THE EFFECT OF GOVERNMENT HIGHWAY SPENDING

ON ROAD USERS' CONGESTION COSTS

Final Report to the Federal Highway Administration

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Introduction

As congestion on the nation's road system worsens, social costs are mounting. Road users' journeys to perform household tasks, to commute to work, or to deliver freight take longer every year. The facts—and so far the costs—are inescapable. Based on a sample of 75 major urbanized areas in the United States, the Texas Transportation Institute estimated that traffic congestion caused roughly 700 million person hours of delay per year in the early 1980s, more than 2 billion hours of delay in 1990, and nearly 3.5 billion hours of delay by 2000.[1] The current costs of congestion—opportunity costs to motorists, reduced productivity of for-hire and private trucking operations, and higher inventory costs for shippers—could approach $50 billion a year. Growth in the nation's population and income ensures that these costs will continue to rise.

The effects of and political obstacles to economists' proposed solution to the problem—charging road users efficient congestion tolls—have been well documented (e.g., Small, Winston, and Evans (1989), Mohring (1999), and Santos, ed. (2004)). But the efficacy of government policy to address the problem—spending billions of dollars annually on our system of roads and freeways—has received little quantitative analysis. The lack of attention is surprising because the issue bears directly on debates about highway spending.

In practice, highway spending is carried out by the states assisted by funds from the Federal Highway Trust Fund, as well as a portion of their general revenues and revenues from their respective gasoline taxes. States are allocated funds from the federal gasoline tax through a complex process that is based to a certain extent on formulas that place the greatest weight on a state's interstate lane miles—as opposed to vehicle miles traveled. Under this system, some

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[1] These figures are reported at http://mobility.tamu.edu. The growth in delay is accounted for by cities that experienced little congestion in the early 1980s but now have measurable congestion and cities that have become even more congested during the past twenty years.

states receive more money from the trust fund than they put in and others receive less than they put in. From 1998 to 2003, the years covered by the 1997 Transportation Equity Act for the 21st Century, highway spending from all sources of government amounted to roughly $80 billion per year.

Each state has considerable flexibility on how to spend its highway funds and may reduce congestion by expanding road capacity or repairing roads in high-density areas. But states may also spend money to perform routine maintenance, build new roads in outlying areas to spur residential and commercial development, or finance transit projects. In any case, highway spending is generally believed to be the primary tool that policymakers use to reduce the costs of congestion to motorists, trucking operations, and firms that ship freight by truck.[2]

The purpose of this paper is to assess the effectiveness of this policy. We estimate econometric models of the determinants of congestion costs to motorists, trucking operations, and firms and find that, on average, one dollar of highway spending in a given year reduces the congestion costs to road users only eleven cents in that year. We also find that if highway spending explicitly attempted to reduce congestion by targeting expenditures to those states whose urbanized areas experience the greatest travel delays, annual congestion costs would fall $7.2 billion or roughly 20 percent. But even so, the congestion cost savings from one dollar of highway spending in a given year would still amount to only nineteen cents in that year. Of course, highway spending seeks to achieve other goals besides reducing congestion. Nonetheless, our findings indicate that such spending, even if allocated more efficiently, is simply not a cost-effective way to reduce congestion. We conclude that the evidence strengthens

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[2] Policymakers may also try to reduce congestion by instituting ramp metering and encouraging employers to create flex-time arrangements and facilitate carpooling.

the economic case for congestion pricing of roadways and provides some insight into policymakers' preference for public spending over road pricing to mitigate congestion costs.

An Empirical Model of Motorists' Congestion Costs

Because congestion affects motorists, trucking operations, and firms that receive freight shipped by truck for different reasons and across different geographical areas, we conduct separate analyses of the effect of government highway spending on these distinct road users. Motorists are primarily affected by congestion when traveling within a city (or urbanized area) on major thoroughfares during peak travel periods, usually to get to and from work. In the traffic engineering literature, highway travel delay in a city is typically specified as a function of the peak-period volume-capacity ratios for the thoroughfares that comprise the city's road system, the attributes of the city, and road users' characteristics.[3]

We extend this formulation by accounting for the effect of state highway expenditures, but doing so raises a fundamental problem. Highway travel is characterized by induced demand; that is, expenditures that expand road capacity and raise peak-period speeds will attract users from transit, alternate routes, off-peak travel times, and so on who tend to fill the available capacity during peak travel periods (Downs (1962)). Given that we are primarily interested in investigating the effect of highway spending on congestion costs, we will not hold constant other variables, such as traffic volume and road capacity, that may be affected by highway spending. By allowing these variables to vary, we avoid possible bias to our estimate of the effect of

[3] We will often interchange the term city with urbanized area and metropolitan statistical area (MSA). Urbanized areas and MSAs are determined by U.S. Census demographic criteria; nonetheless, they are typically associated with a distinct city. Data on congestion for motorists are available for urbanized areas and data on congestion for trucking operations and shipping firms are available for MSAs.

highway spending. For example, if road capacity were held constant we would not account for the improvements in road capacity that result from spending and would therefore underestimate its effect on congestion costs. Similarly, if traffic volume were held constant we would not account for the traffic that spending induces and would therefore overestimate its effect on congestion costs.[4]

The attributes of a city that may affect congestion include its population, weather, public transit system capacity, and geography (e.g., whether few roads traverse a body of water that surrounds part or all of the city). Users' characteristics that may affect congestion include the percentage of trucks in the traffic mix, employment levels, and occupational differences that may be reflected in the extent of off-peak travel.

Based on the preceding considerations, a plausible model of motorists' annual congestion costs in a city can be given by:

$$\textit{Costs} = \exp(\beta_1 * \textit{state highway spending/city population} + \beta_2 * \textit{geography} + \beta_3 * \textit{weather} + \beta_4 * \textit{transit} + \beta_5 * \textit{trucks} + \beta_6 * \textit{employment} + \beta_7 * \textit{off-peak travel} + \mu),$$

where the βs are estimable parameters and μ is an error term. The semi-logarithmic functional form is often used in analyzing delay because marginal delay is an increasing function of travel-related activity and a decreasing function of capacity (or policies that improve capacity). A constant is not included because delay should be approximately zero when travel-related activity is zero.

Note that we divide state spending by a city's population to express spending in terms of each city's relative size within a state. This specification implies that the marginal effect of

[4] Highway spending that induces travelers to switch to peak-period road travel benefits those travelers, but the benefits are (partially) offset by their contribution to congestion.

spending on congestion costs is inversely related to a city's population, which is plausible. We explored alternative specifications such as dividing spending by state population, city population squared, and the log of city population, but we obtained the best statistical fit dividing state spending by city population. We do assume that the coefficient of spending divided by city population is constant across the sample. We tested this assumption by estimating alternative specifications that, for example, interacted the spending variable with dummy variables that classified city sizes by population thresholds; but we could not identify any reliable differences in the coefficients that would cause us to reject our initial specification.

Our empirical analysis is conducted for the period 1982-1996 on 74 of the largest U.S. cities comprising 72 distinct urbanized areas.[5] (It is not possible to get a consistent set of delay data for all road users much beyond 1996.) The urbanized areas correspond to those included in the Texas Transportation Institute (TTI) data base on motorists' delay and account for much of the nation's congestion costs. Annual congestion costs for motorists are obtained for each city as the additional gasoline costs attributable to congestion plus the product of the annual hours of delay per vehicle and motorists' value of time.[6] In our base case, we assume the value of time

[5] New York City and Newark, for example, are separate cities that form an urbanized area. In the few cases where one urbanized area spanned state lines and both states had a substantial amount of vehicle miles traveled, we divided the city's annual delay based on its state's share of vehicle miles traveled. Our sample excluded Anchorage, Honolulu, and Washington, D.C., because we were unable to obtain a complete and accurate set of all the relevant explanatory variables for these cities.

[6] Congestion is also likely to increase vehicle wear and tear, but we are unable to obtain estimates of these costs. In any case, the increase in vehicle operating costs from congestion is primarily due to lower fuel economy from stop and go driving.

to be one-half the average hourly wage in the city (Small (1992)), but we explore how our main findings are affected by alternative assumptions.[7]

The additional fuel costs attributable to congestion and the delay to motorists and trucks are obtained from TTI.[8] TTI estimates intracity delay using data from the U.S. Department of Transportation on traffic volumes for different functional classifications in each city (e.g., interstates and major arterials in Los Angeles). Delay for each classification is calculated as the difference between free-flow speeds and travel speeds during congestion based on speed-flow curves developed from those in the *Highway Capacity Manual*. TTI verifies their estimates of delay by collecting observations in each city on actual free-flow and congested travel speeds. Note that free flow as opposed to optimal travel speed is the relevant benchmark for calculating delay because we are interested in the effect of spending on total congestion costs, not just the portion of congestion costs that would remain if the road authorities implemented efficient pricing.

The travel delays reported in the TTI data conform to notions about the severity of congestion over time and across urban areas. For the entire sample, average daily delay increased from 1.63 minutes/vehicle in 1982 to 6.04 minutes/vehicle in 1996. Motorists in Los Angeles experienced 9 minutes of daily delay in 1982 and nearly 26 minutes of delay in 1996,

[7] Following TTI, we assume 1.25 people per vehicle. City wage data are from the Bureau of Economic Analysis. It is reasonable to use the average wage because the TTI data focus on delay during peak periods when unemployed people are less likely to be traveling. Furthermore, drivers tend to have higher average incomes than people who use other modes to commute to work; thus, it is appropriate to induce some upward bias in the wage.

[8] TTI's estimates of auto delays assume trucks comprise 5 percent of vehicle traffic; thus, we multiply the delay and operating cost figures by 0.95 to focus on only motorists' congestion costs in this section.

while those in Milwaukee experienced 1 minute of delay in 1982 and roughly 5 minutes of delay in 1996.

Using these data, the assumed value of time, and the change in vehicle operating costs, we find that congestion costs to the nation's motorists in the last year of our sample, 1996, amounted to roughly $27.5 billion (2000 dollars).[9] Our estimate is plausible, although it is considerably lower than those reported by TTI because they use a higher value of time for both motorists and truckers.

We obtained gross highway spending by state (not including spending on transit) from annual volumes of the Department of Transportation's *Highway Statistics*. Note that state spending includes funds that are received from federal, state, and local sources. Since the early 1980s, highway spending has been primarily directed towards maintaining the highway capital stock rather than expanding it, as evidenced by the fact that highway mileage has grown only 2 percent during the period of our sample.

Highway spending is not available at a smaller geographical level than a state; however, our interest lies in how state-level expenditures, the relevant policy variable, affect congestion costs—notwithstanding where funds are allocated within a state. We are able to address this issue by accounting for the effects of state highway spending on the major sources of congestion

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[9] Based on our sample, we estimate that annual congestion costs to motorists in 1996 were $24.5 billion (2000 dollars). Our sample accounted for 71.3 percent of national urban VMT. To convert our sample estimate to a national estimate, one might be temped to inflate the sample estimate by 1/.713 or 1.4. However, it is useful to test whether cities' congestion costs are proportional to their VMT. We found that the cities that accounted for 71.3 percent of the sample VMT accounted for 89 percent of the congestion costs in the sample, indicating that the largest cities account for a greater proportion of congestion costs. Thus, we would overestimate national congestion costs by inflating the sample estimate by 1.4. As a more defensible alternative, we obtain a national estimate of annual congestion costs by assuming the relation between congestion costs and VMT in the sample is aligned with the relation between congestion costs and VMT in the nation. Thus, we inflate the sample estimate by 1.12 (1/.89).

costs throughout a state. As noted, we effectively weight spending in each city that experiences significant congestion by a city's share of the state population.

As shown in figure 1, highway spending in the United States has increased during the period of our sample with the aid of major federal legislation. Namely, the 1982 Surface Transportation Assistance Act instituted a 5 cents/gallon increase in the federal gasoline tax that enlarged the Highway Trust Fund, and the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) increased support for highway demonstration projects and other road-related activities. Spending also increased because growth in automobile and truck travel during the period led to greater federal and state gasoline tax receipts.

In our base case, we treat state highway spending as exogenous because it does not appear to be systematically related to an urbanized area's congestion costs, but we test that assumption. We expect that increases in spending will reduce a city's congestion costs, but the magnitude of this effect could be affected by the quality of the state's highway capital stock. For example, spending may have less of an effect on congestion costs in a state with a well-developed road system that is in good condition than in a state with a less developed road system that needs substantial repairs. Thus, we interact spending with a dummy variable indicating the per capita value of a state's highway capital stock in the year preceding spending compared with the per capita value of other states' highway capital stock. Real state highway capital stock data come from Bell and McGuire (1997).[10]

In addition to this consideration, the political forces that surround highway spending suggest that its effect on congestion costs could be reduced for two reasons. First, political

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[10] The highway capital stock was estimated using the perpetual inventory method, in which the value of the capital stock in a given year is based on the current capital investment plus the sum of previous investments that have been adjusted for depreciation and discards. We used the FHWA composite price index to convert the states' highway capital stock to 2000 dollars.

pressures may influence highly urbanized states to distribute their funds among cities in a manner that is not closely related to each city's congestion. Thus, based on data from the U.S. Census, we interacted highway spending with a dummy variable that indicated whether a state is highly urbanized.[11] Second, Altshuler and Luberoff (2003) point out that states with members in Congress who occupy a position of party leadership in the House or Senate are likely to pursue funding for pet (pork barrel) projects that have little to do with reducing congestion. We control for this possibility by interacting spending with a dummy variable that indicated whether at least one member of Congress from the state was in a position of national party leadership.[12]

Turning to the attributes of a city that may affect congestion, we included annual precipitation and the annual number of days with temperature over 90 degrees Fahrenheit to control for the effect of weather. Both variables were obtained from the National Oceanic and Atmospheric Administration and should have a positive effect on congestion costs because they may impair pavement conditions and require drivers to reduce their speed or contribute to vehicle breakdowns that cause delays. We measured transit capacity with bus and heavy, light, and commuter rail directional route miles obtained from the *Section 15 Annual Report* (*National Transit Database*) of the Federal Transit Administration. We expect an increase in rail mileage to reduce congestion by attracting road users to rail. Similarly, an increase in bus mileage could reduce congestion by attracting motorists to bus, but it could also increase congestion because buses take up more road capacity per vehicle than cars and may disturb the traffic flow by stopping enroute and accelerating slowly. Cities that provide exclusive bus lanes may improve

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[11] We obtained the best statistical fits by assuming that a state was highly urbanized if 80 percent of its population lived in an urbanized area. Using alternative thresholds did not have a material effect on our findings.

[12] Positions of party leadership are defined in accordance with those listed in the *Congressional Directory*.

bus service but also experience greater congestion because cars are prevented from using all of the available road capacity. Finally, we controlled for the salient features of a city's geography with a major interstate dummy, defined for cities with either a major north-south interstate (identified by a two-digit number ending in 5) or a major east-west interstate (identified by a two-digit number ending in 0). We expect this variable to have a positive sign because it captures the additional congestion caused by motorists who pass through the area. We also created a bottleneck dummy, defined for cities with few interstates or other roadways that traverse a major body of water (e.g., bay, river, or lake) that is located in a city. Bottleneck routes are prone to becoming congested because motorists often lack alternatives to such routes; thus, we expect this variable to have a positive sign.

Two characteristics of road users that are likely to increase congestion costs in a city are the proportion of truck traffic and the level of employment. A greater share of trucks slows the traffic flow while higher employment leads to more commuters (i.e., traffic) on the road during peak periods. We obtained data on the percentage of VMT attributable to trucks from the Department of Transportation's Highway Performance Monitoring System and data on employment from the Bureau of Economic Analysis. Cities that have more road users, employed or otherwise, who travel during off-peak times will have lower congestion costs. We therefore included vehicle-miles-traveled off peak based on the TTI data. As discussed below, it is appropriate to include this variable because it is not related to highway spending.

Estimation Results

It is not clear how long it takes spending to affect congestion costs. Preliminary estimations revealed little empirical difference between specifying spending as contemporaneous with congestion costs or with a lag; thus, we report results using current spending. To enable us to compare and combine the estimation results for motorists and trucking operations and firms (presented later), we put all relevant variables in 2000 dollars using the consumer price index for urban consumers from the Bureau of Labor Statistics; in the case of highway spending, we used a construction cost index from the Federal Highway Administration.

Parameter estimates based on our semi-log specification of congestion costs are presented in table 1. The model presented in the first column of the table does not include the volume-capacity ratio because it may be affected by highway spending and, in turn, affect the spending coefficients. The model in the second column includes the volume-capacity ratio. We include state fixed effects in both models because, in general, they were statistically significant and had little effect on the spending coefficients. We also experimented with city fixed effects, but they did not fit as well as the state fixed effects. Finally, we did not include year dummies or a time trend in the base model because they would tend to capture changes in VMT that would affect the spending coefficients. We did estimate a model that included the real price of gasoline to capture a broad exogenous influence on congestion costs that varied over time but was not affected by highway spending; however, it was statistically insignificant.

Highway Spending. Our central finding is that state highway spending reduces congestion costs in a city and the effect is statistically significant. We have argued that state highway spending should be treated as exogenous because it is not systematically tied to an urbanized area's congestion costs. We tested this assumption with a Hausman specification test using highway spending in other states as instruments for highway spending in a given state. We found that we could not reject the exogeneity of state highway spending at a high level of statistical significance.

As expected, the beneficial effects of highway spending are reduced for cities in highly urbanized states and in states with at least one member of Congress who is a party leader.[13] The latter finding is consistent with the view that states with party leaders are more likely to receive pork barrel spending that has little effect on congestion. Altshuler and Luberoff (2003) discuss several examples of politically motivated highway spending that results in waste such as the well-known Big Dig in Boston.

We also find that spending is less effective in reducing congestion costs for states that have made the largest per capita investments in their capital stock and more effective in reducing congestion costs for states that have the smallest per capita investment.[14] States that fall into the first category include Kansas, Kentucky, Minnesota, and Nebraska, while states that fall into the second category include California and Florida. This finding may simply reflect the diminishing marginal productivity of capital. But it is also consistent with federal allocations of highway funds that are based on road mileage rather than vehicle miles traveled and motivates interest in whether highway spending would be more efficient if funds were targeted to those areas with the highest congestion costs.

As shown in the second column of the table, state spending has a smaller effect on congestion costs when traffic volume (VMT) and capacity (road miles) are included in the

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[13] We also explored whether the effect of state spending varied when a state had more than one city in our sample. We specified a dummy variable to identify urbanized areas from the same state, but this only affected the state fixed effects. We also interacted the dummy with the spending variable, but this had little effect on the results.

[14] For each year, we constructed dummy variables categorizing states within each decile of the sample based on the value of their per capita highway capital stock in the preceding year. We then interacted these dummies with state spending per urbanized area resident to measure the relative effectiveness of spending for different levels of highway capital investment. We obtained the best statistical fit indicating clear differences among states by characterizing states at or above the 70th percentile as states with high per capita capital stock and states at or below the 20th percentile as states with low per capita capital stock.

model, indicating that we would underestimate the impact of spending if the volume-capacity ratio were held constant. Noland (2000) reports that estimates of the elasticity of induced demand with respect to highway spending tend to be much less than 1.0; thus, it is not surprising that by increasing capacity, spending has reduced congestion even though some traffic has been induced by the additional capacity. Pickrell (2002) reports a similar finding. [15]

Using the coefficients in the first column of the table, we estimate that one dollar of highway spending in the last year of our sample, 1996, reduced motorists' congestion costs only 3.3 cents in that year (2000 dollars).[16] Note that this benefit is not an ongoing return, but only applies to the year in which spending occurred.[17] Although highway spending serves many

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[15] We also explored the effects of including other variables in the model, such as urban density and a time trend, that may affect congestion costs but also may be affected by highway spending. It is possible that congestion would be higher in cities with smaller land areas for a given population because of higher traffic densities. However, spending could expand commuter possibilities and extend urbanized area boundaries. We included the square miles for an urbanized area, assuming constant growth between decennial censuses, and again found that it reduced the effect of highway spending. It is also possible that congestion costs are affected by unobserved effects over time such as technical change in vehicle handling and braking that enables vehicles to travel closer together at higher speeds. We therefore specified a time trend to capture this possibility, but it had a positive effect on congestion costs and reduced the highway spending coefficient. We suspect that the time trend was also capturing growth in VMT, some of which may be related to highway spending.

[16] We obtained this figure by first using the estimated coefficients to predict congestion costs in our sample with and without 1996 highway expenditures by states. We inflated the difference by 1.12, as discussed in footnote 9, to obtain the effect of spending on congestion costs for the nation. We then divided this figure by 1996 national highway spending, $85.2 billion (2000 dollars). If we constructed the inflator by assuming that our sample accounted for 71.3 percent of congestion costs (i.e., its share of VMT equaled its share of congestion costs), then the congestion cost savings from one dollar of spending would be 4.1 cents. Finally, the congestion cost savings per dollar of spending based on all years in the sample was 4.0 cents.

[17] It could be argued that highway spending in 1996 would reduce congestion costs in future years by adding to the value of the capital stock. But such spending supplemented the value of each state's capital stock only six percent on average. In addition, any benefits from this modest improvement in the capital stock would be reduced significantly by depreciation in just a few years. Given that we found that spending reduced motorists' congestion costs only three cents in the year that spending occurred and that additional cost savings in the future would be much

purposes, policymakers frequently cite reducing congestion as among the most important. Thus, our estimate seriously questions the cost-effectiveness of current spending priorities if policymakers wish to achieve this goal.[18] As noted, we did not include several variables in the model that affected congestion costs but were arguably affected to some extent by highway spending. If we included any of these variables in the model, the effect of highway spending on congestion costs would be even lower. Finally, although our estimate is roughly proportional to the value of time that is assumed, the estimate is sufficiently small that the overall finding that spending has a small effect on congestion costs it is not affected by the assumed value. For example, if we assume that motorists value time at 75 percent of the wage instead 50 percent of the wage, congestion costs are reduced 4.5 cents per dollar of spending. If we assume that motorists value time at 25 percent of the wage, costs are reduced 1.5 cents per dollar of spending.

Other parameter estimates. Many urban planners have argued that bus and rail transit merit subsidies partly on the grounds that these modes help reduce congestion. We find that an increase in rail transit mileage reduces congestion costs but bus service actually *increases* congestion costs to motorists, especially when it operates on exclusive bus lanes. Buses disrupt the traffic flow when they share road capacity and contribute to motorists' congestion by having exclusive use of available road capacity that would otherwise be available to all vehicles. Moreover, bus systems operate with very low load factors (roughly 15 percent over the course of the day, moderately higher during peak periods) and transport only a small share of urban travelers.

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smaller, our assessment of the efficacy of highway spending should not be affected by long-run considerations.

[18] It does not appear to be the case that highway spending is ineffective because it induces more traffic. The annual effect of a dollar of spending on motorists' congestion costs only falls from 3.3 cents to 2.4 cents when the volume-capacity ratio is held constant.

The remaining variables have their expected signs and are statistically significant. Annual precipitation, days with extremely high temperatures, routes with potential bottlenecks, a major interstate running through the city, trucks, and higher levels of employment increase a city's congestion costs.[19] Greater off-peak travel decreases these costs.[20] Although it may be argued that even some of these variables such as the presence of bottleneck routes, a major interstate, or the share of truck traffic may be influenced by highway spending, we found that the magnitude of the spending coefficients varied by no more than 6 percent when we included the city and user characteristics individually or collectively in the model.

Empirical Models of Congestion Costs for Trucking Operations and Firms

Congestion also reduces the efficiency of the surface freight sector of the U.S. economy. Firms engaged in activities such as manufacturing, agriculture, and construction (hereafter firms) use for-hire trucking companies and provide their own trucking service to transport freight within and between cities. When traffic congestion increases the time that it takes truckers to deliver shipments, trucking operations incur the opportunity cost of the driver's time and higher vehicle operating costs. In addition, firms incur the costs associated with holding higher

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[19] In addition to the variables reported here, we also estimated specifications that included the number of days with freezing temperatures and, as an alternative way to account for the presence of a bottleneck, a dummy variable that indicated whether a city was adjacent to a body of water. However, these variables did not lead to improvements in the model.

[20] As noted, the reason for including the off-peak variable is to capture demographic differences between cites such as the share of workers who do not commute during peak times. However, it is possible that this variable could capture motorists who shift from peak travel to off-peak travel because of high congestion costs. If this were the case, we would expect that the inclusion of off-peak VMT in the specification would increase the spending coefficient because people would be prevented from shifting to peak times (i.e., we would not be accounting for a specific source of induced demand). But we found that the coefficient for spending decreased slightly when we included the off-peak VMT variable in the model.

inventories to avoid shortages and stockouts that arise when demand for their products exists but none are in inventory. Of course, when congestion imposes costs on trucking companies, these costs are likely to be passed on to firms in higher rates given that trucking operations are highly competitive. However, we will estimate separate models for truckers and firms, rather than combining their congestion costs and estimating a single model, because highway spending may have different effects on their congestion costs.

Trucking Operations. Truckers are potentially exposed to congestion at the origins of the shipments, the locales that the shipments pass through enroute to their destinations, and at the destinations. Congestion raises the cost of trucking operations because drivers are still "on the clock" and must be paid for the additional time spent on deliveries regardless of whether they are sitting in traffic or traveling to their destination at reduced speeds. In addition, trucks suffer losses in fuel efficiency and require greater maintenance when they are driven at the reduced speeds caused by stop-and-go driving conditions. The annual costs of congestion to truckers can be measured as the product of the hourly value of delay per vehicle, including labor and capital costs, and the annual vehicle hours of delay.

Our empirical analysis of the effect of government highway spending on truckers' congestion costs is based on shipping activity between and within 51 of the largest metropolitan statistical areas (MSAs) in the country. We used the 1997 U.S. Census Commodity Flow Survey to determine the number of heavy vehicles transporting freight between and within the MSAs in our sample.[21] The vehicles account for 34.6 percent of the tons of freight shipped by truck in the

[21] The Commodity Flow Survey reports tons of freight shipped between and within MSAs. To determine the number of heavy vehicles used to carry freight, we assumed each truck carries, on average, 12.5 tons or 25,000 pounds. This assumption is reasonable given that trucks that are fully loaded typically carry no more than 20 tons and that some trucks run empty or are partly loaded. Our findings did not change noticeably when we assumed that trucks' average loads were 15 tons or 10 tons.

United States. Note that 70 percent of the tons of freight shipped by truck are transported less than 50 miles; we capture a share of those shipments that are made within the congested cities in our sample.

We used the TTI data to estimate the delay for shipments within an MSA. We obtained estimates of average delay between MSAs (i.e., the 51 X 51 off-diagonal origin destination pairs in our sample) from the Freight Analysis Framework (FAF) developed by the FHWA Office of Freight Management Operations. FAF routes intra- and interstate shipments throughout the country and determines the delay that trucks experience between MSA origins and destinations. Data on traffic volumes and road characteristics that might affect delay, such as shoulder width, inclines, and curves, are collected from state departments of transportation. Using the *Highway Capacity Manual*, delay is calculated as the difference between free-flow speeds, accounting for road characteristics, and estimates of travel speeds under congested conditions based on actual traffic volumes and speed-flow curves.[22] The estimates of delay are quite reasonable. For example, shipments between New York City and Los Angeles were delayed 3 hours by congestion, shipments between Los Angeles and San Francisco delayed 1.5 hours, and shipments between Kansas City, Kansas, and Kansas City, Missouri, delayed only 4 minutes.

The cost of congestion for each vehicle has three components: labor, fuel, and maintenance. Credible estimates of the cost of an hour of delay are roughly \$24 for average compensation, including wages and benefits and \$2 for diesel fuel. We assumed \$4 for maintenance to bring the \$30 per hour total in line with the National Cooperative Highway

[22] We are grateful to Bruce Lambert of the FHWA for his assistance in procuring delay data based on FAF.

Research Program's (2001) estimates.[23] We also performed estimations using alternative values of the hourly cost of congestion. We estimated annual congestion costs incurred by trucks transporting freight from a given origin to a given destination. Summing over all origin-destination pairs, our estimate of congestion costs for the nation's trucking operations in 1997 is $2.46 billion (2000 dollars), which is in proper proportion to motorists' congestion costs, as discussed below.[24]

Firms. Firms that receive freight shipped by trucks are also affected by congestion at the origins of the shipments, the locales that the shipments pass through enroute to the firms' destinations, and at the destinations. Congestion raises firms' costs because it ties up their inventory in transit, thereby forcing firms to hold higher inventories to reduce the probability of a stockout caused by late deliveries. In addition, delays caused by congestion could depreciate the value of perishable shipments such as fresh fruit. The costs that firms attach to the additional time that shipments spend in transit are captured in an implicit discount rate which indicates the loss they incur, as a percentage of shipment value, for each day that their shipments are delayed. The annual costs of congestion to firms can be measured as the product of an implicit daily

[23] Driver wages of roughly $18 per hour are reported in the Bureau of Transportation Statistics' 2000 *Motor Carrier Financial and Operating Information Report*. We inflate this figure 30 percent to account for fringe benefits. The additional diesel fuel costs are obtained by using TTI's assumptions that trucks travel at 60 miles per hour in free-flow conditions and 37.8 miles per hour in congestion and calculating fuel usage based on the Federal Highway Administration's *Highway Economic Review System* fuel economy equations. We use the U.S. Census *Vehicle Inventory and Use Survey* to calculate a weighted average of additional fuel costs based on the distribution of truck sizes and trailer configurations in the country.

[24] Truckers' congestion costs in our sample are $1.13 billion (2000 dollars). As noted, the sample accounts for 34.6 percent of tons of freight shipped by truck in the United States. The cities that compose 34.6 percent of the sample account for 46 percent of the truckers' congestion costs in the sample, indicating that the largest cities account for a greater proportion of congestion costs. Following the argument in footnote 9, we therefore multiplied the sample estimate by 2.17 (1/.46) to obtain a national estimate of the cost of congestion to truckers.

discount rate, the annual value of shipments, and the average delay in days that shipments incur because of congestion.

As in the case of truckers, our empirical analysis is based on shipping activity between and within 51 of the largest metropolitan statistical areas (MSAs) in the country. We used the 1997 U.S. Census Commodity Flow Survey to obtain the value of commodities shipped by truck between and within the MSAs in our sample. The sample accounts for 33.8 percent of the national value of goods shipped by truck. Note that a significant fraction of the value of freight shipped by truck is not exposed to congestion because it is transported short distances or consists of basic manufacturing inputs such as basic metals and chemicals that are hauled between low-density areas. We used the TTI data to estimate the delay for shipments within an MSA and the Freight Analysis Framework to obtain estimates of average delay between MSAs. We classified commodities as either perishable (e.g., fresh produce), bulk (e.g., gravel), or other to quantify shippers' implicit discount rate. Based on estimates derived from Winston's (1981) freight demand model, we assumed for our base case that firms' daily discount rate is 15 percent for perishable commodities, 5 percent for bulk commodities, and 10 percent for other commodities.

We estimated annual congestion costs for firms at each given destination that received freight from each given origin. Summing over all origin-destination pairs, our estimate of the congestion costs for the nation's firms in 1997 is $7.58 billion (2000 dollars).[25] Thus, adding this figure to the $2.46 billion in congestion costs incurred by truckers yields roughly $10 billion in congestion costs for the surface freight sector. Although truck traffic represents roughly 5

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[25] Firms' congestion costs in our sample are $2.98 billion (2000 dollars). The sample accounts for 33.8 percent of the value of goods shipped by truck. The cities that make up 33.8 percent of the sample account for 39.3 percent of the congestion costs in the sample, indicating that the largest cities account for a greater proportion of congestion costs. Thus, to obtain a national estimate of the cost of congestion to firms, we multiplied the estimate derived from the sample by 2.54 (1/.393).

percent of all vehicle miles, our estimate indicates that the freight sector experiences a much higher share, 27 percent ($10 billion/$37.5 billion), of annual congestion costs. This should be expected because truckers travel through multiple urbanized areas to deliver shipments whereas motorists typically travel between their residence and workplace in a given city. In addition, the hourly cost of delay for truck transportation is typically much higher than the hourly cost of delay to auto travelers. For example, based on our assumptions, the average value of an hour of delay for a passenger vehicle is $9.71, while the average value of an hour of delay for a truck, accounting for truckers' costs ($30/hour) and firms' costs ($33.69 per hour, as implied by the inventory costs of congestion), is $63.69.

Specifications. Similar to our model for motorists, we specify the congestion costs of trucking operations that transport freight to a given MSA and of firms in a given MSA that receive freight to be a semi-logarithmic function of highway spending, city attributes, and road user characteristics (allowing variables that may be affected by highway spending to vary). Given that truckers' and firms' congestion costs reflect delay that is in-state and possibly out-of-state, we expand the geographic scope of some of the explanatory variables. Shirley and Winston (2004) report that the value of the highway capital stock varies markedly by the nine Census geographic divisions. Thus, we interact highway spending with a dummy variable for each Census division to explore how the effect of spending on truckers' and shippers' congestion costs varies with a division's investment in its capital stock. We also include as a separate variable highway spending in all other states (out-of-state spending) where freight may be shipped to a given MSA. We control for intermodal competition from water carriers that may reduce intercity freight traffic by including a dummy variable that indicates whether the MSA has direct access to ocean shipping.[26] And we account for congestion caused by trucks in the traffic mix and urbanization by measuring these variables at the state level.[27] Other influences on truckers' and firms' congestion costs are measured at the MSA level.

Estimation Results

As shown in table 2, state highway spending does reduce congestion costs for trucking operations and firms and the effect is statistically significant. (We could not reject the hypothesis that spending is exogenous and obtained the best statistical fits by dividing spending by MSA residents.) We also find that spending is statistically significantly more effective in reducing congestion costs in the New England and Pacific Census divisions—among all divisions these two tend to have the lowest values of per capita highway capital stock.[28] However, we did not find that out-of-state spending had a statistically significant effect on congestion costs, presumably because one state's spending tends to have a diffuse influence on the delay experienced by trucking operations in another state.

Based on the coefficients for each model, we estimate that one dollar of state highway spending in 1997 reduced truckers' congestion costs 4.50 cents (2000 dollars) and reduced firms'

[26] Rail and inland water carriers also provide intermodal competition for intercity trucking operations, but it was difficult to construct measures that indicated the degree to which MSAs were or were not served by these alternative modes.

[27] Data for the number of truck registrations at the state level are from the 1997 U.S. Census Truck Inventory and Use Survey. It is unlikely that this variable is influenced by highway spending (or congestion costs) because trucks are typically registered in states where motor carriers base their operations, which is influenced by tax rates and network considerations.

[28] We interacted division dummies with state spending per MSA resident to measure the relative effectiveness of spending for different regional levels of highway capital investment. Although the dummies could also capture other divisional differences such as topography that may influence the effectiveness of spending, our findings are consistent with the previous findings for motorists that indicate that areas with low capital investment benefit more from spending than areas with high capital investment.

congestion costs 3.56 cents (2000 dollars) in that year.[29] Given that truck journeys are potentially subject to delays in multiple MSAs and that congestion is much more costly on an hourly basis for truckers and firms than for motorists, it is understandable that spending's average effect on the freight sector's congestion costs, 8.1 cents, exceeds its average effect on motorists' congestion costs, 3.3 cents. Even so, the eleven cents reduction in road users' congestion costs in the year in which a dollar of spending occurs is quite small.[30]

In contrast to the parameter estimates for motorists, we did not find that the effect of highway spending for the freight sector was partially reduced by party leadership in Congress or by competition among urbanized areas within a state for highway funds. The former finding suggests that public officials' pork barrel projects may not influence the efficacy of spending over the broad geographical areas that trucking operations traverse. We also did not find that variables that may affect the spending coefficient if they were included in the model (e.g., the volume-capacity ratio), had a statistically significant effect on truckers' and firms' congestion costs, possibly because many vehicles travel through (or around) many MSAs, some of which

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[29] We obtained these figures by using the coefficients to predict congestion costs for truckers and firms in our sample with and without 1997 state highway expenditures and inflating these values by the appropriate inflators given in footnotes 24 and 25. We then divided the congestion cost savings by 1997 national highway spending. Our findings were not particularly sensitive to the assumptions that we made to construct congestion costs. For example, if we doubled (halved) the assumed discount rates for firms, then their average cost savings per dollar of highway spending were 7.6 cents (1.4 cents). If we increased or decreased the assumed $30 hourly cost of congestion for trucks by $5, then the congestion cost savings per dollar of highway spending changed by less than one cent.

[30] Shirley and Winston (2004) found that the rate of return from highway investments during the 1990s was only about 1 percent. Their estimate was based on firms' logistics cost savings and did not include congestion cost savings. According to the findings here, congestion cost savings would not add much to the rate of return.

may be out of state.[31] Finally, we did not find that some variables that had a statistically significant effect on motorists' congestion costs, namely the interstate and bottleneck dummies, extremely high temperatures, and off-peak travel, had a statistically significant effect on truckers' and firms' congestion costs.

However, several other influences do parallel our qualitative findings for motorists. Bus transit capacity, precipitation, trucks, and higher levels of employment and urbanization increase truckers' and firms' congestion costs, while rail transit capacity and intermodal competition from water transportation, as reflected in the costal dummy variable, decrease these costs. As we found previously, including these variables in the model had little effect on the spending coefficients.

Efficient Allocation of Highway Funds Among States

Congestion costs vary significantly among and within states, but the allocation of highway funds is not based on these variations. It is therefore likely that highway spending would be more effective in reducing road users' congestion costs if expenditures were explicitly targeted to the areas in the country with the greatest congestion. We estimated how much the cost-effectiveness of highway spending would improve if funds were allocated to states to minimize total highway costs, *TC*, composed of road users' congestion costs and state highway expenditures, subject to the current level of highway spending. Formally, the problem can be expressed as:

$$\min_{s_i} TC = \sum_i C_m(s_i) + C_t(s_i) + C_f(s_i) + s_i \quad s.t. \ \sum_i s_i = S \ ,$$

[31] We measured the volume-capacity ratio at the MSA and state level. We were not able to construct a measure of it that accounted for out-of-state traffic.

where s_i is highway expenditures by state i, C_m, C_t, and C_f are motorists', truckers', and firms' congestion cost functions as respectively given in table 1, column 1, and table 2, columns 1 and 2, and S is the current level of highway spending in the nation (all appropriate variables are in 2000 dollars).

We find that congestion costs would be reduced $7.2 billion, or more than 20 percent of the annual congestion costs incurred by road users, if state highway expenditures were allocated among states to minimize total highway costs.[32] Motorists' congestion costs would decrease $5.62 billion, truckers' $0.45 billion, and firms' $1.12 billion. Not surprisingly, funding would increase within states, such as California, Florida, Texas, and Washington, that have urbanized areas with high congestion costs and decrease for all of the other states.

Previously, we found that one dollar of annual highway spending benefits the freight sector noticeably more than motorists partly because truck shipments are often delayed by congestion in multiple urbanized areas. However, by curtailing the extent of highway spending throughout the country in favor of greater expenditures in a select group of states with highly congested cities, one dollar of annual spending would reduce motorists' congestion costs 9.02 cents and reduce truckers' and firms' congestion costs 9.94 cents for a combined annual savings of 19 cents. This represents a clear improvement for road users and partly illustrates why current policy is inefficient. Nonetheless, even with a more efficient allocation of funds, highway spending is not a cost-effective way to reduce congestion.

In fact, we have overestimated the gain from allocating highway spending efficiently among states because some states would actually be allocated less money than they raised from their gasoline tax and general revenue. Incorporating a minimum spending constraint to prevent

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[32] We determined the cost savings in the sample from minimizing total highway costs and used the inflators for motorists, truckers, and firms to obtain national cost savings.

this possibility from occurring would reduce the estimated savings. On the other hand, additional cost savings could be achieved by allocating spending more efficiently within states. Although we are unable to quantify these savings, they are unlikely to change our conclusion that even optimal spending is not a cost-effective way to reduce congestion.

Discussion and Policy Implications

We have estimated that one dollar of government spending on highways reduces road users' congestion costs eleven cents in the year that spending occurred. Given that motorists, trucking operations, and firms incur $37.5 billion in annual congestion costs, states would have to spend nearly $350 billion annually to eliminate these costs.[33] Furthermore, it does not appear that reallocating funds to states with the highest congestion costs will make it much easier for the nation to spend its way out of congestion. To be sure, highway spending serves other functions, such as improving the safety and reliability of road travel, but it is clearly an inefficient way to address the problems caused by congestion.

Why is government spending so ineffective? Shirley and Winston (2004) argue that highway spending is compromised by inefficiencies related to pork barrel politics, slow and inappropriate responses to demographic changes, excessive maintenance expenditures due to poor road designs that encourages underbuilding pavement, and inflated labor costs attributable to the Davis Bacon Act. Roth (2003) points out that there is now no explicit mechanism to link state highway expenditures with congestion in specific localities.

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[33] This figure clearly overstates the annual amount of highway spending that would be required to eliminate congestion costs because such huge additions to the capital stock would undoubtedly reduce congestion costs greatly in future years.

But the most fundamental problem that limits the effectiveness of spending for the foreseeable future is that the U.S. intracity road system is largely complete and the nation's urbanized areas have little available land to expand their infrastructure. To be sure, cities that are experiencing sprawl can expand their road system, but these infrastructure investments are not likely to reduce current congestion costs. In most congested cities, it is extremely difficult or prohibitively expensive to widen major freeways and arterials to reduce congestion or for such construction to keep up with traffic growth. Notwithstanding the nation's $15 billion investment to improve Boston's traffic flow, it is highly doubtful that another U.S. city will have the opportunity to replicate that experience or that projects on such a scale come close to being cost effective. By rehabilitating lanes and occasionally widening an arterial, highway spending in most U.S. cities can, at best, have a small effect on delays.

The silver lining in these findings is that they clearly imply that an alternative policy to highway spending is desirable to reduce congestion costs. Economists have argued that road pricing is that alternative, especially because it is effective during rush hours that would otherwise require the most expensive capacity expansions. Moreover, unlike spending road pricing produces benefits without use real resources, except for setting up the tolling mechanism. If the adoption of road pricing were tied to reductions in highway spending, then states could improve their budgets (or use these funds for more socially desirable purposes) without fear that the spending cuts would significantly increase congestion.

Notwithstanding its contribution to efficiency, congestion pricing is criticized—and dismissed as politically infeasible—because it would primarily benefit high-income motorists who value the time savings. However, Small, Winston, and Yan (2004) show that road prices can be adjusted to account for motorists' different preferences and substantially reduce distributional concerns while producing efficiency gains. In contrast, highway spending is financed primarily by the gasoline tax, which is generally considered to be regressive (Chernick and Reschovsky (1997)). We are not aware of estimates of how road pricing would affect the freight sector, but given their high value of time, truckers and shippers are likely to find that efficient congestion tolls are cost effective. Moreover, the freight sector is likely to pass on some of the cost savings to consumers.

In the final analysis, policymakers' lack of interest in congestion tolls may have less to do with pricing's distributional effects than with the distributional effects of highway spending.[34] Highway spending supports projects that are politically popular with federal, state, and local policymakers and constituents. In fact, Senator Rick Santorum, who opposed the 2004 federal transportation spending bill passed by the Senate because of its high price tag, warned any lawmaker "not to get between a congressman and asphalt, because you will always get run over."[35] Supporters of the bill claimed that it had to receive substantial funding to address the traffic-clogged roads that burden the economy. Instituting congestion pricing for road users would be a far more effective solution to clogged roads than the states' highway spending and would justify a reduction in public expenditures. Indeed, road pricing's fatal flaw may be that it threatens one of the most visible ways that elected officials reward their supporters.

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[34] As part of the 2004 highway reauthorization legislation, both the U.S. Senate and House of Representatives passed bills with projected expenditures greatly surpassing gasoline tax revenues. The Senate bill allows states to implement congestion tolls on existing roads, while the House bill allows tolls on newly constructed highways until highway bonds are paid off. Neither bill envisions tolls as a funding source that relieves the states' dependence on gasoline tax revenues.

[35] Christopher Lee, "Highway Bill Passes Senate, Faces Opposition From Bush," *Washington Post*, February 13, 2004, p. A4.

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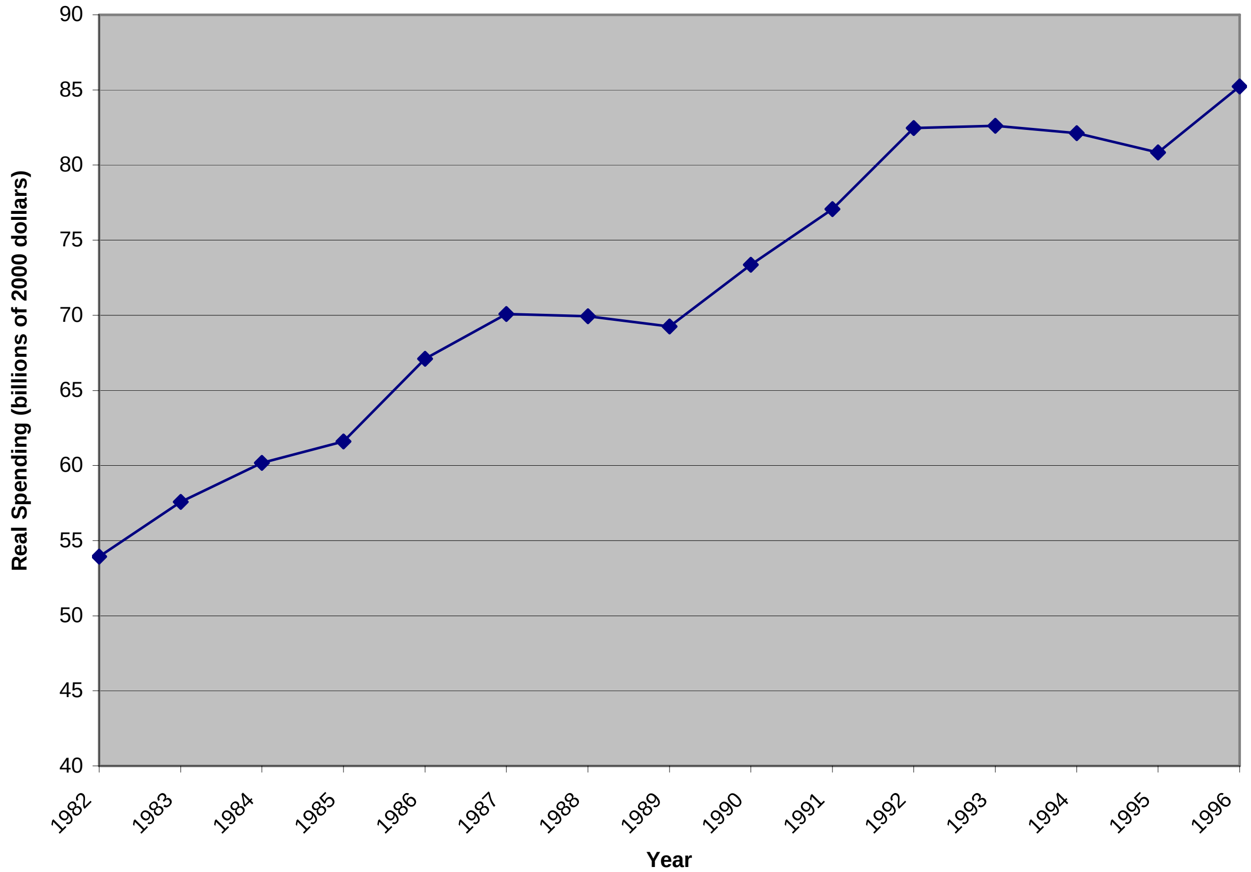
Figure 1. Real Spending on Roads and Highways in the Continental United States 1982-1996 (in 2000 dollars)



Source: Highway Statistics, US Department of Transportation

Table 1: Coefficient Estimates for Motorists' Congestion Costs*

(Dependent variable: *ln* Annual Congestion Costs in an Urbanized Area)

Explanatory Variables (all variables in 2000 dollars, as appropriate)	Base Model	Base Model with Volume-Capacity Ratio
Highway spending divided by urbanized area residents	*-1.30E-4* *(9.62E-6)*	*-1.00E-4* *(7.27E-6)*
Highway spending divided by urbanized area residents interacted with an urbanization dummy (1 if the state is more than 80% urbanized, 0 otherwise)	*3.31E-5* *(5.55E-6)*	*1.99E-5* *(4.19E-6)*
Highway spending divided by urbanized area residents interacted with a political dummy (1 if the state has at least one Congressman in party leadership, 0 otherwise)	*1.99E-5* *(9.28E-6)*	*6.15E-6* *(7.02E-6)*
Highway spending divided by urbanized area residents interacted with a high capital stock dummy (1 if the state's capital stock divided by state residents is at or above the 70th percentile of the sample in the year preceding spending , 0 otherwise)	*8.43E-5* *(2.38E-5)*	*6.62E-5* *(1.94E-5)*
Highway spending divided by urbanized area residents interacted with a low capital stock dummy (1 if the state's capital stock divided by state residents is at or below the 20th percentile of the sample in the year preceding spending, 0 otherwise)	*-3.29E-5* *(1.77E-5)*	*2.47E-5* *(9.35E-6)*
Rail Directional Route Mileage	*-4.90E-4* *(2.69E-4)*	*-2.28E-4* *(1.92E-4)*
Bus Directional Route Mileage (Includes Mixed Right of Way and Combined Right of Way)	*2.44E-4* *(9.82E-5)*	*2.01E-4* *(6.31E-5)*
Exclusive Right of Way Bus Directional Route Mileage	*0.0059* *(0.0012)*	*0.0038* *(0.0011)*
Total Annual Precipitation (hundredths of inches)	*4.56E-4* *(4.53E-5)*	*2.70E-4* *(2.95E-5)*
Annual Number of Days with Temperature over 90°F	*0.0138* *(0.0024)*	*0.0152* *(0.0014)*

Table 1: Coefficient Estimates for Motorists' Congestion Costs (Continued)*

(Dependent variable: *ln* Annual Congestion Costs in an Urbanized Area)

Bottleneck Dummy (1 if a major body of water in the urbanized area is crossed by two or fewer interstates and two or fewer other roadways)	*0.4755* *(0.1093)*	*0.3752* *(0.0858)*
Interstate Dummy (1 if the urbanized area has a major interstate highway running through it, 0 otherwise)	*0.7043* *(0.1249)*	*0.3262* *(0.0797)*
Percentage of Trucks in the Traffic Mix	*0.4376* *(0.0989)*	*0.4165* *(0.0599)*
Urbanized Area Employment	*1.92E-6* *(2.66E-7)*	*1.72E-6* *(2.15E-7)*
Urbanized Area Off-peak Vehicle Miles Traveled	*-4.30E-5* *(1.22E-5)*	*-5.10E-5* *(9.20E-6)*
Urbanized Area Volume-Capacity Ratio (Daily vehicle miles traveled divided by system road miles)	--	*0.7988* *(0.0432)*
State Fixed Effects Included	*Yes*	*Yes*
R^2	*0.85*	*0.92*
Number of Observations	*1110*	*1110*

* White heteroskedasticity-consistent standard errors in parentheses.

Table 2. Coefficient Estimates for Freight Sector Congestion Costs*

(Dependent Variable: *ln* Congestion Costs in an MSA)

Explanatory Variables (all variables in 2000 dollars, as appropriate)	Trucking Operations	Firms
State Highway Spending Divided by Metropolitan Statistical Area Residents	*-0.3256* *(0.0878)*	*-0.1726* *(0.0575)*
State Highway Spending Divided by Metropolitan Statistical Area Residents interacted with a regional dummy (1 if the city is in the New England Census Division, 0 otherwise)	*-2.6036* *(0.6505)*	*-1.0195* *(0.5022)*
State Highway Spending Divided by Metropolitan Statistical Area Residents interacted with a regional dummy (1 if the city is in the Pacific Census Division, 0 otherwise)	*-0.4238* *(0.1128)*	*-0.2114* *(0.0694)*
Rail Directional Route Mileage	*-9.73E-4* *(4.30E-4)*	*-8.00E-4* *(3.35E-4)*
Exclusive Right of Way Bus Directional Route Mileage	*0.0079* *(0.0023)*	*0.0063* *(0.0015)*
Total Precipitation (hundredths of inches in 1996)	*3.76E-4* *(6.11E-5)*	*1.38E-4* *(3.60E-5)*
Registered Trucks in the State (thousands)	*0.0044* *(0.0013)*	*0.0030* *(7.93E-4)*
Metropolitan Statistical Area Employment	*1.54E-7* *(9.31E-8)*	*2.22E-7* *(7.02E-8)*
Percent of State Population in Urban Areas	*0.1017* *(0.0044)*	*0.0327* *(0.0029)*
Coastal Location Dummy (1 if MSA has access to shipping by ocean transportation, 0 otherwise)	*-0.8228* *(0.2914)*	*-0.2369* *(0.1582)*
R^2	*0.65*	*0.83*
Observations	*51*	*51*

*White heteroskedasticity-consistent standard errors in parentheses.