The Impact of Spending Cuts on Road Quality

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Executive Summary. Transportation infrastructure is critical because transportation infrastructure affects economic output. Past literature corroborates the claim that roads support economic growth. However, public spending on transportation and water infrastructure has fallen in the United States since 2003 (Congressional Budget Office 2015). This paper seeks to quantify the consequences of these spending cuts on road quality. The results of this paper indicate that a $100,000 decrease in total government spending per lane mile produces a 5.11 percentage point decrease in the percent of good roads the following year. The spending per lane mile for the states ranges from $50,000 per lane mile to $700,000 per lane mile. Given the importance of road quality on output and vehicle operating costs, this paper recommends that states understand the consequences of spending cuts on roads and consider alternative funding sources.

Introduction

Transportation infrastructure is a key determinant of economic productivity. Roads provide businesses with valuable business opportunities, consumers with lower prices and an increased variety of goods and services, and workers with jobs that would otherwise be inaccessible. According to the National Economic Council and the President's Council of Economic Advisers (2014), "A well-performing transportation network allows businesses to manage inventories and transport goods more cheaply, access a variety of suppliers and markets for their products, and get employees reliably to work. American families benefit too: as consumers, from lower priced goods, and as workers, by gaining better access to jobs," (4).

Moreover, Ingraham (2015) notes that poor roads have more than an aggregate effect. Ingraham writes that poor roads have a measurable dollar cost for individuals. The worse the road conditions, the higher the private costs for maintaining and operating vehicles. For example, the additional vehicle operating cost for Rhode Island, a state where 45 percent of its roads are considered poor quality, is $637. Contrastingly, the additional vehicle operating cost for Massachusetts, a state with 20 percent bad roads, is only $412.

There may be other factors contributing to the differences in vehicle operating costs between the two states. However, Massachusetts and Rhode Island have similar average winter temperatures, 27.4 degrees Fahrenheit and 33.8 degrees Fahrenheit respectively, similar average winter snow falls, 43.8 inches and 31.4 inches (Current Results, 2015), similar median income levels, $63,151 and $58,633 (U.S. Census Bureau, 2014), and similar population densities, 839.4 people per square mile and 1018.1 people per square mile (U.S. Census 2010). Thus, the likely reason for the gap in vehicle operating costs is the difference in road quality. Good roads stimulate production, while bad roads reach into the pockets of individuals.

Given the effect of roads on aggregate production and private costs, governments and individuals ought to be concerned with the quality of their roads. However, transportation funding has fallen in the United States since 2003 for all levels of government as seen in Figure 1. Public spending for transportation and water infrastructure has declined 5 percent at the state and local level and 19 percent at the federal level. There are a number of reasons why states may be struggling to fund roadwork. The gas tax, for one, is becoming an increasingly unreliable source of income (Powers, 2014). The gas tax becomes politically difficult to increase when gas is expensive and less effective when cars increase their fuel efficiency. Nevertheless, there are consequences to delaying road funding. This paper attempts to unearth the impact of spending cuts on road quality, and in doing so, help promote constructive policies for transportation infrastructure.

Background and Literature Review

There have been various efforts to discover the determinants of road quality and maintain high quality road networks. Articles dating back to the 1840s attempted to quantify road usage externalities and find the optimal price to charge drivers. However, most of these economic papers focused on congestion costs rather than vehicle operating costs. Engineers rather than economists were the first to consider the damaging effect of vehicles on roads.

In 1969, the Highway Research Board spent hundreds of millions of dollars to discover the damaging effect of vehicles on roads (Newbery 1988). The Highway Research Board concluded that the damaging power of a vehicle is approximately proportionate to the fourth power of its loading. The Highway Research Board then proposed a standard unit of measurement for the damaging power of vehicles called the Equivalent Standard Axle Loads (ESAL). One ESAL was proposed to be a load of 18,000 pounds. With this scale, trucks could vary from 0.1 ESALs to 50 ESALs. Still, typical trucks are only about 2 to 3 ESALs with a legal limit of 5 ESAL. Private cars were determined to have insignificant damaging factors. Nevertheless, subsequent economic research did not follow until Newbery (1988).

In 1988, economist Newbery became involved in the engineering discussion of road damage and vehicle-operating costs. However, Newbery considered vehicle-operating costs from a new perspective. Newbery noted that when a vehicle damages the road surface and increases its roughness, it increases the vehicle operating costs of subsequent vehicles, and creates a road damage externality. Thus, any optimal toll would have to consider both the effect of an ESAL on road pavement quality as well as the vehicle operating cost for subsequent vehicles. Prior research

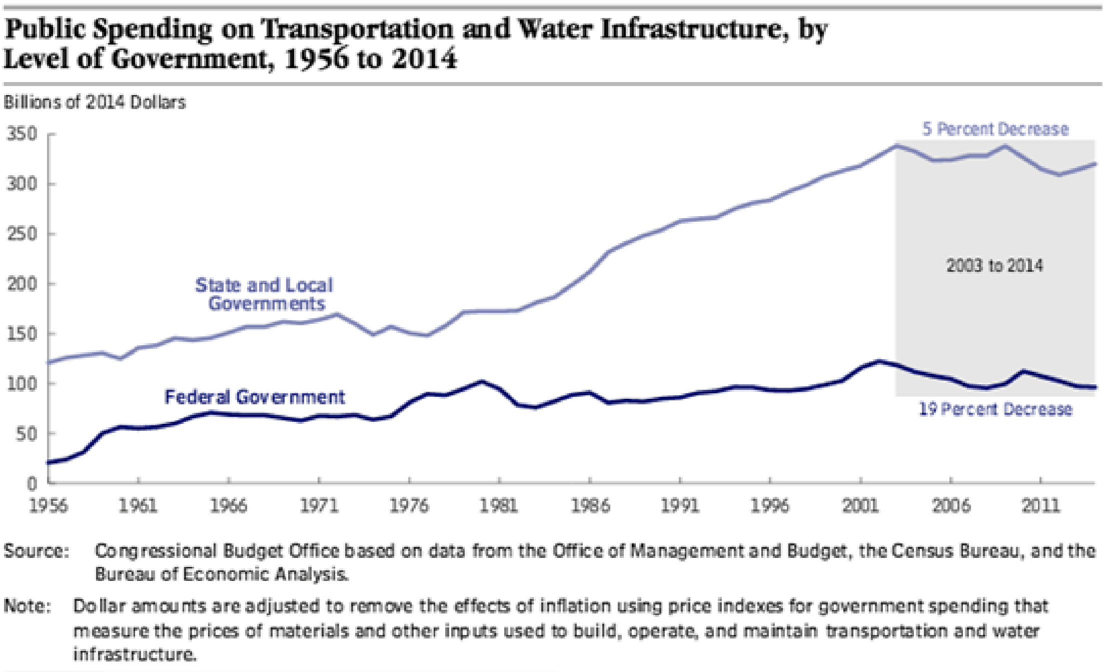

Figure 1: Public Spending on Transition and Water Infrastructure

established that vehicle-operating costs are between 10 and 100 times as large as the maintenance costs on well-trafficked inter-urban roads. Newbery, accordingly, considers both the maintenance costs and the vehicle operating costs in his analysis of the optimal price to charge road users. His analysis assumes that the road damage is caused solely by traffic, there is no traffic growth, and the age distribution of the road network is uniform. Under these conditions, road users should pay fees such that the road damage externality is zero.

However, not all economic studies on the damaging effect of vehicles have subscribed to Newbery's so-called fundamental theorem. Whereas Newbery assumes that only vehicles affect road quality, Haraldsson (2007) posits that weather also affects road quality. Haraldsson notes that empirical studies have shown that the fraction of costs allocated to vehicle damages is 60 to 80 percent for hot dry climates, whereas the cost allocated to vehicles is 20 to 60 percent in cold climates. Haraldsson also finds that, contrary to the typical assumption, both cars and heavy trucks affect the road quality.

More recent articles have attempted to quantify the marginal social cost of an ESAL on roads. Ahmed, Bai, Lavrenz and Labi (2015) present a number of analyses that quantify the marginal social cost (MSC) of an ESAL. Additionally, Ahmed, Bai, Lavrenz and Labi provide their own MSC of an ESAL. Their results show that on average, the marginal pavement damage cost (MPDC) was \$0.0032 ESAL-mile on interstate highways and \$0.1124 per ESAL-mile on non-interstate highways. Their study controlled for pavements of different surface types, functional classes and ages, each of which made a significant difference.

Altogether Ahmed, Bai, Lavrenz and Labi find twelve other studies on the MSC of an ESAL. However, the studies only considered the maintenance expenditure, whereas Ahmed, Bai, Lavrenz and Labi's study considered the maintenance, the rehabilitation and the reconstruction expenditures. Thus, Ahmed, Bai, Lavrenz and Labi claim that their results are the most comprehensive yet.

This paper differs from previous studies in that this paper tests the impact of spending on road quality rather than the impact of vehicle usage on road quality. Previous papers have attempted to show that more road usage, in terms of ESALs, decreases the quality of roads. More specifically, previous papers have attempted to show how many ESALs a road can handle before it needs resurfacing. The previous papers then calculate the cost of an ESAL by dividing the cost resurfacing a road by the total number of ESALs the road experienced before it was resurfaced. With these studies, governments know an approximate amount to charge each driver. However, the link between expenditures and road quality is unclear. Consequently, this paper quantifies the effect of road maintenance and repair expenditures on road quality.

Study Design

This analysis uses Federal Highway Administration (FHWA) data from 1995 to 2004 to track changes in the National Highway System's International Roughness Index (IRI) and total government disbursements per lane mile for 49 of the U.S. states. The real spending per lane mile for the states ranged from about $50,000 per lane mile to $700,000 per lane mile (2005 dollars). Hawaii was not included in the analysis due to missing data. In addition, the data after 2005 become unreliable for most of the states. For example, from 2011 to 2012 the lane miles in California rose from 31,303 miles to 60,125 miles, indicating a change in how the FHWA was measuring lane miles. Also, data on total government disbursements from the FHWA is missing for years 2005 to 2007.

To ensure that changes in road quality were caused by changes in road spending rather than vice versa we construct an instrument for changes in road spending using the quality of roads six years prior. The logic behind the instrumental variable was that the quality of roads six years prior affects spending now, but the quality of roads six years prior does not directly affect the change in quality of roads now. Using the instrumental variable, predicted values were calculated for the intensity of spending. After obtaining these predicted values, changes in the predicted values were lagged one year and used to estimate changes in the road quality.

Findings

The analysis of the FHWA data is found in Table 1. The table contains two regressions. Model

	(1)	(2)
	Total Government Disbursements (in thousands of dollars) Per Lane Mile	**Change in Percentage of Good Roads**
Percentage of Good Roads (Lagged six years)	-190.8***	
	(34.8)	
Predicted Spending on Roads (In thousands of dollars per lane mile, lagged one year)		0.000511*
		(0.000309)
Constant	336.1***	-0.00100
	(17.2)	(0.0023)
R^2	0.0862	0.0329
standard error statistics in parentheses		
*** p<0.10, ** p<0.01, and ***p<0.001**		

Source: http://www.fhwa.dot.gov/policyinformation/statistics

Table 1: Intensity of U.S. State Road Spending on U.S. State Road Quality (1995-2004)

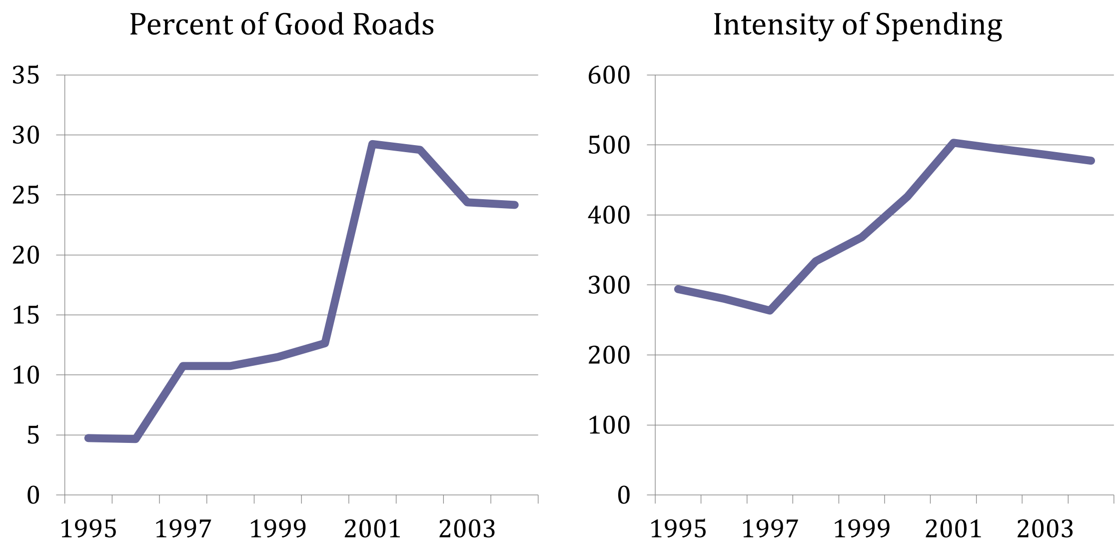

Figure 2. New Jersey's Percent of Good Roads and Intensity of Spending (meausred in thousands of dollars per lane mile).

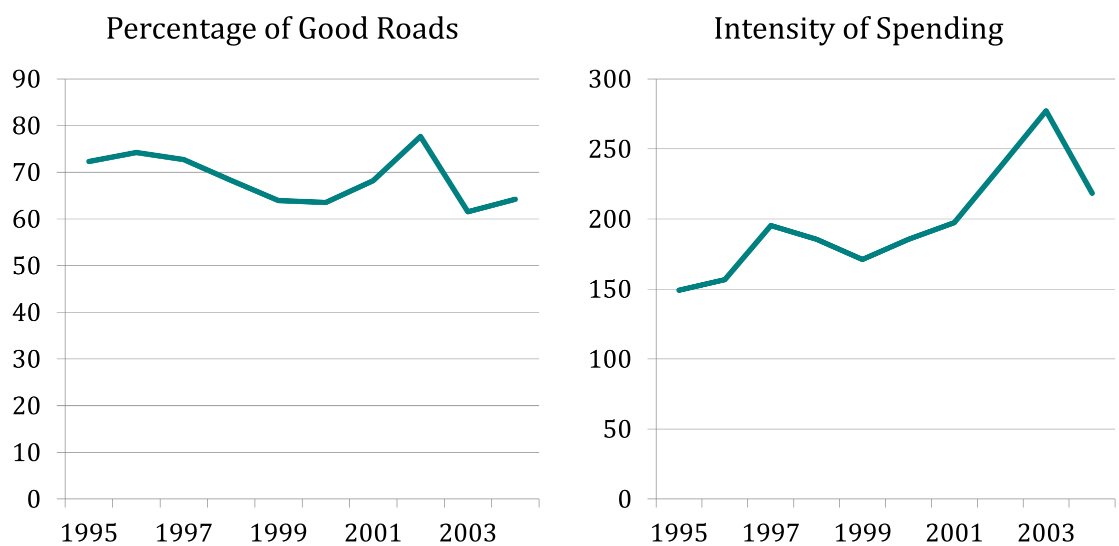

Figure 3. Maine's Percent of Good Roads and Intensity of Spending (meausred in thousands of dollars per lane mile).

1 uses the percentage of the good roads lagged six years, or the instrumental variable, to predict total government disbursements (in thousands on dollars) per lane mile. The results of Model 1 indicate that states with better roads six years prior, spend less on roads now. In particular, the results show that for each additional percentage point in the percentage of good roads six years prior, states spend about $190,800 (2005 dollars) less per lane mile, with significance at the 0.1 percent level.

Model 2 then uses changes in the predicted spending per lane mile, attained from Model 1, to predict changes in the percentage of good roads. This regression contains the main findings of the study. Model 2 shows that when states decrease spending on roads, the quality of their roads decreases the following year. More specifically, the study finds that a $100,000 decrease in total government spending on roads per lane mile of road results in a 5.11 percentage-point decrease in the percentage of good roads for the following year, statistically significant at the .1 level.

For example, New Jersey from 1997 to 2001 increased its spending by $248,000 per mile and the result was an 18 percentage-point increase in the percentage of good roads, as seen in Figure 2. The regression predicts that if such an increase in the intensity of spending had occurred in a single year, a 12.67 percentage-point increase in the percentage of good roads would have resulted.

Maine, by contrast, reduced spending per lane mile by $24,000 between 1997 and 1999 before gradually increasing its spending per lane mile back to normal from 1999 and 2001, as seen in Figure 3. The result was a 5 percentage-point decrease in the percentage of good roads between 1997 and 2001. If that decrease in the intensity of spending had occurred in a single year, the model predicts a 1.2 percentage-point decrease in the percentage of good roads would have resulted. In Maine's case, the spending cut was correlated with a larger effect than the effect predicted by the model.

Recommendations

There are number of possible reasons why states are delaying their transportation funding. The gas tax, for one, is becoming an unreliable source of income with volatile gas prices and fuel-efficient cars. However, states need to know that there are consequences to delaying transportation funding. The general results of this analysis show that there are real consequences to spending cuts on roads. Specifically, this analysis shows that a $100,000 reduction in inflation-adjusted spending per lane mile will decrease the percentage of good roads by 5.11 percentage points the following year. States may want to investigate alternative funding sources before they begin to experience real declines in road quality.

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