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SPECIAL ISSUE PAPER

Interstate spillovers of private capital and public spending

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Abstract The analysis estimates the economic returns on public spending by transportation and non-transportation functions vs. private capital, using a panel data set for 48 contiguous states from 1989 through 2002. These actual spending dollars are used as a more precise measure compared to apportioned state public capitals used in the existing literature. For each type of capital/spending, the interstate spillovers were constructed in such a way that different states are weighted by commodity flows across the states to reflect different degree of inter-state dependence. We find that when spending data rather than capital stock is used, all of the interstate spillover effects are negative and statistically significant, suggesting that infrastructure investment does not contribute to economic growth (at least not directly). Therefore, *crowding out* effects exist among states competing for both private and government funds, in particular if states are highly dependent on allocation of federal funds. These results confirm the finding that previously estimated positive coefficients reflect spurious correlation based on capital stocks and output.

JEL Classification R11 · H72

1 Introduction

Following Ratner's (1983) seminal article, numerous empirical analyses have attempted to estimate the output elasticity of public capital. The topic is important

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in evaluating the efficiency of fiscal spending versus private investment. The earlier analyses often generated large estimates of the output elasticity of public capital stock, sometimes even higher than private capital. For instance, Aschauer (1989) and Munnell (1990a) estimated that the output elasticity with respect to public capital was 0.39 and 0.37, respectively. However, Aaron (1990) and Tatom (1991) refuted these empirical results which imply that rate of return on public investment could be about three times higher than that of private capital. Their main argument was that this estimate was a spurious correlation caused by common trends in variables such as *output* and *capital stock*. In addition, productivity and public capital experienced a sharp change in trend in the early 1970s, which may have led to the higher elasticities reported by Munnell and Aschauer. Subsequently, they removed the trends, taking into account any missing explanatory variables, such as oil price shocks and estimated an elasticity of close to zero. All of these studies used the aggregate data at the national level.

Munnell (1990b) and Lynde and Richmond (1991) used state level data to estimate the output elasticity of public capital, and this disaggregation resulted in lower estimates of returns on public capital than those based on national data. A plausible explanation would be the spillover effect as a result of the network effect of public capital. Most infrastructures have network characteristics. Airline transportation system is a good example. They are operated in hub-spoke network and highways are connected among different states along trade corridors. The stock of capital in one state is expected to affect the production in other states, with effects varying by states. Therefore, the original effect of transportation investment in one state could have been diffused elsewhere.

Other empirical analyses also used panel datasets to develop regional production functions to capture variations across cross-sections and time.[1] While the use of panel data models ameliorates some of the problems embedded in the earlier studies, nonstationarity of the time series could still persist in the panel data. Moreover, almost all state studies were based on state data somewhat arbitrarily apportioned from the national data, which has been a source of debate in the literature. The studies of Garcia-Mila et al. (1996) and Garcia-Mila and McGuire (1992) raised concerns over the positive coefficients estimated in earlier studies. They suspected that spurious correlations may be present in those analyses and suggested that all variables should be transformed using first differences. In fact, their new estimates are completely different from the earlier studies with all of their estimated elasticities of the public capital variables being negative and insignificant. They also found significant differences across the states in output growth rates that are not explained by growth in labor, private capital and public capital, and public capital contributes to only marginal economic growth.

The present paper also studies the economic returns on private and public capital using panel data models, but we are more focused on the interstate spillover effects. First, we have obtained the state fiscal data from the National Association of State Budget Officers (NASBO) dating back to 1989 on an annual basis. These are the

[1] They include Eberts (1986), Garcia-Mila and McGuire (1992), Holtz-Eakin (1994), Boarnet (1998) and Munnell (1990b). The estimated coefficients for public capital stock from these studies ranged from 0 to 0.15, and their differences were mainly attributable to the model specification and the data used.

actual amounts of state spending by functions such as *transportation* and *education*, versus capital stocks used in previous studies. The use of the fiscal data from NASBO enables us to improve the data measures of public capital and distinguish the contributions of transportation and non transportation items. The measure of private capital is still the same, following Munnell (1990b). But we have made the estimation procedure more transparent by updating the data sources whenever necessary. Secondly, we have developed a more effective spillover measure weighted over all partner states for each state. This measure incorporates the network effects of infrastructure across states. Failure to incorporate this weighting matrix does not account for the different influences from other states. In fact, Moomaw et al. (1995) basically used the aggregate public capital stock to measure the interregional spillovers without accounting for the different influences from other states.

The paper has five sections. Section 2 explains the panel data models used in this paper. We use pooled ordinary least squares (OLS) estimations along with fixed-effects or random-effect models. Section 3 explains the data underlying the private and public capital used in the present study. Also the construction of spillover variables for the three different types of capital is also presented. Section 4 reports and interprets the empirical results. The last section provides the conclusion of the study.

2 Model

The relationship between economic output and its inputs, including various capital and the corresponding spillovers, can be described as a Cobb-Douglas production function:

$$P_{it} = K \times L_{it}^{\beta_1} C_{it}^{\beta_2} \ldots v_i w_t, \quad \text{with} \sum_{j=1}^{J} \beta_j = 1 \tag{1}$$

where P_{it} is the gross domestic product by state (GDP);[2] K represents a technology factor, L_{it} is state labor forces; C_{it} is a set of capital variables, including private capital, public spending on transportation as well as on non-transportation functions, and their corresponding inter-state spillover variables; v_i measures individual effects at the state level such as natural endowments, geographic location, trade corridors, economic integration and many others; w_t measures the possible period effect. After some typical transformations as used by Yao (2006), the relationship between capital and economic output can be represented by a panel data model:

$$p_{it} = \beta x_{it} + v_i + w_t + u_{it}, \tag{2}$$

where $v_i + w_t + u_{it}$ is the measure of shocks or error components (Baltagi 2001): v_i enters the error term as the unobserved individual effects (time-invariant), and w_t is the unobserved period effects (time-variant); and u_{it} is white noise. The dependent variable is the logged GDP and the independent variables are logged input variables.

[2] There is a break in GDP by state series in 1997 due to the industry classification system change from SIC (US Standard Industrial Classification) and NAICS (North American Industry Classification System). We realigned the pre-1997 data based on two versions of data in 1997 to be consistent with the latest NAICS data.

x_{it} represents all the relevant explanatory variables. Because of the latter specification, β measures the returns to scale or elasticity.

The presence of cross-section and period specific effects terms, v_i and w_t, may be dealt with using fixed or random effects methods. The fixed effects portions of specifications assume v_i to be fixed parameters to be estimated and the remaining disturbance, u_{it}, stochastic. These estimations include the familiar approach of removing cross-section or period-specific means from the dependent variable and exogenous regressors and then performing the specified regression on the demeaned series (for example, Baltagi 2001). More generally, we apply the results from Davis (2002) for estimating multi-way error components models with our unbalanced data. If we also have similar assumptions for w_t, this would be a two-way fixed-effects model. The random effects specifications assume that the corresponding effects, v_i and u_{it}, are realizations of independent random variables with mean zero and finite variance. Also these random effects would be uncorrelated with each other. Therefore, with different assumptions on error components, we estimated three OLS panel data models: Pooled OLS with no individual effects, (One-way) Fixed Effects, and (One-way) Random Effects.

With the above specification, the coefficient on each explanatory variable can be interpreted as an output elasticity of labor or capital, i.e., by what percent the output can grow with a 1% increase of the input.

3 Data

The data used in this study are on state level. The real GDP by state and state labor force data are obtained from Bureau of Economic Analysis (BEA), while the other variables are collected from other sources or calculated by the authors. Since we focus on the spillover effects of various forms of capital, the spatial diffusion is incorporated in constructing spillover variables. In most literature, each dollar spent by other states has been assumed to have equal interregional spillover effects on any targeted state. This commonly adopted assumption simply overlooks the different degrees of economic ties and geographic connections between states, and it only captures the spillovers of federal spending as a whole. For instance, the same amount of spending on infrastructure in Maine should have less impact than that in Texas on the Arkansas economy because of the closer economic ties and adjacency between the latter two. Likewise, New York might have a closer tie with California than with Mississippi because of larger economic sizes and trading volumes. To measure a different impact of infrastructure in one state compared to others, on any of the other states' economic activities, we use the commodity flow data as a weighting matrix (48 states by 48 states) of inter-state dependence. The approach was initially used by Paul and Cohen (2004) to approximate network effects of infrastructure.

Suppose the total shipments (value) by all modes from state i (origin) to state j (destination) is denoted as S_{ij}, the economic importance of a particular destination state to the origin state can be expressed as

$$W_{ij} = \frac{S_{ij}}{\sum_{j=1}^{J} S_{ij}} \tag{3}$$

Therefore, W is a 48×48 matrix with diagonal elements set to be zero to exclude the state's own capital. Given the total capital expenditure of state j, its contribution to other states can be accounted for accordingly. The total spillovers to one state can be measured by the summed spillovers from all other states to this particular state

$$CS_i = \sum_{j=1}^{J} C_j \times W_{ij} \tag{4}$$

The resulting values are the totals of all the appropriate shares of capital expenditure incurred in other states which have contributed to the output in the ith state. This paper compares the performance of three different types of capital: private capital on everything, public spending on transportation, and public spending on non-transportation functions. Therefore, three types of capital spillovers are calculated.

Public capital

Data on the two public spending variables were obtained from the NASBO archives. Compared with accounting data based on capital stock and depreciation schedules, these fiscal data have certain advantages, particularly reliability, because it represents actual spending by the state governments. Also these data are a more objective measure, which avoids the controversy that ensues from *estimating* state data following Munnell (1990b).

The largest spending function of most state governments is elementary and secondary education. The others include higher education, cash assistance, Medicaid, corrections, and others. Since 1989 when our sample starts, the share of spending on transportation has varied from 3.9 to 26.6%. In a more recent period, the average shares among states have been around 9%. Both spending series are deflated using the price index for private fixed investment in structures from the Bureau of Economic Analysis because a deflator for public spending which includes infrastructure is currently not available.[3]

Private capital

Private capital stocks were calculated by apportioning national stock estimates from the Bureau of Economic Analysis of various sectors among the states, using a procedure similar to Munnell (1990b). This approach was adopted because investment data by states are available only for the manufacturing sector, not for other sectors such as agriculture, transportation by mode, construction, services, and other sectors. The national stock estimates were then apportioned to states on the basis of various shares of each state's economic activity. Table 1 provides the 16 sectors and the data sources used to apportion national capital stocks to the states. The estimation of private capital

[3] The Bureau of Economic Analysis currently does not have an index to deflate the public data because of the lack of comprehensive public capital data to construct such an index.

Table 1 Data description of private capital at the state level

Short name of the sector	Description	Source of data to apportion capital stock to states	Unit of data source
MFGK	Manufacturing sector	Economic Census	dollars
AGK	Agriculture sector	Economic Census	dollar
CONSTRK	Construction sector	Economic Census	dollars
MIK	Mineral industry sector	Economic Census	dollars
RK	Retail trade sector	Economic Census	dollars
WK	Wholesale trade sector	Economic Census	dollars
BANKK	Banking sector	*Deposits by States* in Statistical Abstract of the United States	Number of deposits of insured by commercial banks
RAILK	Railroad sector	*Railroad Facts*, Association of American Railroads	Amount of track mileage by state
TRUCKK	Truck and warehousing sector	*Census of Transportation*, Bureau of the Census	Number of trucks by state
WATERK	Water transportation	*Waterborne Commerce of the United States*, The Army Corps of Engineers	Value of commerce in ports, in dollars
AIRK	Air transportation	*Census of US Civil Aircraft*, Federal Aviation Administration	Number of aircraft by state
ELECK	Electrical services	*Inventory of Power Plants, the United States* in Statistical Abstract of the United States	Generating capacity in each state
GASK	Gas services	*Gas Facts*, American Gas Association	Share of miles of pipelines and main
TELEK	Telephone and telegraph sector	Federal Communication Commission *Statistic of Communications Common Carriers*	Share of miles of wire in cable
SVCSK	Services sector	Economic Census	dollars

stocks is given as

$$K_i = \frac{\text{AGK}_i}{\sum_i \text{AGK}_i} \times \text{AGK} + \frac{\text{MFGK}_i}{\sum_i \text{MFGK}_i} \times \text{MFGK} + \frac{\text{NFNMFGK}_i}{\sum_i \text{NFNMFGK}_i} \times \text{NFNMFGK} \quad (5)$$

Table 2 Data used in estimation

Short names	Description	Unit	Source
RGDP	Real GDP by state	dollars	BEA
LABOR	State labor force	person	BEA
PRIVATEC	Real state private capital	dollars	Authors' calculation
PRIVATEC_S	Real spillovers of private capital from other states	dollars	Authors' calculation
PUBLICC_TS	Real state public expenditure on transportation	dollars	NASBO
PUBLICC_TSS	Real spillovers of public expenditure on transportation from other states	dollars	Authors' calculation
PUBLICC_NTS	Real state public expenditure on non-transportation	dollars	NASBO
PUBLICC_NTSS	Real spillovers of public expenditure on non-transportation from other states	dollars	Authors' calculation

where AGK is the BEA constant-cost of capital stock in the agricultural sector; MFGK is the BEA constant-cost of capital stock in the manufacturing sector; NFNMFGK is the BEA constant-cost of capital stock in the non-farm and non-manufacturing sectors; AGK_i is the proxy of capital stock in agriculture in the ith state; MFGK_i is the proxy of capital stock in manufacturing in the ith state; NFNMFGK_i is the proxy of capital stock in the non-farm and non-manufacturing sectors in the ith state.

The estimates of capital stock in the non-farm and non-manufacturing sectors were apportioned to the states according to the sum of the estimates of the following sectors: construction (CONSTR), mining (MI), retail (R) and wholesale (W) trades, banking (BANK), railroad transportation (RAIL), trucking and warehousing (TRUCK), water transportation (WATER), air transportation (AIR), electric services (ELEC), gas services (GAS), telephone services (TEL), and the services sector (SVCS). The following equation describes the apportioning process for these sectors:

$$\begin{aligned}\text{NFNMFGK}_i =\ & (\text{shCONSTRK}_i * \text{CONSTRK}) + (\text{shMIK}_i * \text{MIK}) \\ & + (\text{shRK}_i * \text{RK}) + (\text{shWK}_i * WK) + (\text{shBANKK}_i * \text{BANKK}) \\ & + (\text{shRAILK}_i * \text{RAILK}) + (\text{shTRUCKK}_i * \text{TRUCKK}) \\ & + (\text{shWATERK}_i * \text{WATERK})(\text{shAIRK}_i + \text{AIRK}) \\ & + (\text{shELECK}_i + \text{ELECK}) + (\text{shGASK}_i + \text{GASK}) \\ & + (\text{shTELEK}_i * \text{TELEK}) + (\text{shSVCSK}_i * \text{SVCSK}) \end{aligned} \tag{6}$$

where sh is the states' share used to apportion the sector's national assets to a given state.

Given three types of capital measures at each state, the spillovers received by each state from all others are constructed using the methodology explained in Eqs. (3) and (4), namely PC_S, PUBC_TS and PUBC_NTS. There are eight log transformed variables for 48 panels for a period of 14 years. The complete list of these variables is presented in Table 2.

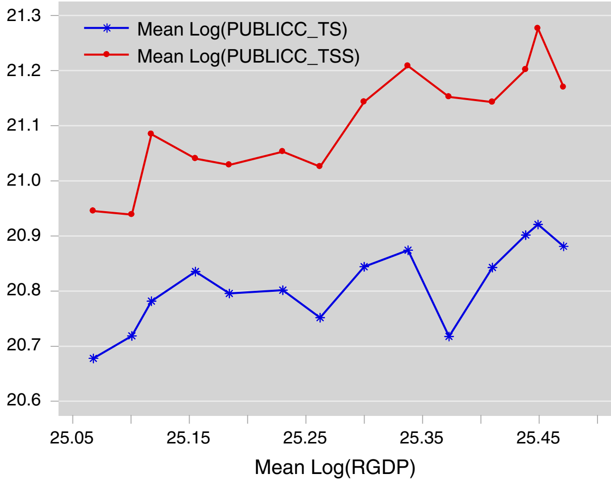

Fig. 1 Scatter diagram: GDP by State vs. Public spending on transportation

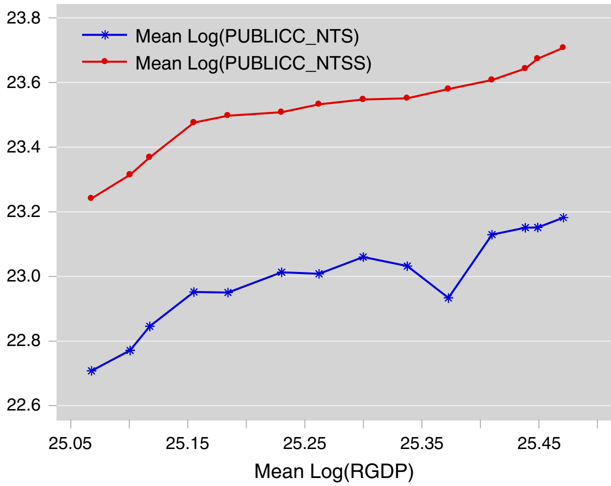

Fig. 2 GDP by State vs. Public spending on non- transportation

4 Empirical results

Figures 1, 2, 3 and 4 illustrate scatter diagrams between the dependent variable, GDP by state, and different types of inputs, both at the state averages. As expected, most inputs are positively correlated with output. But some of these correlations could be weakened by outliers, nonlinear features, and cross-sectional variations. Figures 1 and 2 show nonlinear relationships between two types of public spending (on transportation and on non-transportation) and GDP by state, while Figs. 3 and 4 suggest a close linear relationship between private capital as well as labor and output. Two public spending variables and their spillovers are dominated by typical increasing returns to

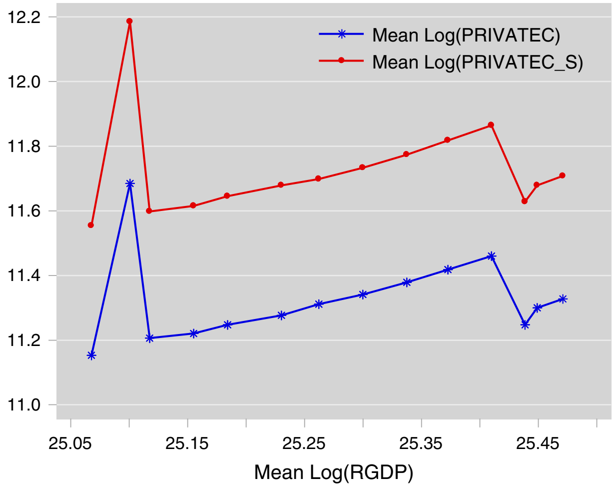

Fig. 3 GDP by State vs. Private capital

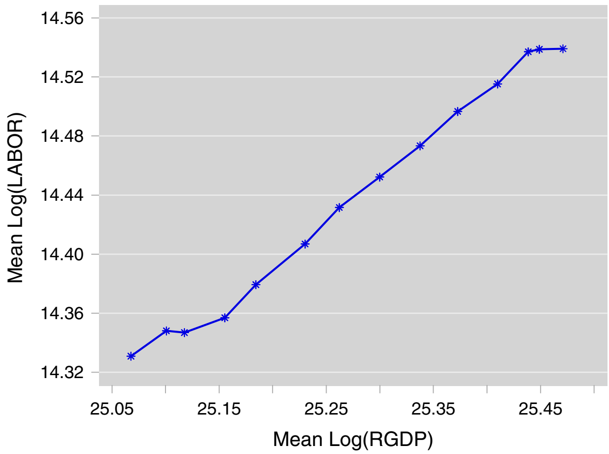

Fig. 4 GDP by State vs. Labor

scale relative to GDP by state. At the lower level, public capital accumulate faster relative to output, suggesting a lower return to scales. After the capital stocks have reached a certain level, the returns on public spending improve. But the extra gains vanish at an even higher stage.C It appears that a specification based on logged-level series might not fit the actual data as well.

Consistent with Fig. 4, the correlation between GDP and labor is almost perfectly close to 1. The three types of capital are all significantly and positively correlated with output. But their spillover variables are all negatively and insignificantly correlated with output. CAs suggested by Figs. 1, 2 and 3 the scatter diagrams for each type of capital are all paralleled to their corresponding spillovers. The insignificance or significance in the linear correlation might be misleading for those nonlinear relationships.

Table 3 Log linear production function estimates

Dependent variable: LOG(RGDP)						
	(1) OLS		(2) Fixed effects		(3) Random effects	
C	6.695***	(14.457)	15.733***	(6.854)	2.549***	(6.872)
LOG(LABOR)	0.867***	(37.784)	1.432***	(24.21)	1.115***	(47.92)
LOG(PRIVATEC)	0.083***	(4.167)	0.008	(0.381)	0.017	(0.882)
LOG(PRIVATEC_S)	−0.279***	(−8.814)	−0.190**	(−2.449)	−0.055***	(−2.985)
LOG(PUBLICC_TS)	−0.016	(−0.846)	−0.016*	(−1.949)	−0.013	(−1.509)
LOG(PUBLICC_TSS)	−0.021	(−0.419)	−0.107***	(−2.574)	−0.042	(−1.611)
LOG(PUBLICC_NTS)	0.140***	(6.760)	0.017*	(1.785)	0.023**	(2.402)
LOG(PUBLICC_NTSS)	0.254***	(5.197)	−0.290***	(−3.112)	0.327***	(13.621)
Observations	680		680		680	
Adjusted R^2	0.980		0.998		0.953	
SSR	14.681		1.374		35.405	

* Statistically significant at 10% level
** Statistically significant at 5% level
*** Statistically significant at 1% level; t-statistics are included in parentheses

Normally, a state's output can be affected by capital of other states in two ways: competitive or diffusive. The first type illustrates that one state's success would rule out the possibility of competitors' successes with similar capital level and technologies. This is a typical case of a dynamic game, where a rise in a one's efforts to develop economy, such as investing in infrastructure and education, increases the probability of its own success but lowers that of others, i.e. negative spillovers. The other externality illustrates that one state benefits from other states' capital stocks by means of manufacturer-supplier network, reduction of travel time, and logistics costs. The economics of innovation of new technology has a well-developed literature on knowledge spillovers as given by Yao (2006), which is not widely used in transportation research. In our case, if the competitive spillover dominates the diffusive effect, the net effect of spillovers will be negative.

Table 3 shows the estimates of the log linear production using different OLS methods. The estimated labor elasticity (0.867–1.432) is greater than previous results. One can argue that the 1990s witnessed a consistent productivity improvement in United States, and this trend continued even during the 2001 recession. While most other studies were based on much earlier data, this present study is complemented by relatively small estimates of private capital elasticity (0.008–0.083). All three models estimate negative effects of public spending on transportation and interstate spillovers of both private capital and public spending on transportation.

Two well-known specification tests are introduced to evaluate different models. The first determines if the included fixed effects are redundant with the explanatory variables currently used in the pool equation, similar to Wooldridge (2002, p. 262). Both cross-section dummies and period dummies are significantly different from zero. Hausman (1978) provided another specification test to compare random effects against fixed-effects models to see if the random effects are uncorrelated with explanatory variables. The χ^2 statistic for the Hausman test is 240.6, which indicates that random-effect specification is inferior to the fixed-effects specification. Therefore, model (2) with fixed effects has the best specification among three.

Model (2) also fits data best, where all inter-state spillovers are negative and statistically significant.[4] There is a "crowding out" effect among states in efforts to attract private as well as public capital given the national total. While both the effects of state's two public spending functions on itself are statistically significant, one of them is positive and the other negative. Public spending on education and other non-transportation items has a positive relationship with economic growth: 1% of such spending would increase economic growth by 1.7%. But one's economic development could be hindered to a larger degree by peer states' similar efforts to obtain capital. The elasticity of private capital on output, however, is not significant.

Garcia-Mila et al. (1996) and Garcia-Mila and McGuire (1992) both raised concerns over positive coefficients estimated in previous studies. They suspect that spurious correlations may be present in those approaches and suggested that all series be transformed into first differences. The new estimates for Garcia-Mila et al. (1996) are significantly different from previous studies, with all estimated elasticities of all public capital variables negative and insignificant. They also found that there are significant differences across the states in output growth rates not explained by growth in labor, private capital and public capital. To confirm these results, we estimated three models using log first differences, which are presented in Table 4. The fixed-effects model is still the best specification, where only the interstate spillover effects are now statistically significant. The magnitude of the spillovers vary from −0.024 to −0.094. The insignificance of elasticities of state's own capital on itself, however, are consistent with the results of Garcia-Mila et al. (1996).

One plausible explanation for these negative and insignificant estimates is that both private capital and public spending have measurement error, and taking first difference would increase the bias. Table 5 presents estimates for a specification test as suggested by Grilches and Hausman (1986). We estimated all the models with variables measured at logged-second differences ($\log(x_t/x_{t-2})$) and logged third differences ($\log(x_t/x_{t-3})$). Both models are estimated, using the fixed effect, and the results indicate that measurement errors are not important for these variables. However, the estimate for public spending on non transportation functions dropped to the range from −0.001 to 0.001, close to zero, and that on public spending also decreased from −0.001 to −0.005.

5 Conclusions

This paper attempts to understand the economic returns of transportation investment versus other capital in three ways: the use of fiscal data, the consideration of capital spillovers, and the application of the panel data models. Employing state level data for private capital, output, and public spending on transportation and non-transportation

[4] Previously, the estimate of public capital on highways was positive (Garcia-Mila et al. 1996). There is, however, a clear difference between measures of stocks and flows.

Table 4 Production function estimates with log first difference

Dependent variable: LOG(RGDP/RGDP(-1))						
	(1) OLS		(2) Fixed effects		(3) Random effects	
C	0.015***	(8.327)	0.021***	(8.796)	0.015***	(7.365)
LOG(LABOR)	0.931***	(15.75)	0.878***	(11.31)	0.885***	(15.29)
LOG(PRIVATEC)	−0.008	(−0.931)	−0.010	(−1.226)	−0.008	(−0.979)
LOG(PRIVATEC_S)	0.005	(0.655)	−0.039*	(−1.916)	0.005	(0.736)
LOG(PUBLICC_TS)	−0.002	(−0.554)	−0.001	(−0.369)	−0.001	(−0.482)
LOG(PUBLICC_TSS)	−0.014	(−1.365)	−0.024*	(−1.786)	−0.015	(−1.564)
LOG(PUBLICC_NTS)	0.000	(0.108)	−0.001	(−0.486)	0.000	(−0.056)
LOG(PUBLICC_NTSS)	0.042	(1.397)	−0.094*	(−1.694)	0.045*	(1.677)
Observations	624		624		624	
Adjusted R^2	0.291		0.477		0.298	
SSR	0.295		0.196		0.296	

* Statistically significant at 10% level
** Statistically significant at 5% level
*** Statistically significant at 1% level; t-statistics are included in parentheses

Table 5 Test for measurement error

	(1) Log 2nd difference		(2) Log 3rd difference	
C	0.033***	(7.015)	0.045***	(6.347)
LOG(LABOR)	0.987***	(15.26)	1.046***	(16.24)
LOG(PRIVATEC)	−0.009	(−0.826)	0.011	(0.916)
LOG(PRIVATEC_S)	−0.086**	(−2.145)	−0.076*	(−1.652)
LOG(PUBLICC_TS)	−0.005	(−1.401)	−0.007*	(−1.785)
LOG(PUBLICC_TSS)	−0.022	(−1.118)	−0.014	(−0.617)
LOG(PUBLICC_NTS)	0.001	(0.386)	0.003	(0.613)
LOG(PUBLICC_NTSS)	−0.063	(−1.252)	−0.049	(−0.935)
Observations	571		522	
Adjusted R^2	0.691		0.775	
SSR	0.293		0.360	

* Statistically significant at 10% level
** Statistically significant at 5% level
*** Statistically significant at 1% level; t-statistics are included in parentheses

functions, we estimate several specifications of a Cobb-Douglas production function. Earlier studies had reported a positive and significant effect of public capital on private sector output, which later was attributed to spurious estimates due to trends in the time series.

Our results are more consistent with studies based on de-trended data but not with the results of Holtz-Eakin (1994), Munnell (1990b), Eberts (1986), and Holtz-Eakin and Schwartz (1995) shown in Table 6. The fixed-effects model estimates an insignificant

Table 6 Summary of empirical estimates of public capital's output elasticity

Author(s)	Type of public capital	Data sample	Output elasticity
National level analyses			
Aschauer (1989)	Non military, non residential	1949–1985	0.39
Munnell (1990a)	Non military, non residential	1949–1987	0.34
Holtz-Eakin (1994)	Nonmilitary, nonresidential	48 states	0.02
State level analyses			
Munnell (1990b)	Non military, non residential	48 states, 1970–1986	0.15
Garcia-Mila and McGuire (1992)	Nonmilitary, nonresidential	48 states, 1970–1983	0.20
Garcia-Mila et al. (1996)	Non military, Non residential	48 states,1970–1983	−0.058
Regional studies			
Eberts (1986)	Core infrastructure	38 MSAs, 1958–1978	0.04
Holtz-Eakin and Schwartz (1995)	Highway infrastructure	48 states	0.05

elasticity of private capital, and a negative elasticity of public spending on transportation infrastructure and a positive elasticity of public spending on education and other services. Both the latter two are statistically significant. These results confirm that previously estimated positive coefficients may reflect a spurious correlation based on capital stock and output. All three inter-state spillovers are negative and significant, suggesting that public spending on infrastructure of other states does not positively contribute to economic growth (at least not directly). Therefore, *crowding out* effects exist among states competing for both private and government funds, particularly if they are dependent on allocation of federal funds.

The negative spillovers are robust when variables are measured in first differences and in the subsequent tests for measurement errors. Therefore, the impact of public spending on transportation, education and other functions go far beyond the state borders. There is little evidence to support the possible measurement errors in the data used in this study, but these results do confirm what previous studies found based on similar approaches: capital/spending in isolation has little impact on a state's economic growth.

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