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Is Infrastructure Spending Like Other Spending?

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Although infrastructure is a key input into economic growth, there is very limited systematic evidence on variation in infrastructure costs across over space and time. In this paper, we review what evidence exists on the drivers of infrastructure costs. We then turn to a specific example—the Interstate highway system—to understand how some of these drivers work in action. Specifically, we document spatial variation in the cost of US infrastructure, focusing on the cost of constructing one new mile of Interstate highway over the period of major Interstate development. The variation in spending across states is large. If states spending over the median had limited their expenditure per mile to that of the median state, the Interstate system would have cost about $260 billion, or 40 percent less, to build. We also investigate whether the pattern of spatial variation in Interstate spending per mile is similar to that of other locally important spending; similarity may indicate common cost drivers. The coefficient of variation for Interstate spending per mile is about four times that of Medicare per enrollee and twice that of Medicaid per enrollee. Variation in Interstate spending conditional on geographic cost drivers remains larger than that of publicly provided healthcare. In a multivariate framework, Interstate spending per mile, net of geographic controls for cost of construction, is most strongly statistically related to Medicare spending per enrollee. An additional $1,000 in Medicare spending is associated with $1.3 million more dollars in Interstate spending per mile. Income and other demographic factors partially mediate this relationship.

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Infrastructure—capital investment in roads, water, school facilities and sewerage—is a key input into economic growth (Munnell, 1992). Economic historians credit infrastructure investments with large increases in social welfare. For example, Beach et al. (2016) show that large-scale water purification in the US in the first part of the twentieth century decreased mortality and meaningfully increased human capital formation (see also Ferrie and Troesken (2008) and Cutler and Miller (2005)). Duranton and Turner (2012) find that the large capital investment in the Interstate system yielded broad-based increases in employment. And Allen and Arkolakis (2019) argue that large welfare gains are possible with improvements to selected segments of the Interstate system.

But these benefits are available only infrastructure is buildable at reasonable cost. Despite the importance of infrastructure, there is very limited evidence on how much individual pieces of infrastructure cost and on whether any components drive the bulk of costs. While there is frequently contemporaneous coverage of specific instances of high cost infrastructure—New York City's new subways, Boston's big dig, or California's high speed rail—without systematic evidence it is hard to evaluate whether these projects are well-publicized outliers or typical expenditures (Goldman, 2012; Barro, 2019; Varghese, 2019). The limited evidence in the literature suggests that costs are rising. Looking at the construction sector as a whole over the last 70 years, Swei (2018) finds limited evidence of real growth in materials prices, but substantial growth in labor costs. Brooks and Liscow (2019) find that the cost to build a mile of Interstate highway tripled between the 1960s and 1980s. Mehrotra et al. (2019) find that this trend continued for both new Interstate construction and Interstate maintenance from 1980 onward.

This increase in costs may explain the much-decried state of US infrastructure, even while spending has stayed fairly constant. At the dawn of the Interstate system, the US spent just over 2.5 percent of GDP on infrastructure; it now spends 2.3 percent of GDP on infrastructure

(Congressional Budget Office, 2018).[2] Considering only new capital investments, the US in 2016 spends about the same per capita as it did in 1956: slightly more than $530 per person (2017 dollars).

If per-unit infrastructure costs increase, the same amount of spending translates into quite a bit less physical capital to facilitate trade or improve human capital. There is a general belief that the quality of US infrastructure is low. The American Society of Civil Engineers consistently gives US infrastructure a failing grade (American Society of Civil Engineers, 2017). However, there is substantial variation in quality across type. While US commercial rail is in good shape, US passenger rail quality is low (McBride, 2018).

In this project, we first discuss the state of the literature on the drivers of infrastructure cost, discussing the extant evidence on the six major cost drivers: we focus on infrastructure for hllist them here; then finish up paragraph.

We then focus on infrastructure for which we can consistently measure cost over time and space: the US Interstate system. New Interstate construction is particularly useful because a new mile of Interstate is at least uniformly defined over time and space. While all highway miles are certainly not exactly comparable, comparisons across different types of infrastructure, or even the same type of infrastructure at different levels of depreciation, are even more fraught. In related work, we analyze the temporal variation in Interstate spending from 1956 to 1993 (Brooks and Liscow, 2019). Here we focus on two related research questions. Is there substantial geographic variation in per mile Interstate spending? And does the spatial variation in Interstate spending correlate with any other fiscally important spending? The answer to the latter question is particularly intriguing, as it may hint at cost drivers at work in infrastructure and beyond.

For this analysis we assemble novel data on the cost of the US Interstate highway system from the Federal Highway Administration's *Highway Statistics* yearbooks. We combine these

[2] These figures are federal and state and local expenditures together.

data with the date of mileage completion (Baum-Snow, 2007) to calculate spending per mile (as in Brooks and Liscow (2019)). We use multiple spatial data sources to calculate population density, slope and wetlands and rivers by Interstate segment to control for the differential physical costs of constructing segments. We also assemble private spending on construction and healthcare, as well as public spending including Medicare, Medicaid and state and local government general spending.

Putting these data together, we find that there is substantial spatial variation in spending per new Interstate mile, even conditional on geographic covariates that determine cost. The coefficient of variation in Interstate spending is about twice as large as that of Medicaid in 1991, and about four times as large as that of Medicare. Furthermore, this coefficient of variation for Interstate spending per mile is markedly larger in the period of Interstate construction from 1971 to 1993. Of all the types of spending we analyze, Medicare spending per enrollee is is most strongly statistically related with spending per new Interstate mile net of geographic covariates. Each additional $1,000 of Medicare spending per capita (mean $5,650) is associated with an additional $3.4 million dollars in Interstate spending, or about 20 percent of mean spending per mile.

The first section of our paper presents background on the Interstate highway system. The following section discusses the relevant literature on Interstate spending and potentially related public spending, teeing up questions for analysis. We then present the data we use, followed by the statistical analysis. The final section concludes.

1 Interstate Construction

Though in plan since at least the 1940s, the Interstate System formally began with the Federal-Aid Highway Act of 1956. This Act authorized a roughly 41,000 mile system to be built out over what contemporaries estimated to be a 13 years at a cost of $25 billion, or

$192 in 2016 dollars. In reality, Interstate construction was not complete until much later, with the vast majority of miles completed by 1993. The total cost exceeded $504 billion (2016 dollars). (We provide a summary of the program here; for more complete details, see Brooks and Liscow (2019).) All states have at least some Interstate miles.

The Interstate construction program was a federal-state partnership. For each new mile of Interstate—our focus in this paper—the federal government paid 90 percent of the cost;[3] states bore the remaining ten percent. States were required to build roads up to "Interstate standards." This set of standards meant two lanes in each direction, full control of access, a design that yielded a minimum speed of 50 miles per hour and that would support the projected traffic in 1975 (a requirement later changed to be projected traffic 20 years after completion). The Interstate program was administered by state departments of transportation, which put projects out to bid. States varied in the bidding systems they used (Pietroforte and Miller, 2002, p. 429).

In practice, states had broad latitude in ordering the segments they built, and at what expense. However, the funding structure caps the amount states can spend in any one year. Even if highway construction exceeded the minimum limits set by the federal government, states would still be reimbursed, though expenses were subject to approval by federal regulators. In each year of the program, the revenue available for highway spending came from the gas tax. The federal government split the gas tax revenue among states in proportion to the estimated cost of completion of remaining highway miles. Thus, states had to choose between constructing quickly at lower spending per mile, or slowly at higher spending per mile.

The pace of construction slowed as the program aged. Most states built the bulk of their miles in the first two decades of the program; the 1950s and 1960s saw 60 percent of total miles constructed. States built another thirty percent of system mileage in the 1970s and

[3]There were some exceptions for different types of specialized programs.

they built the remaining ten percent in the 1980s and early 1990s.

2 What Drives Spending?

In this section, we first review evidence on the major drivers of infrastructure costs, and then turn to literature specific to our comparison of Interstate spending and other public spending.

2.1 What Does the Literature Conclude About Cost Drivers?

this section is not complete. I've put previously written parts in here that we intend to put together

There are many potential drivers of variation in Interstate spending. We divide the likely drivers of variation into seven categories (as listed in McKinsey Global Institute (2013)):

1. Technical explanations
    - Design standards, the type and location of projects, and materials costs
2. Bidding and procurement
    - These include the extent of market concentration in the construction industry and procurement institutions.
3. Labor Costs
4. Regulatory Environment
    - These include environmental regulation, litigation threat, eminent domain costs.
5. Political institutions
    - Jurisdictional fragmentation
    - Common or civil law
6. Project management
    - Management quality

- Economies of scale

Looking prospectively, Winston (2013) highlight a number of technology innovations—most important among them the driverless car—that have the potential to decrease cost.

here we would expand on these topics. We also plan to discuss the work of the hard-to-pronounce guy whose last name starts with Bj...

In related work, we focus on the temporal variation in Interstate spending (Brooks and Liscow, 2019). We find that from the beginning of Interstate construction to the end, states increase spending per new Interstate mile by about three times in real terms. This increase remains economically meaningful even conditional on the difficulty of highway construction. In exploring the drivers of this cost increase, we find that neither labor nor materials prices increase in any meaningful way over the period, meaning that they cannot drive the temporal increase.

We do find that the cost increase—which begins in earnest in the early 1970s—is consistent with the rise of "citizen voice," which we define as the set of legal and statutory opportunities that began in this period for citizens to give voice to their demands to the government (see related argument in Altshuler and Luberoff (2003) and Glaeser and Ponzetto (2018)). These include, but are not limited to, a Supreme Court decision that gave those dissatisfied with agency implementation the right to sue and the passage of additional legislation, such as the 1969 National Environmental Policy Act that gave citizens more opportunities to challenge government choices.

2.2 What Creates Geographic Variation in Spending?

Outside of some popular press profiles, there has been very limited work on the geographic variation in infrastructure spending. *New York Magazine* profiled New York City's new transport infrastructure and found that for the same amount of money, New York gets "four new miles of tunneled LIRR [Long Island Rail Road] route and one new terminal station" while "London will get 14 miles serving seven stations" (Barro, 2019).[4] Equally eye-popping, Gordon and Schleicher (2015) find that the US leads the world in the cost of building new rail. These authors rule out a number of obvious suspects for these high costs: land, labor costs, and a decentralized system of infrastructure creation. The Reason Foundation also provides a state-level ranking of road spending, which highlights the declining quality of US road infrastructure, along with its increasing costs (see, for example Feigenbaum et al. (2019)). At a recent Transportation Review Board convening, a top Federal Highway Administration (FHWA) official acknowledged that while FHWA monitors spending, it does not keep track of costs on a per-project basis needs cite.

In contrast to the temporal variation we examine in Brooks and Liscow (2019), we focus here on cross-state variation. In particular, we ask whether the geographic variation in Interstate spending is correlated with geographic variation in the largest categories of public spending. Such patterns of correlation can give us insight into what cost drivers of spending are. If they are features unique to Interstate spending, this suggests something specific about the details of the program. If, instead, states are high spenders across a number of categories, this points to either institutions or cultural factors that are state specific.

Spending is the product of the price per unit and the quantity of units. Our focus throughout the rest of this paper is on per-unit spending, particularly the cost of building one Interstate mile. Importantly, because we focus on government spending, there can sometimes be restrictive limits on the type of output—for example, a minimum number of lanes of Interstate, or a minimum pavement thickness—that require a minimum quantity of inputs.

Over one-half of total government spending consists of education, health and pensions. Broadly, economists believe that institutions play a crucial role in determining state spending levels (see review in Besley and Case (2003)). Ideology also plays a role in spending decisions,

[4] Rosenthal (2019) presents a similar example in the *New York Times*.

and empirical work suggests that ideology plays a greater role as income increases (Pickering and Rockey, 2013). But, to the best of our knowledge, there is no overarching economic model for explaining levels of government spending.

To gain a better handle on the comparison of spending across types, we begin by looking at how much leeway local governments have in spending decisions across these three types of spending.

Rank ordering these major categories of spending by federal control would have pensions as the most stringently federally controlled, followed by health—first Medicare, followed by Medicaid—and then education. US federal pensions—Social Security—are a mechanical function of federal rules and worker contributions. Therefore, while we do expect geographic variation in pension spending, it is driven entirely by formulaic decisions, and not by the decisions of local government officials, or even local lobbies, who have no role in determining Social Security payments. For this reason we do not include Social Security expenditures in our empirical work.

Federally funded health care does have some regional input. Decisions about coverage and reimbursement to Medicare, the federal program of health care for those over 65, are entirely federal. However, patients purchase care in a local market, and the prices they face in that market and the type of care they receive generate geographic variation. In addition, Medicare reimbursement rates vary regionally. In contrast, the Medicaid program, which provides states with block grants to provide healthcare to the poor, allows for state decisions about whom to cover and to a lesser degree what to cover.

Finally, education spending in the US is almost entirely based on local decisions. Local governments—frequently school districts—make decisions about teacher salaries and facilities virtually without regard to federal preferences, and without substantial federal subsidy. States do frequently work to equalize within-state spending, but there is no oversight body that works to equalize per student spending across states.

Where does Interstate spending fit in this pattern of federal control? We place the Interstate system closest to Medicaid, but with somewhat more federal limitations. In the Interstate system, states have virtually no ability to include sections of highways not in the original 1947 plan. States must also comply with federal standards for interstate construction, as described above. However, states are in charge of the local implementation of highways. They retain the right to build Interstates that exceed federal standards. In addition, they hire from local labor markets that may be quite small, and potentially contend with regional road builder market concentration.

Although there is a near-vacuum in work on the geographic variation in highway costs, the geographic variation in Medicare has been studied intensely (see Wennberg and Gittelsohn (1973); Cutler and Sheiner (1999); Martin et al. (2007)). The most prominent strand of the literature, led largely by researchers at Dartmouth, argues that there is substantial unexplained variation in Medicare costs. In implementing these studies, researchers usually adjust spending for Medicare prices, so that the effects are driven by the quantity of procedures, rather than the price of procedures (Skinner and Fisher, 2010). Variation in prices is mechanical, because the federal government sets Medicare reimbursement rates. Quantity differences in healthcare, however, could be driven by, for example, different physician practice styles across the country.

The excellent overview in Congressional Budget Office (2008) divides the drivers of Medicare spending into four main categories: prices; health and illness status; regional preferences about the use of healthcare services; and residual variation. The summary of the literature suggests unsurprisingly that price is not a major driver. While this literature argues that regional variation in individual preferences for care is generally not a large driver, the report acknowledges that it is very difficult to measure regional preferences and that demographics' ability to explain preferences may be limited. This literature points out that the unexplained variation is large, and that addressing factors that cause the variation, such as physician practices, could yield large savings in the program.

A host of more recent work builds on these findings. For example, Gottlieb et al. (2010) analyze Medicare spending after adjusting for local price differences and find that utilization—not prices—drives Medicare spending. Finkelstein et al. (2016) also find an important role for place-based variation. They use patient migration to show that "40 to 50 percent of geographic variation in utilization is attributable to demand-side factors, including health and preferences, with the remainder due to place-specific supply factors." Similarly, Molitor (2018) shows that physicians change practice styles after moving and estimates that place can explain between 60 to 80 percent of physician practice differences.

In contrast, Sheiner argues that using state-level Medicare spending data—like the data we use in this paper—and a very limited set of state health status controls can explain a large amount of the cross-sectional variation in Medicare spending (Sheiner, 2014). She takes this as evidence that differing practice styles do not explain a large amount of variation in spending. Further, she is skeptical of the ability of geographic variation in Medicare spending to illuminate "inefficiencies in our healthcare system" (Sheiner, 2014, p. 1). Our work addresses part of this concern. If spending of multiple types is consistently high in some states, it may suggest key factors at work.

3 Data

To investigate whether the geographic patterns of Interstate spending per mile are similar to other state spending, we collect four types of data. These are Interstate spending per mile; measures of geographic differences in construction costs; public and private spending by states; and key demographic covariates.

3.1 Spending per mile

To construct Interstate spending per mile, we need both the numerator—spending—and the denominator—miles. For annual Interstate spending, we digitize state level data from the US Department of Transportation's *Highway Statistics* yearbooks for years 1956 to 1993. These volumes report annual federal spending on new Interstate miles by state. The data appendix of Brooks and Liscow (2019) details how we adjust these to account for small anomalies and issues due to two special rules on apportionment. Here and throughout, we adjust all dollar figures to 2016 dollars, adjusted using the CPI-U.

For the denominator of spending per mile, we measure miles constructed by year of completion from Baum-Snow (2007). For each roughly one-mile segment of Interstate, we observe the exact location of that segment and the year in which the segment was completed.

Because spending is counted when it occurs and miles are counted when completed, the timing of spending usually pre-dates timing of completion of miles.[5] In this paper, we focus on either the entire time period—in which case there is no temporal mis-match—or two long time periods, in which case this issue is substantially lessened.

3.2 Geographic Features

To account for geographic differences that drive spending per mile, we rely on what researchers generally believe to be the three main drivers of physical construction costs (Balboni, 2019; Faber, 2014; Alder, 2019). The first is population density, with data from the Decennial Census (specific files as noted in the data appendix). We measure population density for each one-mile segment as the population density of the census tract in which the largest part of the segment falls, when tract data are available, or the population density of

[5] In addition, we adjust spending to be a weighted average of the year the segment opens and the two years prior. See details in (Brooks and Liscow, 2019).

the county, when tract data are not available.[6] We use population density from the census year closest to the opening of each segment.[7] We create a state-year, or state-period, measure by taking a segment-weighted year or period average. For all other geographic variables, we follow a similar procedure of weighting by the number of miles built in a given year.

The second measure of geography relevant to Interstate cost is the slope of terrain. We measure the average state slope by first finding the average slope of land within 50 m of each segment using USGS's National Elevation Map. We create a state-year or state-period measure of slope by taking a segment-length weighted average of all segment slopes for a state in a year or period.

The final measure of geography is based on the length of the segment, in miles, that intersects wetlands or rivers. We define wetlands as the any of water types in the Cowardin classification system from the US Fish and Wildlife Service (2018) Wetlands Inventory dataset. This definition includes rivers (and any other large body of water). The final state-year or state-period measure is the average segment share in wetlands or rivers, weighted by segment length.

3.3 Public Private and Private Public Spending

We have several measures of private and public spending with which we correlate our Interstate construction cost measure. To compare Interstate spending to private spending, we use an index of residential private construction costs from R.S. Means, indexed to 100 in 1993, courtesy of Raven Molloy. Molloy collected these data for every five years from 1940 to 1980 and then annually 1981 to 2003. We also include private health insurance expenditures per enrollee in 2001 (the earliest year available) from the Centers for Medicare and

[6] The entire country is tracted only in 1990; in 1950, tract data are available only for selected central cities.

[7] For example, we attribute the 1960 census characteristics to segments opening from 1956-1964, and the 1970 census characteristics for segments opening 1965-1974.

Medicaid Services' "Health Expenditures by State of Residence, 1991-2014" (see Appendix for complete citation details). Private health insurance expenditures include expenditures by both the insurer and the insured.

We also compare Interstate spending to public spending. For Medicare and Medicaid, we use spending per enrollee, also from the Centers for Medicare and Medicaid Services' "Health Expenditures by State of Residence, 1991-2014."

We use a host of government spending measures from the Census of Governments (relying only on full censuses in 1967, 1972, 1977, 1982, 1987 and 1992). We use data on total state-wide local government expenditures (the sum of state and all local expenditures) and rely on the time-consistent compilation from Willamette University (Pierson et al., 2015). To avoid problems of differing state and local responsibilities, we aggregate all state and local government spending by state and year. These data do not include state-level accounts in 1967, so most of our data work relies on state-aggregate measures from 1972 onward.

3.4 Interstate Outcomes

To assess whether Interstate spending correlates with post-construction outcomes, we collect the number of accidents and fatalities per mile from the oldest relevant *Highway Statistics*, which is 1995. We also collect 2015 state maintenance spending per mile, again from *Highway Statistics*. We use later measures of maintenance expenditures so as to assess the long-run quality of Interstate construction.

4 Findings

Combining these data, we first describe the extent and magnitude of geographic variation in spending. We then assess whether geographic variation in Interstate spending is related to geographic variation in other state spending categories.

4.1 Descriptive Statistics on Cross-State Variation

We begin with the magnitude of the state variation. Figure 1 presents state spending per Interstate mile over the entire period of construction, 1956-2013. In these raw data, average state spending per mile is \$11.5 million. The bars in the figure present deviations from this average. Delaware spent the most of any state per mile, at just over \$50 million dollars per mile; the top three spenders also include New Jersey at over \$30 million per mile, and Connecticut at just under \$25 million per mile. North Dakota spent the least of any state per mile, at roughly \$3 million per mile. Excluding the top three spending states still leaves a \$30 million per mile difference between the highest and lowest spending states.

The figure demarcates the four census regions in shades of purple. Western states tend to spend the least per mile; Northeastern states (and some states the Census denotes as South, but which may be more intuitively northeastern—Delaware and Maryland) are the highest spending ones. There are no Northeastern states in the bottom portion of the spending distribution.

This geographic variation is also visible in the top panel of Figure 3, which maps spending per mile by state for the entire period of construction. It is clear that unconditional spending per mile is highest in the Northeast and West Coast; states in these regions are mostly in the top quartile of spending per mile (the darkest purple).

Some of this variation in spending may be due to variation in costs due to factors outside of state control. For example, it is more expensive to construct roads in areas that with greater elevation changes. To disentangle spending that is a political choice from spending due to the pre-existing physical and human geography, we regress spending per mile on three key covariates, denoted G_s. The vector G_s includes average population density, average slope, and share of miles in wetlands or rivers of segments constructed (see data section for more specifics on the calculation of these measures). Specifically, we estimate

$$\text{spend per mile}_s = \beta_0 + \beta_1 G_s + \epsilon_s \tag{1}$$

where s indicates state. We use the estimated residual, $\hat{\epsilon}_s$, as our measure of spending net of physical costs. We weight all regressions by the number of Interstate miles built in a state so that the results approximate the average mile, rather than the average state.

Figure 2 presents these $\hat{\epsilon}_s$ residuals. By construction, they average to zero. The first factor to note when comparing Figures 1 and 2 is that the magnitude of the variation shrinks substantially. Instead of an almost \$50 million maximal difference between the highest and lowest spending states (as in Figure 1), the maximal difference falls to about \$25 million. Notably, Delaware—the highest spending state in the first graph—is now the lowest spending state, spending almost \$15 million fewer dollars per mile than the average state.[8]

The bottom panel of Figure 3 shows this residualized spending in a state map. While Washington state and parts of the mid-Atlantic region remain in the top quartile of spending, much of New England and the Northeast moves out of the top quartile of spending. In addition, much of the South now falls into the second highest quartile of spending per mile. The resulting distribution shows a fair amount of within-region heterogeneity in costs. For example, New York is in the bottom quartile, while most of its neighbors are in the top quartile. Louisiana is in the top quartile, while the rest of the South is in lower quartiles. Washington is in the top quartile, while Oregon is in the lowest.

To directly compare raw spending per mile with the residual, Figure 4 displays a rank-rank correlation. On the horizontal axis, the graph shows each state's rank in spending per mile. On the vertical axis, the graph shows the state's rank in spending conditional on geographic covariates (the residual from Equation 1). These two values do not generally lie

[8] Delaware has very few interstate miles, and many of these miles are adjacent to or are over water.

along the 45-degree line, as they would if the ranks were perfectly correlated. In fact, the correlation coefficient for these two ranks is relatively low, at 0.3.

Interestingly, we find that the controls change the ranks of high spending states more than the ranks of low spending states. There are virtually no states in the top left quadrant (unconditionally low, and conditionally high spending), but quite a few states in both the top right (high conditionally and unconditionally) and bottom right (high unconditionally, low conditionally) quadrants.

To summarize this cross-sectional variation, and to compare the variance in state Interstate spending to state behavior in other areas, we turn to Table 1. The first row of the table shows the national average spending per mile from 1956 to 1993 of $11.5 million, with a coefficient of variation of 0.58. The analogous numbers for the remaining variables are useful references for the regressions below.

4.2 Covariation with Public and Private Spending

Before turning to multivariate analysis, we show that the coefficient of variation in Interstate spending per mile far exceeds the coefficients of variation in any of the spending categories with which we make comparisons. Table 2 presents means (repeated from Table 1), the coefficient of variation (column 2; standard deviation divided by mean), and the residual variance, conditional on geographic variables, divided by the mean (column 3). Even conditional on geographic measures of costs, the variation in Interstate spending per mile remains the highest at 0.372; Medicaid per enrollee is in second at 0.311.

For this full period, among the non-Interstate spending categories the highest coefficient of variation is 0.32 for Medicaid per enrollee—slightly more than half of that for Interstate spending per mile. Private health insurance spending per enrollee has the smallest coefficient of variation—about one-eighth the size of Interstate spending per mile. Comparing the interquartile range in Table 1's column 3 to means in column 1, it is clear that the distribution of spending per Interstate mile has more high outliers.

The table then repeats this pattern for the second period in columns 4 to 6. Here the difference in the extent of variation between spending per mile and the other measures of spending is only widened. Geographic measures of cost impact the residual variance less, leading to a smaller change in the measure of interest. In the second period, the conditional measure os 0.659 and the unconditional measure is 0.582. In contrast, for the full period the unconditional measure is 0.582 and the conditional measure is 0.379.

In fact, the only measures in Table 2 that approach or exceed that of Interstate spending per mile are our other measures of Interstate quality, including fatalities or accidents per vehicle miles traveled and maintenances per mile. Only spending on maintenance per mile exceeds the variation in initial spending per mile. This holds whether we use the conditional or unconditional measure, and whether or not we consider the entire period, or just the second half.

To more formally analyze whether the variation in Interstate spending per new mile across states is driven by a set of common factors that cause generally high spending, or whether high Interstate spending per mile is driven by factors more specific to highway construction, we estimate regressions of the form

$$\text{spend per mile}_s = \beta_0 + \beta_1 G_s + \beta_2 C_s + \epsilon_s. \tag{2}$$

The dependent variable is state Interstate spending per mile over the 1956 to 1993 period. As before, G_s is the vector of the three key geographic covariates as defined for Equation 1 above. We denote additional covariates as C_s.

We are interested in the magnitude and direction of the coefficient on covariate C_s (β_2) as well as how much variation remains in cross-state spending after its inclusion. We measure this residual variation in three ways: the standard deviation of the residuals; the difference between the 75th and 25th percentiles of the residual distribution; and the difference between the 90th and 10th percentiles of the residual distribution.

The top panel of Table 3 shows that, with no covariates, the standard deviation of the residuals of Interstate spending per new mile is \$10.5 million; this is slightly higher than the difference between the 75th and 25th percentile residuals of \$9.4 million. There is substantial variation at the tails of the distribution, as evidenced by the much greater difference between the 90th and 10th percentile of the residuals: \$23 million.

The second row in the table reports results for the estimation of Equation 1. The inclusion of geographic covariates explains about 85 percent of the variation in spending, as shown by the R^2 in column (3), and cuts the standard deviation of the residuals by more than half to \$4.4 million (relative to a mean of \$11.5 million per mile; see Table 1). The other measures of residual variation shrink by even larger shares. This row serves as the baseline to which we compare whether spending measures explain a meaningful portion of the remaining variation.

To do so, we move now to our second object of interest: does highway spending per mile co-vary with the major categories of public or private spending? We assess this question by sequentially assessing the relationship of covariates to state Interstate spending per mile. We begin with the entire time period of Interstate construction, 1956-1993, in the top half of the table. We then turn to the second half of the Interstate construction period, 1971 to 1993, when total spending declined, but when spending per mile was higher and more varied, in the lower panel of the table.

We first consider the correlation between Interstate spending per new mile and private spending on goods that the government also provides. The first row of private spending is residential private construction spending, as measured by a constant quality index (see data section and appendix for greater details). There is virtually no relationship between the variation in private residential construction spending and Interstate spending per mile for the 1956-1993 period—despite the fact that both types of spending may operate in similar markets. This is consistent with the result in Brooks and Liscow (2019) that cross-state variation in labor costs explains none of the temporal increase in Interstate spending per mile. The coefficient on residential private spending construction costs is small and very imprecisely estimated; the measures of residual variance are barely changed by the addition of this additional covariate.

We find a similar imprecise correlation when we instead include private health insurance expenditures per user from 2001 (the earliest available year). These are private expenditures by individuals and insurance companies for health care, including premiums and health care expenses, as well as administrative expenses by health insurers. Costliness of private care may speak to the regulatory environment in the state. However, we see no strong relationship between highway spending and private health insurance expenses, as standard errors are large.

We now turn to public spending, which may have different drivers than private spending. We begin with health expenditures—Medicare and Medicaid—per enrollee as of 1991, the earliest year with digitized costs. These two programs operate under very different funding models. Medicare funding decisions are almost exclusively federal. States have no control over what or how much the system covers, nor do they bear any fiscal liability for the program. These federal decisions manifest locally through individuals' choices and hospital and health care provider choices. In contrast, Medicaid decisions include substantial state discretion, subject to federal rules. States have some ability to choose who is covered, above certain minimum limits, and to expand the type of coverage. In form, the Interstate program is probably closer to Medicare, in the sense that states cannot limit coverage—if we analogize coverage to Interstate miles that the state must construct. However, states could provide Interstate quality above the minimum bar, as states can provide health care above a required minimum. for Medicaid.

Interestingly, between these two, only Medicare spending is statistically significantly related to Interstate spending; it is also the only variable in the table that yields a notable decrease in Interstate spending residuals. For each additional $1,000 of Medicare spending—an amount slightly smaller than the interquartile range for this variable—a state spends an additional $1.3 million dollars to build an Interstate mile. This $1.3 million is roughly ten percent of the average state expenditure per mile. Comparing the final two columns of the table, it is clear that this stems from the explanatory power at the tails of the state spending distribution. In contrast, the Medicaid program, with substantially more state discretion, has virtually no relationship with Interstate spending and makes no meaningful change to the residual variance.

We now shift from healthcare expenditures to a direct measure of overall state and local spending. To abstract from institutional differences in government organization across states, we use state aggregate spending.[9] This measure of total expenditure per capita is not statistically related to per mile Interstate spending; its inclusion actually slightly increases variation in the residuals. Therefore, if there is a common component that drives Interstate spending per mile and Medicare spending per enrollee, this component has little impact on local spending.

In Appendix Table 1 we also consider the two key discretionary categories of local government, education spending and capital spending. Both of these are not statistically related to Interstate spending per mile, nor do they have any appreciable impact on the residual variation.

We then repeat this analysis, but for the second period of spending, from 1971 to 1993, in the bottom half of Table 3. The first line of this panel shows that the residual variation with

[9]Because the digital Census of Governments does not have state governments in 1967, we make an additional measure that uses data from Census years (ending in 2 and 7) from 1967 to 1992, but excludes state governments; this is "Local (no state) exp per capita, $1,000s." Results with this measure are in Appendix Table 1.

no covariates is quite a bit higher in this period—a standard deviation of 16.1, relative to 10.5 overall. The second line shows that, conditional on geographic controls, the difference between the 10th and 90th percentiles is twice as high: 16.4 relative to 8.2. Furthermore, the inclusion of geographic covariates explains less of the variation in spending. The second row shows a R^2 of 0.67 for this specification, rather than 0.84 for the whole period. The residual variation of $10.2 million per mile is much larger than it is for the whole period (which is $4.4 million per mile).

With this greater variation in Interstate spending, we see more statistically strong relationships with both private and public spending. In this second period, a two-unit increase in the private residential construction index (about one-third of the interquartile range for this variable) is associated with $1 million additional Interstate spending per mile. Even more strikingly, a $250 increase in private insurance spending—the magnitude of the interquartile range—is associated with slightly more than $2 million more in Interstate spending per mile. This is about 14 percent of mean Interstate spending per mile.

On the public spending side, the picture is somewhat more mixed. Medicaid spending is still statistically unrelated to Interstate spending and its inclusion has no impact on the residual variation in spending. In contrast, we do see a statistically meaningful covariance between Medicare per enrollee and local government expenditures per capita in the second period. An additional $1,000 of Medicare spending—four-fifths of the interquartile range—is associated with an additional $3.4 million dollars in spending per mile, compared to an average of $15.2 million per mile. An additional $1,000 of local government spending—roughly three-fifths of the interquartile range—is associated with $1.1 million additional spending per mile. Medicare spending reduces the residual variation in the middle of the distribution (columns 4 and 5, standard deviation and interquartile range), whereas local government spending is more tied to reductions in residual variation at the tails of the distribution (column 6, 90-10 percentile difference).

To better understand the relationship with Medicare, Figure 5 shows the raw correlation between Interstate spending per mile from 1971 to 1993 on the horizontal axis and Medicare spending per enrollee on the vertical axis. The two series are clearly related, particularly at the high end of spending. The distribution of Medicare spending is substantially less skewed than the distribution of Interstate spending. The bottom panel shows this relationship, conditional on the geographic covariates; both axes present residuals.[10] The positive correlation remains, as does the much less symmetric distribution of Interstate spending. These findings suggest both that there may be a common cost component and that there is something additional driving the greater skewness in Interstate spending per mile.

If states are spending more on Interstate highways but are in some sense "getting more"—safer roads, or longer-lasting roads—the cross-state variation would have a different interpretation. In Table 4 we assess whether state spending is correlated with measurable highway outcomes. As in the previous table, the top panel covers the entire period, and the bottom panel the higher variance second period. The first two rows of each panel of the table repeat the first two rows of each panel of Table 3 for reference. Controlling for fatalities per hundreds of millions of vehicle miles traveled (VMT) has no additional explanatory power for the variance in state spending—it in fact raises the residual variation at the tails of the distribution. Accidents per 100,000 of VMT have similarly no relationship with Interstate spending per mile.

States that spend more money to build a new Interstate mile also spend more to maintain those miles, as measured by per mile maintenance costs per state in 2015. Each additional million dollar of maintenance per mile is associated with an additional $200,000 dollars of initial highway construction. Although this is a statistically significant relationship, the relationship accounts for very little of the residual variation in spending, either as measured

[10]Because these regressions are weighted by miles constructed, the average of the points in the figures may not average to zero.

by R^2 (84 to 85), or by the change in the standard deviation of the residuals (4.4 vs 4.5).

This pattern is similar when we limit the analysis to the second period, 1971 to 1993. States with higher highway maintenance expenditures are those that initially spent more per mile. This variation now does seem to explain some portion of the variation in the residual at the tails. However, unlike for the overall period, there is a significant relationship between fatalities per vehicle mile traveled on Interstates and construction spending per mile. Reducing fatalities by the amount of the interquartile range—0.55 per 100 million vehicle miles traveled—is associated with $2.5 million dollars of additional Interstate spending per mile, or about 15 percent of the mean.

Given that spending behavior does seem to be correlated in some cases, we now turn to a multivariate analysis in Table 5 to better understand whether these different spending measures are independently related to Interstate spending and whether there are common demographic factors that can explain their relationship. As before, the dependent variable is spending per mile (in millions of 2016 dollars). We focus here on the second period, 1971 to 1993, since that is where Interstate spending variation is larger. The regression reported in the first column includes the geographic controls from the previous tables, as well as the four spending variables most statistically significantly related to Interstate spending. In this multivariate context, only the coefficient on Medicare per enrollee is estimated with any precision. The inclusion of all spending covariates does very little to moderate the residual variation (compare the last three rows of column 1 to the last three rows in Table 3 in the "geographic covariates" row).

The remaining columns of the table test whether there are demographic factors that drive all these types of spending; if this is the case, then conditional on these factors the relationship between spending types declines. Columns 2, 3 and 4 include education, median home value, and median family income independently. Their individual inclusion has very little impact on the Medicare coefficient, suggesting that the relationship between higher Medicare spending and higher Interstate spending is not jointly driven by, for example, high home values—or the tastes that drive high home values. Of the three covariates, median family income has the most impact on the other spending coefficients, erasing any positive correlation between private health insurance per capita and highway spending. In this specification, conditional on state median family income, states that spend more on local government spend less per mile on Interstate construction.

In the final column, we include all three demographic measures together (recall that we have only 48 observations, and this is now a specification with 10 covariates). We now have no power to discriminate between spending coefficients. Interestingly, the residual variation in spending has not moderated, and the interquartile range of the residual is larger than in column 1. While the coefficients on the spending variables retain their signs, we lose the ability to precisely estimate coefficients.

discuss new Figure 6

5 Discussion and Conclusion

In this paper, we show that the geographic variation in Interstate spending per mile is large. If states in the top half of the spending distribution had capped their spending at the median, the Interstate system would have cost 40 percent less to build. Put differently, the coefficient of variation in Interstate spending is 0.58—about four times that of Medicare per enrollee and twice that of Medicaid per enrollee. The high relative variance in Interstate spending per new mile remains even conditional on geographic features that determine cost. In other words, variation in Interstate spending per mile is at least as economically meaningful as the variation in other categories of spending—Medicare and education—to which economists have devoted reams of papers.

In addition, we show that the geographic pattern in spending per Interstate mile is related, surprisingly, to spending per Medicare enrollee. An additional $1,000 dollars of Medicare spending is associated with an additional $1.3 million dollars of Interstate spending per mile, or about ten percent of the mean. Notably, in both of these cases, the federal government maintains considerable authority: it sets prices for Medicare and minimum highway standards for the Interstates.

In Brooks and Liscow (2019), we show that temporal increases in the cost of constructing a new Interstate mile are driven by input quantities rather than prices. We conclude this based on two pieces of evidence: nationally, real prices for labor and materials change little from 1956 to 1993, and cross-state variation in labor prices is not correlated with Interstate costs. Our finding is very similar to the argument in the Medicare spending literature that it is quantities, rather than prices that drive variation in spending (see Gottlieb et al. (2010), Finkelstein et al. (2016) and others discussion in Section 2. These results suggest that the same common features may drive both Medicare spending and high infrastructure costs.

To the extent that Medicare and Interstate spending are related, we offer two speculative and related hypotheses. First, higher average incomes in a state, by increasing demand, could drive the provision of "more." This is consistent with Brooks and Liscow (2019), in which we show that increases in incomes and housing values statistically explain the entire increase in Interstate cost per mile over the period. Further, we show that this explanation is driven almost entirely by the post-1970 relationship between demographics and Interstate cost per mile. This suggests a change in the strength or quantity of "citizen voice" that links socioeconomic status to spending outcomes. Here we find that similar controls reduce the relationship between Medicare spending per enrollee and Interstate construction costs. This suggests that these factors may play be a common factor explaining both forms of spending (although the present paper does not speak to the relationship between Medicare and Interstate spending over time).

How would these increases in quantity manifest? In healthcare, "more" could be more additional healthcare screenings, more appointments with specialists, or more luxurious hospital surroundings. For Interstates, "more" can be more public consultation, more noise walls, or construction that is more sensitive to the local environment. That is, the same factors that drive greater healthcare treatment intensity may also drive Interstate construction that is more expensive.

Second, and relatedly, states may differ in culture, which could be either the underlying preferences of state citizens or the institutions that aggregate those preferences, or both. This is consistent with our finding that a correlation between Interstate spending and Medicare spending persists even conditional on some degraphic factors. It is also consistent with the findings in the Medicare spending literature, some of which argues that higher spending is driven by a "culture of practice" (Gottlieb et al., 2010; Molitor, 2018). In the Interstate realm, this would be a "culture of production", where higher production costs could be due to state procurement practices, underlying preferences of state voters, or the state-specific market concentration of construction firms.

A central concern of the Medicare spending literature is that higher treatment costs are not associated with better health outcomes; see Chandra et al. (2011) and Fisher et al. (2003) among many others. The picture for Interstate highways is more nuanced. We find that more Interstate spending per mile is associated with fewer fatalities, but higher future maintenance. Lowered future fatalities given higher initial investment is consistent with more spending delivering higher quality. However, more initial Interstate spending is not associated with lower future highway maintenance. This could be because more initially expensive highway miles are also more expensive to maintain. Alternatively this could be because states that initially choose high spending also choose make high spending for maintenance. Of course, a full analysis of quality requires a more holistic analysis, beyond the three factors we consider here.

While we find a correlation between Interstate spending per mile and Medicare spending per enrollee, we find no such relationship with Medicaid spending. This is consistent with an important role for income in generating spending. If higher income yields greater demand for spending, this means that it is the relatively wealthy who drive at least some of the spending increases. These relatively wealthy people are in the Medicare population. They are, however, by definition, not in the Medicaid population. This bolsters the case that part of the common driver of higher costs is higher income, or some institutional features that develop in the presence of higher income people.

Any increase in the quality of US infrastructure depends crucially on managing per unit costs. Understanding what drives Interstate costs and the extent to which these costs justify benefits is crucial if we seek to spend more to improve the state of US infrastructure.

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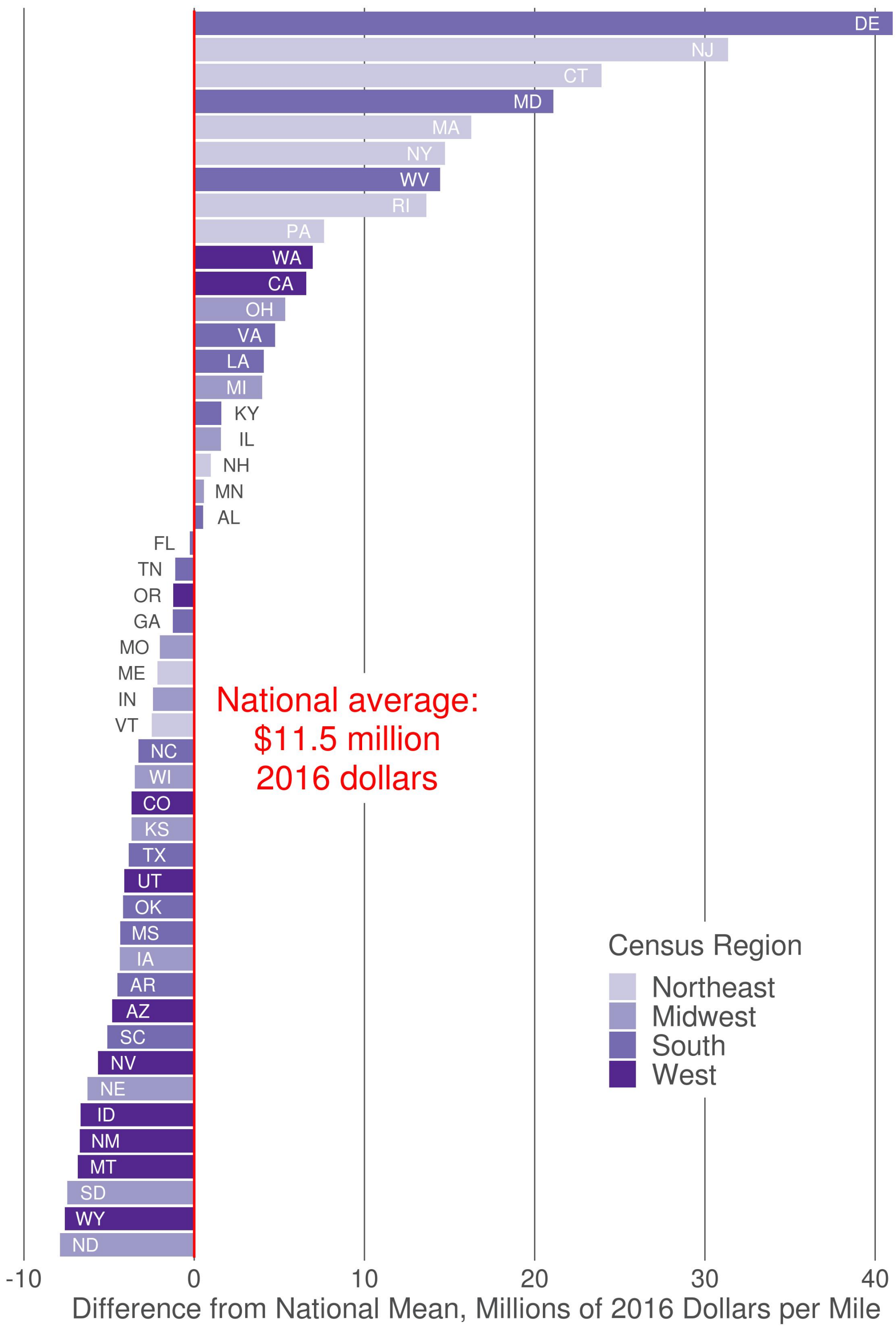
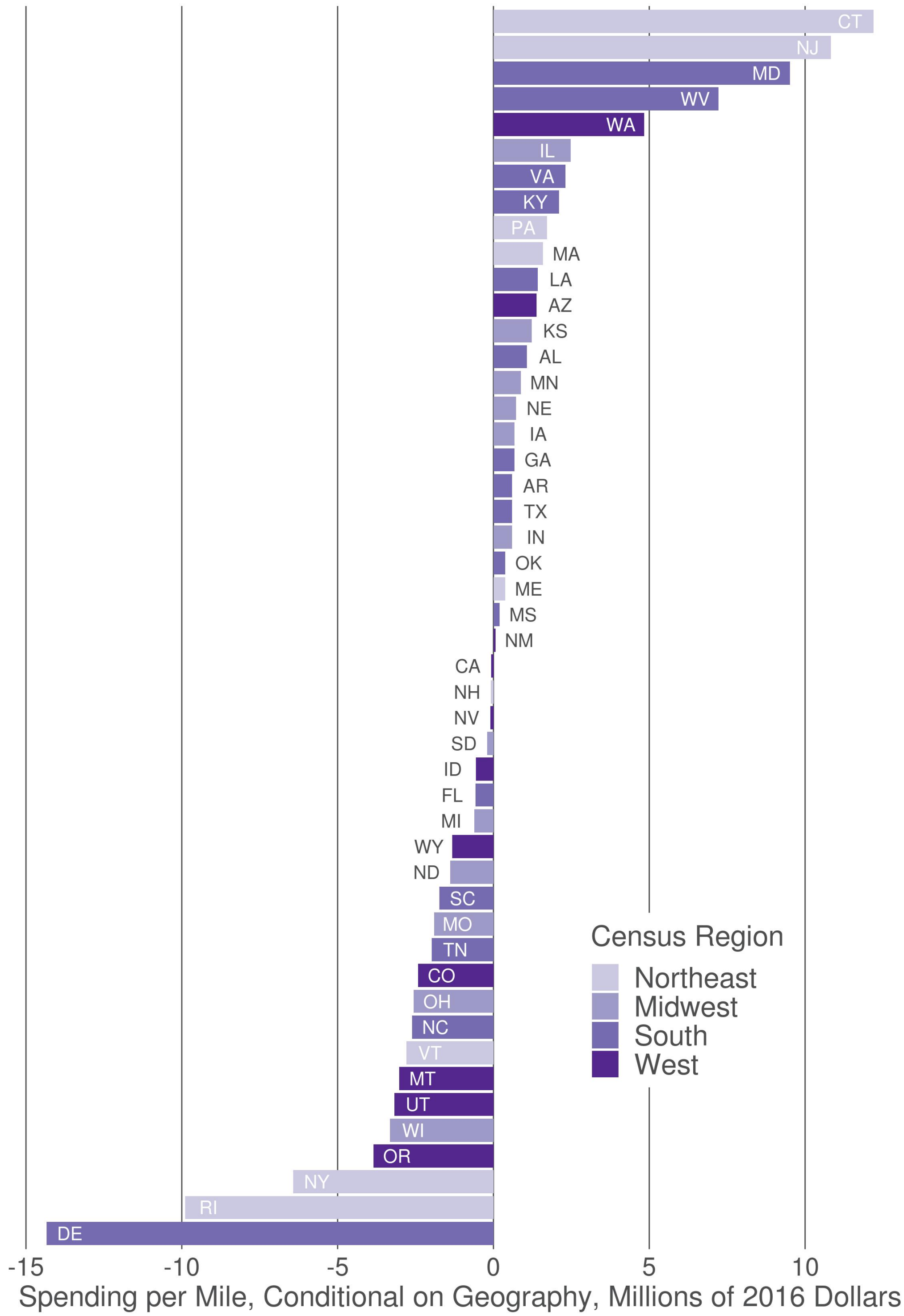
Figure 1: Interstate Spending per New Mile: Absolute Difference from National Average



Note: This figure presents deviations from national average Interstate construction spending per mile by state, 1956-1993. We omit Alaska, Hawaii and Washington, DC.

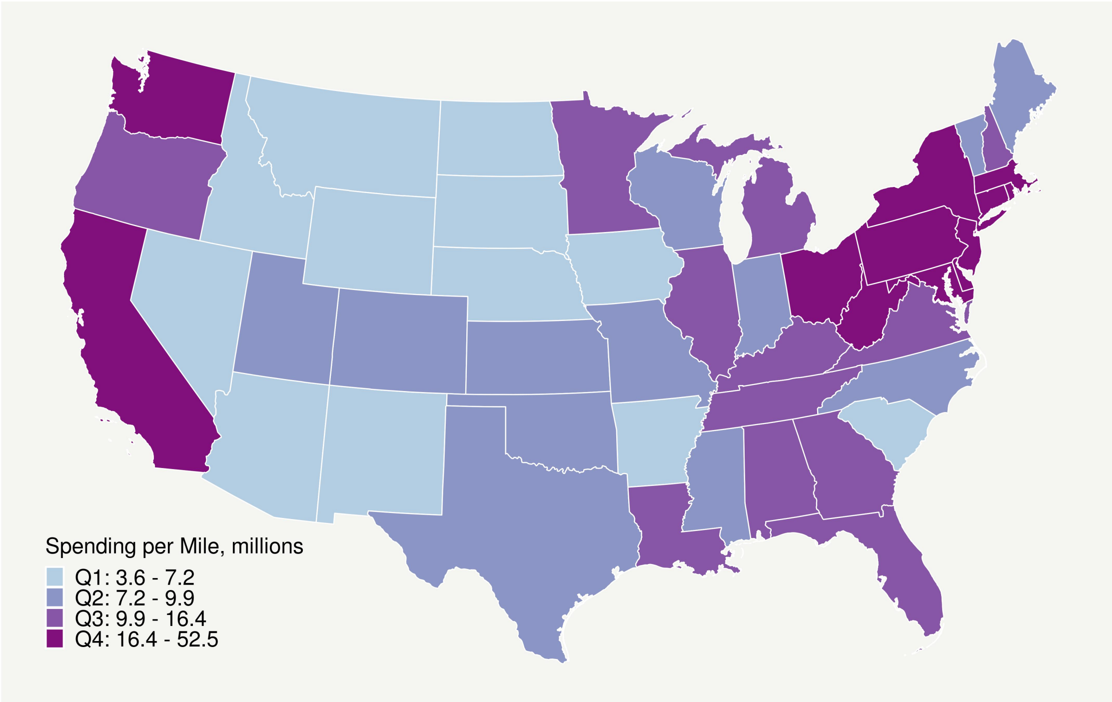
Figure 2: Interstate Spending per New Mile: Residual Difference in State Spending From National Average, Net of Geography



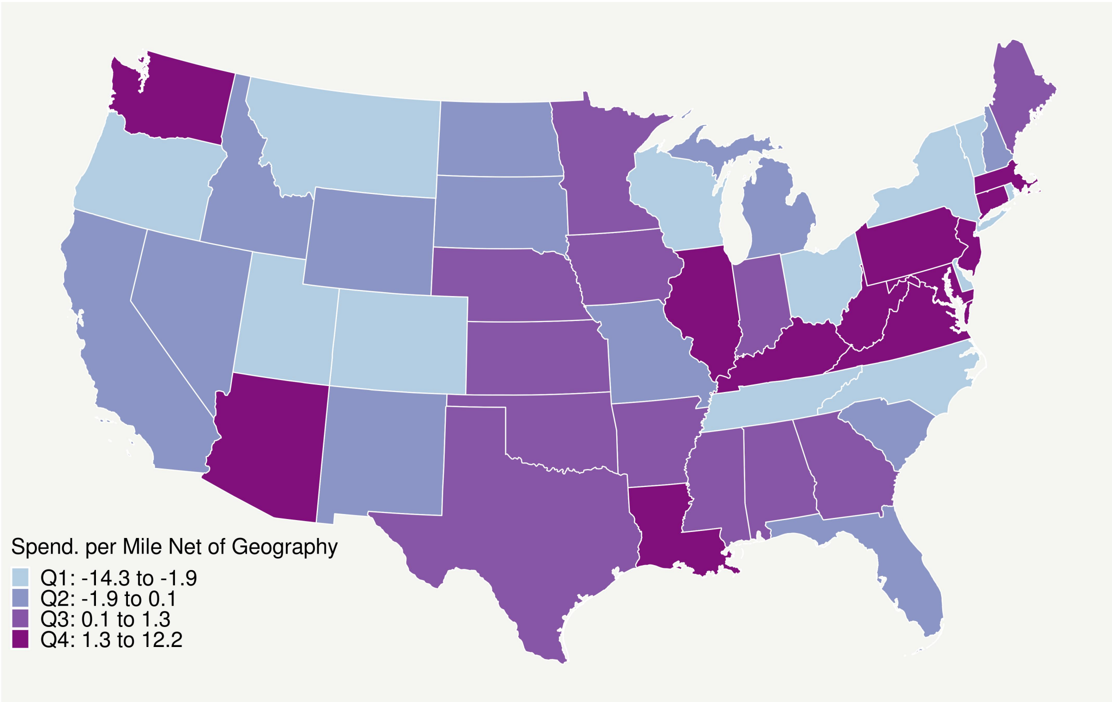
Note: This figure reports residuals from a regression of average Interstate spending per mile, 1956 to 1993, on population density, slope and the extent of wetlands or rivers (see Equation 1 and surrounding text for specific details on variables).

Figure 3: Interstate Spending per Mile Mapped

(a) Spending per Mile, millions of 2016 dollars

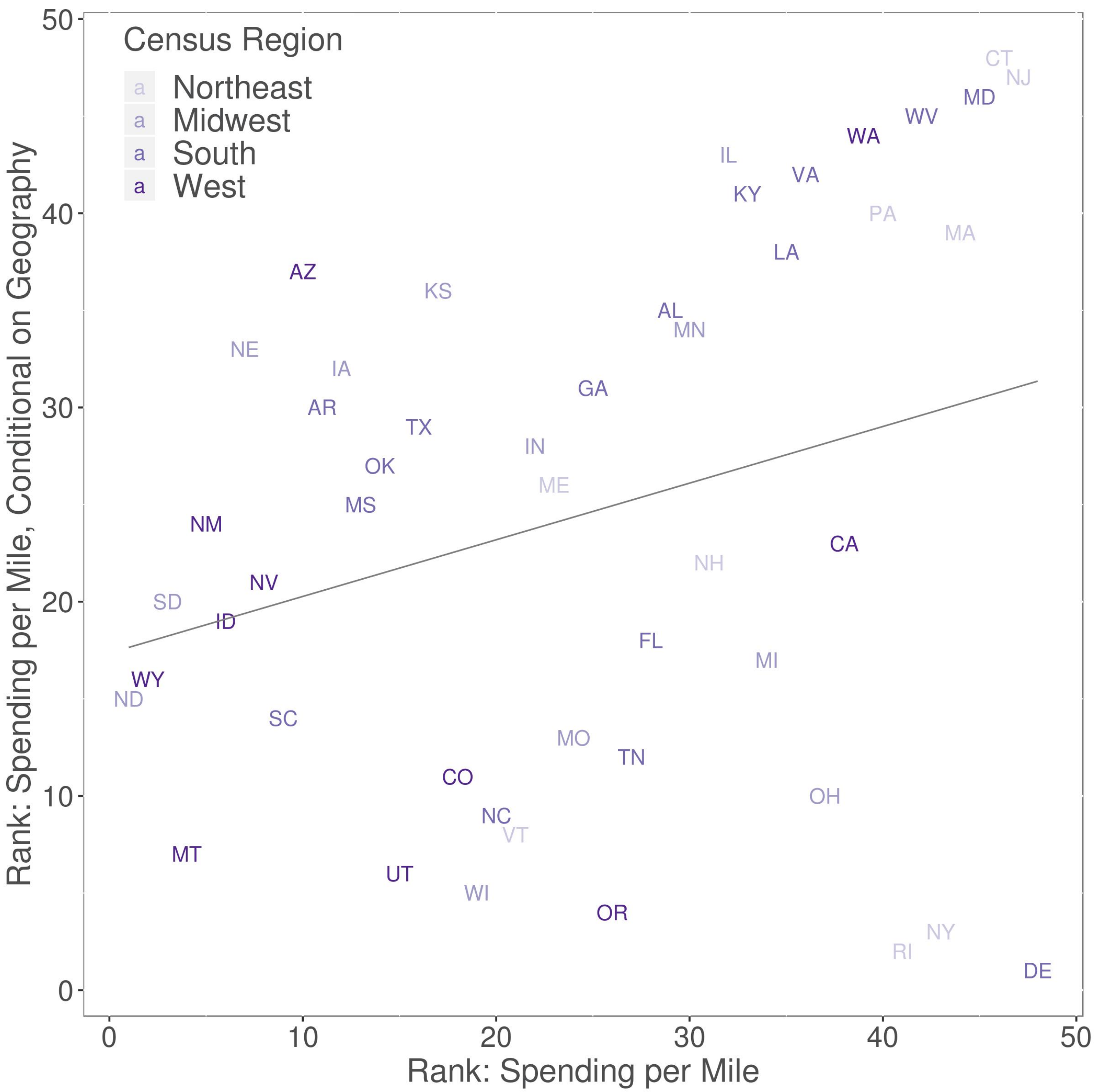


(b) Spending per Mile, Conditional on Geographic Covariates, millions of 2016 dollars



Note: Part (a) maps the Interstate spending per mile from Figure 1. Part (b) maps Interstate spending per mile conditional on geography as in Figure 2.

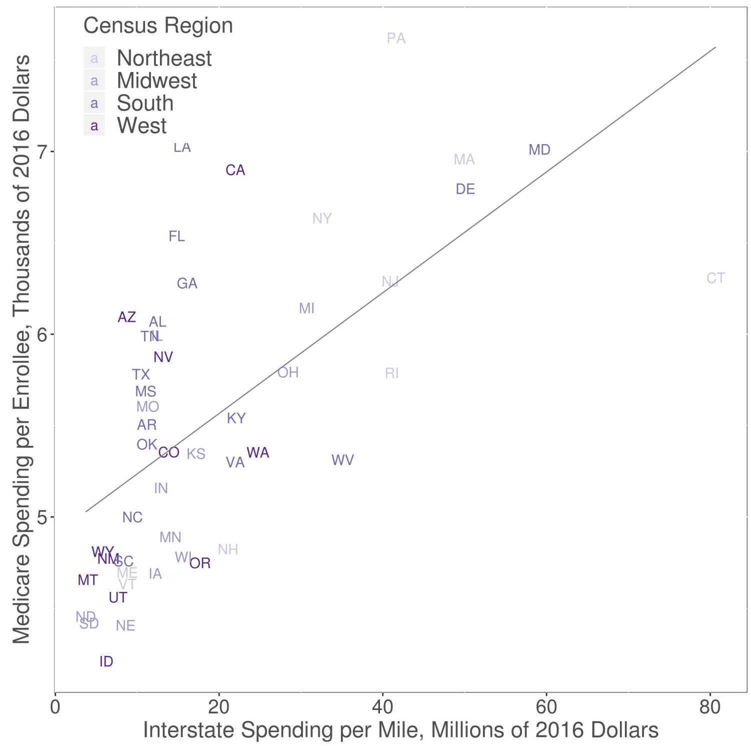
Figure 4: Rank-Rank Correlation: Raw Spending and Spending Conditional on Geographic Covariates



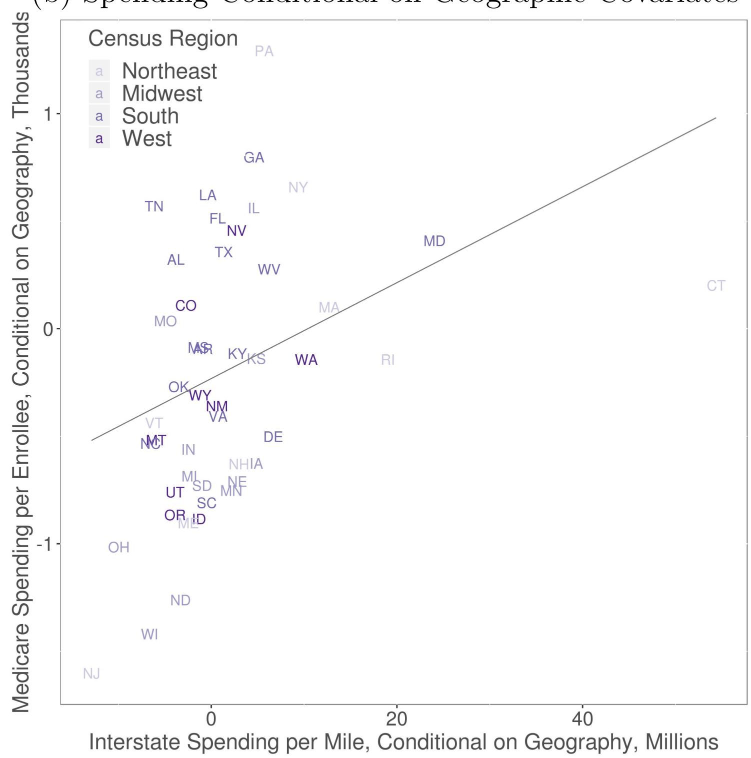
Note: This figure shows each state's rank (from 1 to 48) in Interstate spending per mile on the horizontal axis versus the state's rank in Interstate spending per mile conditional on geographic covariates on the vertical axis.

Figure 5: Correlation: Interstate Spending per Mile and Medicare Spending per Enrollee

(a) Raw Spending



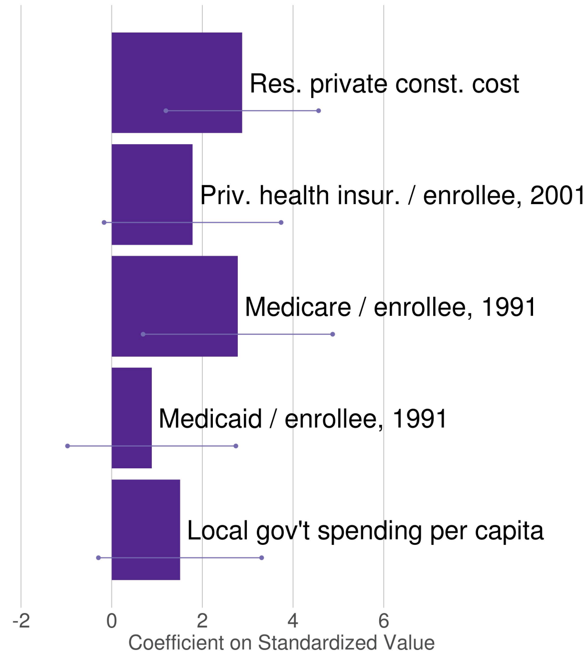
(b) Spending Conditional on Geographic Covariates



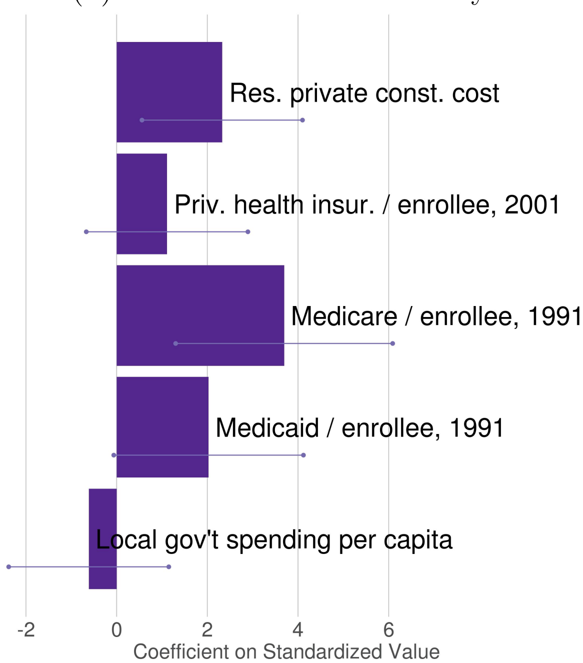
Note: The top panel of this figure shows the relationship between Interstate spending per mile after 1970 (horizontal axis) and Medicare spending per enrollee, 1991 (vertical axis; both in 2016 dollars). The bottom panel shows these two measures conditional on the three geographic covariates that we use throughout.

Figure 6: Relating Interstate Spending to Other Spending: Standardized Coefficients

(a) Covariates Entered Individually



(b) Covariates Entered Jointly



Note: These two figures present results from Table 5 column 1, second panel, but where the variables are standardized to mean zero standard deviation one to allow direct comparisons of magnitudes across variables. In all cases, this table uses data from the second period of 1971 to 1993. In the top panel, each coefficient is from a separate regression. Thus, the first row presents the coefficient from a regression of spending per mile on residential private construction and the three geographic covariates. The error bars show 95 percent confidence intervals. The bottom panel shows coefficients from one regression, in which all covariates are standardized.

Table 1: Geographic Variation in Interstate and Other Local Spending

	Entire Cross-Section			Period 1: 1956 to 1970			Period 2: 1971 to 1993		
	Mean	Std. Dev.	Diff: p75 to p25	Mean	Std. Dev.	Diff: p75 to p25	Mean	Std. Dev.	Diff: p75 to p25
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Spending/Mile, $ millions	11.51	6.7	8.18	8.75	5.15	6.26	15.52	10.65	8.25
Private Spending									
Res. Const. Cost Index	31.53	4.93	5.83	19.83	1.7	2.12	48.55	5.66	5.84
Health Ins./Enrollee., 2001, $1,000s	2.95	0.21	0.24	.	1.3	.	2.94	0.21	0.22
Public Spending, all $1,000s									
Medicaid per enrollee, 1991	6.01	1.93	2.17	.	0.41	.	5.97	1.91	2.44
Medicare per enrollee, 1992	5.65	0.83	1.27	.	1.93	.	5.65	0.83	1.32
Local Govt. Exp. per capita	6.5	1.31	1.8	.	1.3	.	6.94	1.34	1.58
Interstate Outcomes									
Fatalities per VMT, 1995*	0.86	0.4	0.55	.	0.41	.	0.88	0.39	0.53
Accidents per VMT, 1995*	3.71	1.95	2.17	.	1.93	.	3.73	1.97	2.36
Maint. per Mile, millions, 1995	5.73	4.27	4.92	.	4.2	.	5.92	4.35	5.52

Note: *Fatalities are per 100 million vehicle miles traveled. Accidents are per 10,000 vehicle miles traveled (VMT). All rows contain 48 observations, with the exception of accidents, which has 47. We omit Alaska, Hawaii and Washington, DC. We weight all summary statistics by Interstate miles constructed in that state. Because of this, summary statistics for time-invariant variables, such as Medicaid spending in 1991, may vary slightly across the two time periods. “Residential construction costs” are an index where 1993 is 100. “Local government spending” is the total of all state and local government spending in the Census of Governments for all census years after 1967 (1967 does not report state-level information).

Table 2: Coefficient of Variation: Interstate and Other Local Spending

	Entire Cross-Section			Period 2: 1971 to 1993		
	Mean	CV: Std. Dev./ Mean	Residual Std. Dev./ Mean	Mean	CV: Std. Dev./ Mean	Residual Std. Dev./ Mean
	(1)	(2)	(3)	(4)	(5)	(6)
Spending/Mile, $ millions	11.51	0.582	0.379	15.52	0.686	0.659
Private Spending						
Res. Const. Cost Index	31.53	0.156	0.145	48.55	0.117	0.153
Health Ins./Enrollee., 2001, $1,000s	2.95	0.072	0.072	2.94	0.07	0.078
Public Spending, all $1,000s						
Medicaid per enrollee, 1991	6.01	0.32	0.311	5.97	0.321	0.32
Medicare per enrollee, 1992	5.65	0.146	0.152	5.65	0.146	0.117
Local Govt. Exp. per capita	6.5	0.201	0.208	6.94	0.193	0.187
Interstate Outcomes						
Fatalities per VMT, 1995*	0.86	0.469	0.543	0.88	0.445	0.408
Accidents per VMT, 1995*	3.71	0.525	0.478	3.73	0.529	0.403
Maint. per Mile, millions, 1995	5.73	0.745	0.661	5.92	0.735	0.899

Note: For variables, please see note to Table 1. This table presents coefficients of variation (standard deviation divided by mean) for Interstate spending per mile and other related or major public spending categories. The first set of three columns shows results for the entire period; the second set show results just for 1971 to 1993.

Table 3: Relationship Between Interstate Spending Per New Mile and Public and Private Spending

	Coeff.	Std. Error	R^2	Residual Variation: Std. Dev.	Residual Variation: p75 - p25	Residual Variation: p90 - p10
	(1)	(2)	(3)	(4)	(5)	(6)
Interstate Spending per Mile: Entire Period, 1956-1993						
No covariates				10.51	9.41	23
Geographic covariates			0.84	4.37	3.25	8.16
Geographic covariates and						
Private Spending						
Res. Const. Spending, 1993 = 100	0.03	0.1	0.84	4.34	3.18	7.99
Health Insurance per User, 2001, $1000s	-0.34	1.99	0.84	4.38	3.27	8.02
Public Spending, all $1,000s						
Medicaid per enrollee, 1991	-0.23	0.22	0.84	4.42	3.67	8.17
Medicare per enrollee, 1991	1.29**	0.47	0.85	3.93	3.2	7.86
Local Govt. Exp per capita	-0.32	0.36	0.84	4.46	3.63	8.64
Interstate Spending per Mile: Second Half, 1971 - 1993						
No covariates				16.08	14.32	35.43
Geographic covariates			0.67	10.23	8	16.4
Geographic covariates and						
Private Spending						
Res. Const. Spending, 1993 = 100	0.51**	0.2	0.74	8.78	7.97	16.44
Health Insurance per User, 2001, $1000s	8.66*	4.99	0.7	9.68	7.27	14.62
Public Spending, all $1,000s						
Medicaid per enrollee, 1991	0.46	0.46	0.68	10.06	8.08	16.56
Medicare per enrollee, 1991	3.37**	1	0.72	9.69	7.06	15.59
Local Govt. Exp per capita	1.13**	0.57	0.69	10.06	7.67	14.13

Note: All rows contain 48 observations. *** Statistically significant at the 1% level. ** Statistically significant at the 5% level. * Statistically significant at the 10% level. All regressions are weighted by Interstate miles constructed. The first row in each panel reports results from a regression on Interstate spending per mile on a constant. The second row in each panel reports a regression of Interstate spending per mile on a constant and the three geographic covariates discussed in the text. All rows in each panel following "Geographic covariates and" report results from the estimation of Interstate spending per mile on geographic covariates and the named covariate (as in Equation 2).

Table 4: Relationship Between Spending Per Mile and Highway Outcomes

				Residual Variation		
	Coeff.	Std. Error	R^2	Std. Dev.	p75 - p25	p90 - p10
	(1)	(2)	(3)	(4)	(5)	(6)
Interstate Spending per Mile: Entire Period, 1956-1993						
No Covariates				10.51	9.41	23
Geographic covariates			0.84	4.37	3.25	8.16
Geographic covariates and highway outccome						
Fatalities per 100m miles of VMT	-1.39	1.04	0.84	4.23	3.64	8.38
Accidents per 1m miles of VMT	-0.05	0.22	0.83	4.41	3.18	8.28
Highway maintenance per mile, millions	0.21**	0.08	0.85	4.5	3.02	7.41
Interstate Spending per Mile: Second Half, 1971 - 1993						
No Covariates				16.08	14.32	35.43
Geographic covariates			0.67	10.23	8	16.4
Geographic covariates and highway outccome						
Fatalities per 100m miles of VMT	-4.51**	2.2	0.69	10.29	7.64	16.81
Accidents per 100,000 miles of VMT	0.26	0.46	0.66	10.23	7.85	15.13
Highway maintenance per mile, millions	0.44**	0.2	0.7	10.06	7.56	13.8

Note: All rows contain 48 observations, except for accidents which has 47. *** Statistically significant at the 1% level. ** Statistically significant at the 5% level. * Statistically significant at the 10% level. All regressions are weighted by Interstate miles constructed. The first row in each panel reports results from a regression on Interstate spending per mile on a constant. The second row in each panel reports a regression of Interstate spending per mile on a constant and the three geographic covariates discussed in the text. All rows in each panel following "Geographic covariates and" report results from the estimation of Interstate spending per mile on geographic covariates and the named covariate (as in Equation 2).

Table 5: Demographic Factors May Drive Health and Infrastructure Spending

	DV: Interstate Spending per Mile				
	(1)	(2)	(3)	(4)	(5)
Priv. Res. Const. Cost Index	0.074	0.065	0.022	0.013	0.055
	(0.106)	(0.117)	(0.110)	(0.108)	(0.113)
Priv. Health Ins. Exp per User, $1,000s	0.634	0.686	0.846	-0.110	-0.943
	(2.386)	(2.431)	(2.352)	(2.354)	(2.546)
Medicare per Enrl., 1991, $1,000s	1.231*	1.267*	1.158*	1.234**	0.859
	(0.616)	(0.653)	(0.608)	(0.599)	(0.654)
Local Govt. Exp p.c., $1,000s	-0.385	-0.442	-0.824*	-0.729*	-0.485
	(0.376)	(0.484)	(0.470)	(0.411)	(0.510)
Share Education HS or More		0.016			-0.158
		(0.086)			(0.111)
Median Home Value			0.045		0.013
			(0.030)		(0.045)
Median Family Income				1.535*	2.335
				(0.837)	(1.470)
Adjusted R^2	0.832	0.828	0.837	0.841	0.842
Geographic Covariates	x	x	x	x	x
Residual Variation					
Standard Deviation	3.94	3.94	3.60	3.59	3.37
75-25 Percentile	3.11	2.99	3.16	3.13	3.47
90-10 Percentile	8.12	8.13	8.61	8.11	7.95

Notes: *** Statistically significant at the 1% level. ** Statistically significant at the 5% level. * Statistically significant at the 10% level. All estimations use 48 states and weight by Interstate miles constructed. "Geographic controls" indicates the inclusion of measures of population density, slope and wetlands and rivers. Education, home value and income are from the Decennial Census. s

Appendix Table 1: Correlation Between Spending per Mile and Additional Measures of Public Spending

	Coeff.	Std. Error	R^2	Residual Variation: Std. Dev.	Residual Variation: p75 - p25	Residual Variation: p90 - p10
	(1)	(2)	(3)	(4)	(5)	(6)
Entire Period: 1956-1993						
No Covariates				10.51	9.41	23
Geographic covariates			0.84	4.37	3.25	8.16
Geographic covariates and *Public Spending*						
Local (no state) exp per capita, $1000s	-0.57	0.58	0.84	4.53	3.51	8.71
Primary & secnd. education per capita	-1.11	1.44	0.84	4.39	3.51	8.51
Capital outlays per capita, $1000s	0.07	1.88	0.84	4.37	3.23	8.11
Second Half: 1970 - 1993						
No Covariates				16.08	14.32	35.43
Geographic covariates			0.67	10.23	8	16.4
Geographic covariates and *Public Spending*						
Local (no state) exp per capita, $1000s	1.61*	0.82	0.69	10.22	8.01	14.92
Primary & secnd. education per capita	2.79	3.36	0.68	10.06	8.19	15.68
Capital outlays per capita, $1000s	5.36	3.51	0.69	10.18	7.99	14.97

Note: All rows contain 48 observations (except for accdents, which has 47). All summary statistics are weighted by Interstate miles constructed; therefore summary statistics for variables, such as Medicaid spending in 1991, may vary slightly across the two time periods.

6 Data Appendix

1. Interstate spending per mile

   See Data Appendix in Brooks and Liscow (2019).

2. Geographic Features

   (a) Population density

   We use tract population density, or county density when tract data are not available. We use data from the following Decennial Census files:

   - fill in

   (b) Slope We measure the average slope within 50m of a segment using the Digital Elevation Map from USGS.

   (c) Wetlands We use the length, in miles, that the segment touches wetlands, defined as any of the types of wetlands classified by the Cowardin system, from US Fish and Wildlife Service (2018) National Wetlands Inventory dataset.

3. Public and private spending

   (a) Healthcare spending

   We measure Medicare spending per enrollee, Medicare spending per enrollee and private health insurance spending per enrollee from the Centers for Medicare and Medicaid Services' "Health Expenditures by State of Residence, 1991-2014." We specifically use Tables 23 ("Medicare Per Enrollee State Estimates by State of Residence"), 26 ("Medicaid Per Enrollee State Estimates by State of Residence"), and 29 ("Private Health Insurance Per Enrollee State Estimates by State of Residence").

   We download data from `https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsSt` `html`

   The Centers for Medicare and Medicaid Services define private health insurance in the National Health Expenditure Accounts as "Includes premiums paid to traditional managed care, self-insured health plans and indemnity plans. This category also includes the net cost of private health insurance which is the difference between health premiums earned and benefits incurred. The net cost consists of insurers costs of paying bills, advertising, sales commissions, and other administrative costs; net additions to reserves; rate credits and dividends; premium taxes; and profits or losses." See `https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/quickref.pdf`

(b) State and Local expenditures

We use the 1967, 1972, 1977, 1982, 1987 and 1992 Censuses of Governments, as compiled by Wilammette University researchers Pierson et al. (2015).

These data do not contain state expenditures in 1967. Thus, to be time-consistent, we create a panel of spending per cenus year. Specifically, we data on total local (non-state) spending per capita per year, parks and recreation spending per capita per year, elementary and secondary education spending both per capita and per enrollee per year, and total education spending (which includes higher education and other small categories) per capita per year.

4. Other Interstate measures

(a) Highway maintenance

We rely on the 2015 Highway Statistics data and use tables XX (variables) and XX (variables) to measure

(b) Fatalities per Interstate Vehicle Miles Traveled, 1994

We use oldest available digital data on highway fatalities from Section 5 of *Highway Statistics, 1995*. Specifically, we use rely upon

- Total rural Interstate System fatalities and injuries, Table FI-6
- Total urban Interstate System fatalities and injuries, Table FI-7

Both tables also include vehicles traveled and are available at `https://www.fhwa.dot.gov/ohim/1995/section5.htm`. Fatalities are expressed per 100 million miles of vehicle travel.

5. Private construction spending

(a) Private residential construction costs

These data were assembled by Raven Molloy, who has generously shared them. Raven used city-level historical cost indexes from Company (2003). She matched the city names to Census place IDs, merged with city-level housing unit counts, and created state-wide averages. We use these state-wide averages. Costs are indexed and not in nominal dollars. Molloy uses these data in Saks (2008).

(b) Private health insurance spending

We measure private health insurance spending per enrollee from the Centers for Medicare and Medicaid Services' "Health Expenditures by State of Residence, 1991-2014." We use Table 29 ("Private Health Insurance Per Enrollee State Estimates by State of Residence").

We download data from `https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsSt html`

6. Demographics

   We use data on population from the Decennial Census. Specifically, we rely on the Census of Population and Housing for 1950 - 2000. We use state median family income[11], percent of adults over the age of 25 that have graduated high school, and median home values. All final variables are state-period averages weighted by miles.We use data on population from the Decennial Census.

7. Inflation adjustment

   We use the CPI-U from the Federal Reserve Bank of Minneapolis, downloaded from `https://www.minneapolisfed.org/community/financial-and-economic-education/cpi-calculator-information/consumer-price-index-and-inflation-rates-1913`.We

[11]Note that due to issues of data availability, we use mean family income for 1970.