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Is There a Link Between Highway Funding, Construction Costs and Employment?

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INTRODUCTION

The challenges facing the U.S. highway system are immense. First, there has been a marked deterioration in the existing infrastructure due to delayed maintenance. Second, transportation demands are much greater than before and the cost of congestion has increased accordingly. Third, the economic crisis has led to large budget deficits, and despite the recent burst of stimulus-related budget increases, the prognosis for future funding is uncertain. Perhaps at no other time since the inception of the interstate system has there been such a keen interest to maximize the effectiveness of government highway spending.

This study contributes to this interest by examining the relationship between government highway expenditures and construction costs. If, for example, an increase in government highway spending leads to an increase in construction costs, will this diminish the effectiveness of the spending in maintaining or improving infrastructure? Knowledge of the spending-cost relationship can assist policy makers with the design and implementation of capital and maintenance programs. In the current economic environment, an additional interest is in quantifying how effective highway spending is at creating employment. Estimates of that relationship are included herein.

This research estimated the relationship between government spending on highways and construction costs using state-level panel data across the fifty states and the District of Columbia from 1980-2006. While controlling for local economic conditions and state and year fixed effects, it was found that a 1 % increase in highway expenditures is associated with at most a 0.10% increase in highway construction costs. The data indicate that the principal influences on construction costs are factors related to the general state of the economy. Examination of state-level data on individual construction inputs – excavation, asphalt, steel and concrete – provided even weaker evidence that highway expenditures affect construction costs. However, national-level data from 1972-2006 provide stronger indications that highway expenditures affect construction costs, particularly in markets for asphalt, steel and concrete. The difference in state-level and national-level results might be attributed to several factors: data quality, sample size or the existence of substantial spillovers. In regard to employment, this research estimated that a 1% increase in expenditures is associated with between a 0.12 and 0.18 % increase in construction industry employment.

LITERATURE

Construction costs are widely discussed in the construction engineering and management literature, but primarily with the goal of assisting state engineers in estimating costs for particular projects. One strand of research is the design of optimization tools such as that in El-Rayes, et al (1), who presented an algorithm for analyzing a time-cost-quality tradeoff. Among empirical papers, Wilmot and Cheng (2) estimated costs for construction projects in Louisiana. For our research purposes, their most relevant result was that a 1% increase in the number of contracts in a year increased the price of asphalt pavement by 0.042%. Odeck (3) examined the incidence of cost overruns on highway construction projects in Norway and found that smaller projects and longer completion times were key determinants of actual costs exceeding original estimated costs. Wilson (4) synthesized research on value engineering and found that this had the potential to reduce project costs. Research by Damnjanovic, et al (5), and Anderson, et al (6) examined strategies that state transportation agencies can pursue for better estimating and controlling costs. They noted a number of factors that led to project cost escalation and separated them into *internal* and *external* categories. The *internal* factors mostly reflect contracting, engineering and management practices, whereas the *external* factors include market conditions, competition, inflation, local regulation, and uncertainty (5, 6).

In the economics literature, much attention has been paid to the highway project bidding procedure and the differential bidding behavior of new and experienced firms, as well as the possibility of collusion (7,8,9). There also has been considerable interest in the political economy of highway funding, including investigations of the relationship between federal and state highway spending (10, 11) and analysis of the apparent stability of the political coalition behind the federal highway program (12). An important recent paper by Winston, et al (13) examined the effectiveness of highway expenditures in reducing congestion, concluding a relatively inefficient mechanism existed for doing so.

The study herein contrasts with the existing literature. Examining the effect of highway expenditures and construction costs, the economic logic is straightforward. An increase in highway expenditures signals an increase in the demand for highway construction services, and should thereby increase the prices of inputs. Highway expenditures are not endogenous to construction costs, because the stream of spending is largely dictated by federal legislation approved beforehand. Additionally, the variation in spending increases between the states is not typically related to variations in local costs, but rather the outcome of a political negotiation that emphasizes other factors (12). By a similar argument, highway expenditures are not endogenous to employment in the construction industry. For example, in the case of the recent increase in highway expenditures, the level of unemployment at the time the bill was passed influenced the level of highway spending, but the actual flow of expenditures was not influenced by the unemployment at the time the spending actually took place. Further, there is no evidence that Congress designed the stimulus program to allocate more funds to states that had witnessed greater changes in employment. Even if it had, the endogeneity bias would imply a negative relationship – larger increases in highway spending would be associated with larger decreases in employment. As discussed below, this is exactly the opposite of the relationship this research detected.

DATA

Construction costs were modeled as a function of five classes of independent variables: expenditures, local economic conditions, characteristics of the highway system and its intensity of use, and state and time fixed effects. Descriptive statistics are given in Table 1. Costs, expenditures, and Gross State Product (GSP) were deflated using the Bureau of Labor Statistics *Producer Price Index* (14).

Table 1: Descriptive Statistics

Variable	Units	Mean	Standard Deviation
Cost (Composite)	Index deflated to 1982 with PPI	103	42
Cost25 (Composite)	Index deflated to 1982 with PPI	98	20
Excavation	Index deflated to 1982 with PPI	103	60
Asphalt	Index deflated to 1982 with PPI	96	23
Reinforced Steel	Index deflated to 1982 with PPI	129	227
Structural Concrete	Index deflated to 1982 with PPI	132	113
Total Exp.	Thousands of 1982 dollars	665642	631742
Federal Exp.	Thousands of 1982 dollars	279012	257462
Gross State Product	Millions of 1982 dollars	107759	136451
Housing Units	Number	29351	38900
Interstate Lane-Miles	Number	3905	2808
Crude Oil	1982 dollars per barrel	42	21
Heavy Construction Employment	Number of full-time and part-time employees	18551	20899

The measure of construction costs are based on the state-level construction cost indexes compiled by the Federal Highway Administration (FHWA) and published in *Price Trends in Federal-Aid Highway Construction* (15). The indexes are created from bid prices from large construction projects that states reported to the FHWA. The composite cost index, as well as input specific indexes for excavation, asphalt, reinforced steel and structural concrete were used in this research. A General Accounting Office report (16) noted that these data might not be of the highest quality. An examination of the raw data seems to confirm this suspicion, with extraordinarily high or low prices and index values occurring in adjacent years in some cases. The potential problems with the data were mitigated by employing four different construction cost measures. The first was the raw data as reported by the FHWA. The other estimated any observations for which the percentage change year-to-year exceeded 25, 33 or 50 %, respectively. In the event that very large changes reflect reporting error, results based on these restricted samples will be more accurate. In other words, the estimates in this research, using different samples, will reflect a range of possible parameter values.

Federal and state highway expenditures are taken from the FHWA *Highway Statistics* (17) publications. In the case of state expenditures, Hendren and Niemeier (18) question whether these data have been reported accurately and consistently across states and whether the data are indeed reliable. Accordingly, this study used some specifications with total expenditures (federal plus state) and others with federal expenditure only.

Consistent with the literature, the general economic environment in the state should be related to construction costs. In a period of economic expansion, other sectors will compete with highway construction for labor and other inputs, which drive up costs. Housing construction is likely to be especially competitive in that regard. Thus, real GSP, obtained from the Bureau of Economic Analysis (19) and the number of housing units authorized by building permits from the U.S. Census Bureau (20) are included in this research.

Our research also tested whether state-specific time-varying characteristics of the highway system impact the sensitivity of construction costs to highway spending. It is plausible that these characteristics, and how they change over time, might influence the types of projects undertaken, and these differences in projects might influence the trajectory of costs. In particular, lane-miles of the interstate highways were examined in the state. Estimations using lane-miles of all roads and highways were also conducted with similar results.

A number of global market factors also might be important, such as energy prices. As a result, in some specifications, the domestic price of crude oil was used. However, because there are probably many other common time-varying factors that affect all states, year fixed effects were employed in most specifications (they cannot be employed along with our crude oil variable because of perfect multicollinearity).

As mentioned in the literature review, a likely number of *internal* state-specific time-varying factors may impact construction costs, for example those related to the distribution of project characteristics, management and contracting practices, including the intensity of use of value engineering. Unfortunately, insufficient data exist that might enable us to add these data to our panel of costs from 1980-2006. What might be feasible for future work is discussed in the conclusions. The inclusion of state fixed effects will at least account for those state-specific factors in the literature that do not vary over time.

Finally, in regressions on employment, the number of full and part-time employees in heavy and civil engineering construction as reported by the Bureau of Economic Analysis (21) was used as the endogenous variable.

COST ESTIMATES

Our econometric model of construction costs is below. The baseline specification is:

$$Cost_{it} = \alpha + \beta Expenditure_{it} + \gamma GSP_{it} + \lambda Housing_{it} + \theta HWY_{it} + \Sigma\delta_i D_i + \Sigma\tau_t D_t + \varepsilon_{it}$$

Where Cost is the construction cost index, Expenditure is federal highway spending, GSP is Gross State Product, Housing is housing units, HWY is the appropriate highway variable and the variables D are the state and year fixed effects. Variables are in logs, with the exception of the fixed effects. Standard errors are estimated permitting observations within groups to be correlated (22).

Table 2 presents the results using the composite cost index. This research does not estimate any statistically or economically significant impact of highway expenditures on costs when using the full sample, and only a relatively small statistically significant effect when using the restricted sample that eliminates any percentage changes in the index greater than 25%. This is true whether or not crude oil or year fixed effects was used or whether federal expenditures only or total expenditures were used. The results are robust to the inclusion of lagged variables, which, with the exception of housing market, appear to have very little or no impact. In the instances where a statistically significant relationship between highway spending and costs appear, the coefficients imply a positive relationship between highway spending and costs, and that for every 1% change in federal highway expenditures, construction costs will change by between 0.06 and 0.11%. This implies that even a 20% increase in highway spending would yield only a 2% increase in the composite cost index.

The coefficients on GSP and Housing are positive and significant in nearly all specifications. The size of the GSP coefficient suggests that the general state of the economy is the most important influence on construction costs among the variables considered. The estimate of housing effects fall within a rather narrow range, regardless of the Cost measurement used. There is no evidence that the extent of a state's highway system has an impact on construction costs. Lastly, crude oil is significant and important when included, as are the year fixed effects (individual coefficients not reported). The R2 estimates indicate that year fixed effects, as expected, add more explanatory power than the crude oil price.

Table 2: Composite Index of Construction Costs

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7) restricted sample	(8) restricted sample	(9) restricted sample	(10) restricted sample
Total Expenditure	-0.014 (0.049)	0.012 (0.045)	-0.017 (0.040)		-0.046 (0.079)	-0.051 (0.070)	0.060* (0.035)		0.107*** (0.035)	0.050* (0.027)
Federal Expenditure				0.009 (0.027)				0.060** (0.026)		
Gross State Product	0.223*** (0.046)	0.347*** (0.044)	0.282*** (0.084)	0.279*** (0.084)	0.392** (0.156)	0.251 (0.158)	0.135 (0.097)	0.163* (0.092)	0.167*** (0.053)	0.200 (0.120)
Housing Market	0.118*** (0.019)	0.086*** (0.017)	0.078*** (0.020)	0.080*** (0.020)	0.014 (0.037)	0.063* (0.035)	0.077*** (0.018)	0.083*** (0.017)	0.081*** (0.018)	0.030 (0.020)
Interstate Lane-Miles	-0.031 (0.036)	0.008 (0.042)	0.035 (0.051)	0.033 (0.050)	-0.002 (0.034)	0.018 (0.037)	0.020 (0.030)	0.021 (0.030)	-0.012 (0.022)	0.000 (0.000)
Crude Oil Price		0.174*** (0.017)			0.144*** (0.021)				0.140*** (0.017)	
Lagged Total Expenditure					0.047 (0.055)	0.042 (0.053)				-0.008 (0.030)
Lagged Gross State Product					-0.046 (0.136)	0.020 (0.155)				-0.062 (0.135)
Lagged Housing Market					0.103*** (0.022)	0.030 (0.029)				0.051** (0.022)
Year Fixed Effects	No	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes
R2 within	0.1649	0.2427	0.3228	0.3223	0.2631	0.3271	0.4442	0.4419	0.2920	0.4494
R2 between	0.0170	0.0186	0.0124	0.0133	0.0182	0.0142	0.0011	0.0014	0.0055	0.0014
R2 overall	0.0004	0.0004	0.0084	0.0070	0.0006	0.0083	0.0164	0.0122	0.0008	0.0157
F – statistic	43.00***	49.31***	29.30***	32.7***	37.94***	21.66***	31.91***	28.69***	33.56***	40.86***
N	1290	1290	1290	1298	1234	1234	1056	1063	1056	1002

1. *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Estimates of the influences on individual input price indexes are presented in Tables 3A and 3B. With respect to excavation and asphalt (Table 3A), the results are broadly consistent with what was found for the composite index. Highway expenditures have little, if any, impact on excavation or asphalt costs. Economic activity in the state has far more consistently significant estimated effects. Not surprisingly, the crude oil price is an important determinant of asphalt prices, but the specifications with year fixed effects still have considerably more explanatory power, because those effects pick up not only crude oil price effects, but also many others.

With respect to Table 3B (steel and concrete), once again highway expenditures have no statistically significant impact on the dependent variables. GSP is especially important, and a robust predictor of price movements for these inputs. At a minimum, the results indicate for every 1% change in GSP, steel prices change by 0.13 and 0.15%, and concrete prices change between 0.21 and 0.24%. Full sample estimates are at least twice that.

Still, while the models have R2 for within state variation well above 0.2% in most specifications, the between state variation is mostly unexplained. It would be ideal to include variables about time-varying state policies and project characteristics in future studies if such variables become available. Another possibility is that spillovers exist. Spending in one state may raise the cost of construction in other states, most likely those within geographic proximity or sharing similar suppliers of key inputs. As a first pass at exploring this possibility, this research examined national-level data. It is also probable that national level data are less affected by reporting errors that may plague any individual state's data. The downsides are that the sample is much smaller and does not overlap temporally with our panel. Extending the national level data to 1972-2006 instead of our state-level panel of 1980-2006 boosts the power of the test.

The national-level results are reported in Table 4. The dependent variables are the national level cost indexes as reported in the FHWA's *Price Trends* (15). Again, these indexes are adjusted for inflation by using the Producer Price Index. The independent variables are real gross domestic product, as reported by the Federal Reserve Bank of St. Louis in their FRED database. The housing starts data are from the Bureau of the Census, and the crude oil variable is the same as the state-level analysis. Miles of public roads from the FHWA's *Highway Statistics* (17) were obtained and finally, a time trend was included.

Table 3A. Input Price Indices: Excavation and Asphalt

Variable	Excavation (1)	Excavation (2)	Excavation (3) restricted sample	Excavation (4) restricted sample	Asphalt (1)	Asphalt (2)	Asphalt (3) restricted sample	Asphalt (4) restricted sample
Total Expenditure	0.087 (0.071)	0.056 (0.070)	0.115 (0.120)	0.097 (0.134)	0.036 (0.033)	-0.005 (0.036)	0.079**	0.046 (0.036)
Gross State Product	0.527*** (0.100)	0.114 (0.174)	0.349*** (0.110)	0.178 (0.148)	0.095** (0.041)	0.131 (0.094)	0.049 (0.038)	0.142** (0.070)
Housing Market	0.011 (0.049)	-0.013 (0.052)	-0.006 (0.062)	0.011 (0.060)	0.104*** (0.025)	0.071** (0.028)	0.095*** (0.016)	0.061*** (0.013)
Interstate Lane-Miles	-0.116* (0.058)	-0.119** (0.048)	-0.054 (0.054)	-0.035 (0.059)	0.044 (0.053)	0.058 (0.059)	0.014 (0.025)	0.030 (0.034)
Crude Oil Price	0.068 (0.044)		0.006 (0.043)		0.232*** (0.027)		0.199*** (0.017)	
Year Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes
R2 within	0.1416	0.1989	0.1792	0.2413	0.1639	0.2363	0.3061	0.5015
R2 between	0.0763	0.1140	0.0681	0.0728	0.0394	0.0354	0.0360	0.0180
R2 overall	0.0049	0.0453	0.0048	0.0012	0.0415	0.0662	0.0538	0.0656
F-statistic	17.93***	13.11***	11.24***	4.48***	21.40***	26.85***	46.98***	24.42***
N	1225	1225	663	663	1229	1229	1082	1082

1. *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Table 3B. Input Price Indices: Reinforced Steel and Structural Steel

Variable	Reinforced Steel (1)	Reinforced Steel (2)	Reinforced Steel (3) restricted sample	Reinforced Steel (4) restricted sample	Structural Concrete (1)	Structural Concrete (2)	Structural Concrete (1) restricted sample	Structural Concrete (2) restricted sample
Total Expenditure	0.012 (0.054)	0.009 (0.048)	0.047 (0.041)	0.040 (0.036)	-0.074 (0.133)	-0.123 (0.135)	0.048 (0.041)	0.033 (0.042)
Gross State Product	0.813*** (0.078)	0.328*** (0.084)	0.159*** (0.055)	0.131* (0.069)	0.828*** (0.105)	0.353** (0.172)	0.212*** (0.053)	0.239** (0.091)
Housing Market	-0.010 (0.026)	-0.002 (0.028)	0.022 (0.017)	0.033** (0.014)	0.059 (0.036)	0.073* (0.037)	0.044** (0.021)	0.038 (0.024)
Interstate Lane-Miles	-0.007 (0.053)	-0.011 (0.048)	0.009 (0.039)	0.028 (0.036)	-0.026 (0.075)	-0.024 (0.085)	-0.011 (0.039)	0.014 (0.040)
Crude Oil Price	0.187*** (0.030)		0.118*** (0.018)		0.156*** (0.028)		0.073*** (0.018)	
Year Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes
R2 within	0.3378	0.4082	0.1546	0.4267	0.3374	0.3765	0.1655	0.2589
R2 between	0.0041	0.0053	0.0098	0.0172	0.0089	0.0058	0.0034	0.0026
R2 overall	0.0069	0.0808	0.0003	0.0182	0.0067	0.0656	0.0029	0.0064
F-statistic	81.88***	63.26***	13.43***	23.81***	62.33***	33.08***	14.91***	8.79***
N	1207	1207	973	973	1212	1212	888	888

1. *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Table 4. National

Variable	Composite	Excavation	Asphalt	Reinforced Steel	Structural Concrete
Total Expenditure	0.561*** (0.112)	-0.083 (0.167)	0.549*** (0.141)	0.826*** (0.245)	0.507*** (0.156)
Gross Domestic Product	1.226*** (0.310)	2.169*** (0.728)	0.035 (0.532)	0.799 (0.987)	1.918*** (0.478)
Housing Market	-0.081* (0.044)	0.056 (0.074)	0.050 (0.063)	-0.155 (0.114)	-0.149** (0.065)
Roads	3.766*** (1.34)	-0.230 (2.651)	0.463 (2.375)	3.189 (2.612)	3.997** (1.710)
Crude Oil	0.141*** (0.039)	-0.019 (0.054)	0.285*** (0.045)	0.215*** (0.671)	0.081 (0.058)
Time	-0.052*** (0.009)	-0.054** (0.021)	-0.015 (0.014)	-0.049 (0.029)	-0.073*** (0.014)
R2	0.7614	0.7250	0.6632	0.4445	0.5713
N	35	35	35	35	35

1. *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

The national-level results contrast markedly with those at state-level. In particular, highway expenditures are estimated to have large, statistically significant effects on the composite index, asphalt, reinforced steel and structural concrete. The effects range from 0.507 (concrete) to 0.826 (steel). According to the estimates, only excavation costs are not affected by highway expenditures. Real gross domestic product has a strong effect on the composite index, excavation and concrete costs, but a statistically insignificant impact on asphalt and steel costs. The national housing market either has a relatively small negative effect or no effect at all on construction costs, according to the estimates. Increases in the mileage of public roads are estimated to have a large effect on the composite index, as well as concrete. The coefficient on steel is also large, but not statistically significant. Crude oil prices are important for the asphalt, steel and composite indexes. Finally, a small negative time trend is noted for excavation, structural concrete and the composite index. The results raise significant questions that can only be answered by further research. In particular, the state-level model can be extended to take spillovers into account, and it is possible that it also can be extended back to 1972 to match the time period of the national-level data.

EMPLOYMENT ESTIMATES

In this section, estimates are provided of the effect of highway spending on employment in heavy and civil engineering construction industries. These include, but are not limited, to highway and bridge construction. (In the 2002 Economic Census, highway and bridge construction employment averaged 40% of heavy and civil engineering construction employment (23).) As with estimates of construction costs, this model is a simple reduced-form expression that employs both state and year fixed effects.

$$\text{EMPLOYMENT}_{it} = \alpha + \beta\text{Expenditures}_{it} + \gamma\text{GSP}_{it} + \lambda\text{Housing}_{it} + \Sigma\delta_i D_i + \Sigma\tau_t D_t + \varepsilon_{it}$$

In Table 5, two variations are presented, one as above and one that omits year fixed effects. In both cases the coefficients are positive, of economic importance, and statistically significant. They suggest that a 1% change in highway spending yields between a 0.125 and 0.187% change in employment in this industry. The effect of expenditures on employment, however, is substantially less than the estimated impact of GSP. Also note that despite this very parsimonious model, the R2 are quite high, explaining about 85% of the overall variation in heavy and civil engineering employment.

Table 5. Employment in Heavy and Civil Engineering Construction Industries

Variable		
Total Expenditure	0.125** (0.057)	0.187*** (0.048)
Gross State Product	0.206** (0.086)	0.671*** (0.170)
Housing Market	0.118 (0.036)	0.087** (0.041)
Year Fixed Effects	No	Yes
R2 within	0.3897	0.5467
R2 between	0.9043	0.8635
R2 overall	0.8610	0.8493
F-statistic	30.88***	35.76***
N	1336	1336

1. *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

The estimates of the effect on highway spending on employment in heavy and civil engineering construction are exclusively short-run (same year) impacts on the industry involved in highway construction only. No estimates take into account any potential knock-on or multiplier effects. Estimation of such effects would require a structural econometric model, or an input-output model such as the JOBMOD program used by the FHWA (24). Furthermore, the estimates do not take into account the possibility that the infrastructure repaired, maintained or expanded will facilitate employment growth over the medium or long term in other industries.

CONCLUSION

The analysis of state-level data on construction costs provides little evidence that highway expenditures affect costs. The results indicate that fluctuations in GSP have the most significant impact. Additionally, crude oil prices and the housing market often play important roles. Idiosyncratic regional or temporal factors also are important, as suggested by the performance of fixed effects. However, much of the variation remains unexplained. This could be due to omitted variables that reflect state-specific but time-varying construction policies that have sizeable impacts on costs. Other possibilities include spillovers or noisy data. The contrasting results yielded from national-level regressions suggest that actual impacts of expenditures on costs could be more substantial. Future research will augment the existing model to take into account spillovers and policy factors. In contrast to the results on the effect of highway expenditures, strong results indicate the responsiveness of highway construction costs to fluctuations in state-level economic activity. This clearly indicates that state departments of transportation could obtain significant cost savings if they undertake major highway programs during economic downturns and focus only on the most urgent projects during business cycle peaks.

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