect of subways on LFP results from comparing changes in LFP over time to changes in subway service over time.

17. That is,

$$\frac{130\ miles}{0.14\ miles/1{,}000\ people} \sim 0.93m$$

This is smaller than the average population of the 12 subway cities under consideration and appears to reflect just working-age population.

18. The cost per job estimates rely on the mean estimate of the effect of subways on LFP. This mean estimate is 0.504 (Pang 2017 Tab. 3, Pan. A, Col. 1). The 95 percent confidence interval for this point estimate is [0.13,0.87]. That is, we cannot reject the possibility that the effect of subways on LFP is as small as 0.13. This means that we cannot reject the possibility that subways create only about one third as many jobs as the cost estimate above is based on.

19. It is also important to note that the direct effect of public transit construction on employment is also likely to be small. The share of a typical dollar of highway spending that goes to wages is only about 0.22 (e.g., Larson 1990). Most spending on highways goes to raw materials and machinery. Similarly, Garin (2016) finds that stimulus spending on highways following the 2008 financial crisis (under the American Recovery and Reinvestment Act of 2009 [ARRA]), had a very small effect on employment.

20. The share of revenue provided to the Highway Trust Fund from general revenue was 17 percent in 2013, 35 percent in 2014, 16 percent in 2015, and 61 percent in 2016.

21. This example is taken from Turner and Mehotra (2015).

22. One caveat is required here. There is pretty good evidence that highway expansions increase the population growth rate of U.S. cities. Thus, to the extent that we expand the highway network, doing so in high-wage cities will lead to a shift in population from lower-wage places to higher-wage places. This should lead to increases in the average wage. This is the same basic intuition developed in Shoag (2019).

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Highlights

In this paper, Matthew Turner of Brown University examines the current state of U.S. infrastructure and explores the implications of infrastructure investment for the organization, location, and level of economic activity in urban and rural areas. He proposes different reforms that focus on improving mobility and reducing transportation costs for the highway and bus transit systems.

The Proposal

Explore policy options to improve the functioning and efficiency of buses. Evaluating bus routes and shifting service toward those with high demand could make the public transit system function more effectively while relying on other measures to insure coverage.

Increase the federal and state gas tax to make it a sufficient source of funding for the Highway Trust Fund. This would reduce the share of Highway Trust Fund revenues that come from general revenue, thereby diminishing the implicit subsidy to driving.

Implement congestion pricing. Pricing transportation access at peak times provides drivers with an incentive to exploit unused off-peak capacity, thereby improving travel times for both public transit users and drivers. Such plans also generate revenue that can be used to upgrade transit.

Benefits

The available evidence suggests that large-scale investments in transportation infrastructure may be an expensive way to increase economic opportunity. However, policy changes that focus particularly on improving the reliability and effectiveness of the bus transit system would disproportionately serve low-income workers at a modest expense. Proper management of congestion would also help to connect workers with economic opportunity.

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