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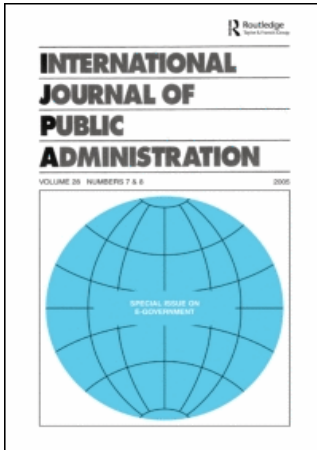
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THE ROLE OF PUBLIC CAPITAL IN THE ECONOMIC DEVELOPMENT PROCESS

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ABSTRACT

This paper reviews the evidence of public infrastructure's impact on economic development. The evidence indicates the marginal net social returns is low. The paper also examines the effect of economic, demographic, and political forces on infrastructure investment. Finally, the literature suggests that improving maintenance and reducing congestion can greatly increase the benefits from the existing public capital stock.

INTRODUCTION

There is a large and growing literature investigating the impact of public infrastructure on economic development. At the most basic level, public infrastructure such as roads and sewers make direct contributions to commerce and health. An efficient road and highway system helps to move people and their product in a timely low-cost manner. Modern water and sewage systems have improved health in the industrialized world and are making a similar contribution in many of today's emerging economies.

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Much of the current public infrastructure research centers on attempts to measure the impact of additional public investment on economic growth at the national, industry, and regional level. Examinations of the return to incremental investment in the United States and other industrialized countries yield mixed results. For developing economies, the potential return is higher.

The fact that studies show that additional infrastructure investment fails to significantly raise output or lower net social cost at the national or state level does not imply the return on all infrastructure projects is zero. It should be kept in mind that selective projects may pass a cost-benefit test. Construction of a new road in a growing area is likely to provide a high return for taxpayers. In related work, there are studies which suggest there is a greater return to maintenance and managing congestion than there is to new construction. How infrastructure is used may turn out to be more important than total quantity. Poor maintenance and congestion greatly reduces the benefits of public capital, especially in developing economies.

Other research has shown that a decline in the demand for public capital investment along with higher production costs occurred at about the same time infrastructure investment slowed. This suggests the decline in public investment in the 1970s may have been efficient. In addition, political arrangements influence decisions on infrastructure. In particular, the adoption of term limits, citizen initiatives and budgeting procedures alter the politically chosen level of infrastructure investment.

THE IMPACT OF PUBLIC CAPITAL ON PRIVATE PRODUCTION

Much of the economic analysis on the impact of government investment on the economy has focused on the direct effect of public capital on output. A common approach is to estimate a production function which includes public capital, in addition to measures of labor and private capital. Public capital is sometimes broken down into components – highways, structures and equipment, and sewage systems. What this approach tries to measure is the impact of public capital on output, holding private capital and labor constant. If the estimated impact turns out to be positive, then public capital has a positive marginal product, just like any other input. For example, suppose a new wider highway reduces the time associated with truck deliveries. This increase transportation productivity results directly in greater private output using the same amount of private capital and labor.

Public capital also influences output indirectly by increasing the marginal product of private capital or labor. As a result, private input use

risers and output increases. Continuing the previous example, the higher marginal product of the driver resulting from the new road, will encourage firms to purchase more trucks, leading to a further expansion of output. This is referred to as the “crowding in” effect of public investment.

On the other hand, public capital can serve as a replacement or substitute for private capital. Increasing public capital investment results in less private investment, and a lower private capital stock. In this situation, public investment “crowds out” private investment, resulting in a negligible impact on output. An example of this would be when a government builds an access road that would otherwise been funded by a private firm.

There are a number of different types of production functions which can be estimated, with the most well known being the Cobb-Douglas production function.

$$Q = \alpha + \beta K + \gamma L + \varphi G + \varepsilon \quad (1)$$

In this specification, Q is the logarithm of output, K is the logarithm of private capital, L is the logarithm of labor, G is the logarithm of public capital and ε is a random disturbance term. The coefficients α, β, γ , and φ are coefficients to be estimated. The coefficient α is the intercept term. The other coefficients measure the impact of an increase in a specific input on output, holding the other two inputs constant. If the coefficients on private capital and labor sum to one ($\beta + \gamma = 1$), then there are constant returns to scale with respect to private inputs. If the coefficients on all three inputs sum to one ($\beta + \gamma + \varphi = 1$), then there are constant returns to scale with respect to all inputs.

A drawback to the Cobb-Douglas production function is that it places restrictions on the relationships between inputs which may not be realistic. For example, it assumes an elasticity of substitution between any two inputs of one. Many alternative production functions have been developed. A common alternative is the translog production function.⁽¹⁾ Equation 2 illustrates the translog production function.

$$Q = \alpha + \beta K + \gamma L + \varphi G + \delta K^2 + \zeta L^2 + \eta G^2 + \lambda KL + \mu KG + \nu LG + \varepsilon \quad (2)$$

All variables are the same as those in equation 1. The squared terms capture possible returns to scale and the interactive terms enable us to assess the substitutability or complementarity between inputs.

As an example, if the coefficient on the public-private capital interactive term (μ) is significantly positive, it means that public and private capital are complements in production. This implies an increase in public capital raises the marginal productivity of private capital, resulting with a greater use of private capital. A negative (μ) would imply public and private

capital are substitutes in production. Furthermore, the translog production function does not place any restrictions on the elasticity of substitution between inputs.

Estimating a production function assumes output is the endogenous variable and inputs are exogenous. Friedlaender points out that this poses a potentially serious specification problem.⁽²⁾ Movements in factor prices are not controlled in the production-function analysis. However, if factor prices vary over time, the utilization rate of the inputs will also vary, making them endogenous. This introduces simultaneous equation bias into the model. Real wages and real interest rates have vary substantially over the last 30 years making this an important issue for infrastructure studies.

An alternative approach is to estimate the cost function which is the dual of the production function. This approach assumes exogenous input prices and output; cost and input quantities are endogenous. Firms are assumed to pick input quantities which minimize costs for a given level of output, input prices, and technology. Studies taking this approach usually estimate a translog cost function like the one shown in equation 3.

$$C = \alpha + \beta Q + \gamma P_K + \delta P_L + \zeta P_G + 1/2\eta P_K^2 + 1/2\theta P_L^2 + 1/2\kappa P_G^2 + 1/2\lambda P_K P_L + 1/2\mu P_K P_G + 1/2\nu P_L P_G + \varepsilon \quad (3)$$

Here C equals the logarithm of cost, P_i ($i = K, L,$ and G) equals the logarithm of factor prices for private capital (K), labor (L), and public capital (G), and Q equals the logarithm of output. The cost function can be estimated directly, or input demand equations derived from the cost function can be estimated jointly, which improves the efficiency of the estimate. From these estimates, the marginal products and elasticities of substitution of the various inputs can be recovered. All three of these approaches have been used in the infrastructure literature and are reviewed in the next section.

A REVIEW OF THE EVIDENCE

Aggregate Studies

The empirical literature which measures infrastructure's impact on the economy was stimulated by the work of David Aschauer.⁽³⁾ Aschauer estimated a Cobb-Douglas production function for the U.S. economy for the period from 1949 to 1985. The production function is specified in capital-intensive form, so output, labor, and public capital are expressed relative to private capital. He also examines the impact of public capital on total factor productivity.

His results show nonmilitary public capital to have a significant impact on output and productivity, *three times greater* than that of private capital. 'Core' infrastructure which consists of streets, highways, airports, mass transit, sewers, and water systems have the most explanatory power. He concludes that the slowdown of productivity growth from 2% a year (1950–1970) to .8% (1971–1985) can be explained by slower growth in the nonmilitary public capital stock (4.1% for 1950–1970 versus 1.6% from 1971–1985). Munnell, using a longer sample, gets similar but smaller aggregate results.⁽⁴⁾ The fact that public capital had an impact on output three times greater than private capital led some analysts to question these results and to conduct further research.

A study by Ford and Poret attempts to replicate Aschauer's study using data from 12 O.E.C.D. countries for the period beginning in the middle 1960s and ending in late 1980s.⁽⁵⁾ They find that infrastructure investment starts to decline in the mid-1970s in all these countries. This coincides with a slowdown in total factor productivity in all these countries. Ford and Poret find a consistent, significant relationship between infrastructure and total factor productivity for the five countries – U.S., Germany, Canada, Belgium, and Sweden. However, given the similar levels of economic development, the estimates suggest an implausibly wide range for the marginal product of private and public capital across countries. The implied marginal product for public capital ranges from a low of .45 in the United States to a high of 1.7 in Germany. Similar negative results are obtained in a panel study of seven O.E.C.D. countries by Evans and Karros.⁽⁶⁾

Tatom argues that Aschauer and Munnell use an inappropriate method to detrend the data.⁽⁷⁾ Both researchers used a deterministic time trend rather than taking first differences of each data series. The former method is correct only when the data is trend stationary, but Tatom finds evidence of nonstationarity in the data (and possible quadratic trends). As Tatom notes, failure to correct for nonstationary can result in finding spurious correlation between variables in the regression. Two variables may appear to be correlated, but the correlation is actually an artifact of an improper detrending method. Under these circumstances, ordinary least squares estimates are not consistent and the standard distributions used in hypothesis testing are invalid.

When the aggregate U.S. production function is estimated in first differences, Tatom finds little relationship between public capital and output. Alternatively, when he estimates the model with a quadratic time trend, public capital remains significant but the impact on output is cut in half.

Tatom was also concerned about whether the direction of causality is from public capital to output or the reverse. Rather than public infrastructure raising productivity and output, it may be that higher output

makes a country rich enough to invest in infrastructure. Using a Granger causality test, he finds support for his suspicion about reverse causality. His data suggests that changes in public infrastructure *do not* cause total factor productivity to change, but, changes in total factor productivity *do* cause changes in public infrastructure.⁽⁸⁾ This result would lead policy makers away from increasing public-capital investment as a means for promoting faster economic growth.

Finn develops a general-equilibrium model of the U.S. economy in order to estimate the impact of government investment on highway capital on private output.⁽⁹⁾ She disaggregates public capital into narrow categories under the assumption that the impact on private output varies considerably between infrastructure types.

The production function and investment-decision rules are estimated using a generalized method of moments technique for the sample period from 1950 to 1989. Finn finds highway capital has a positive and significant impact on private output. For the period 1970 through 1989, the decline in highway capital reduced the economy's growth rate by .1 of a percent. Her results suggest the impact of highways on private output is significant, but much smaller than Aschauer's estimates.

Easterly and Rebelo examine the impact of fiscal policy on economic growth for a large cross-section of countries.⁽¹⁰⁾ In order to capture long-run effects, they use the average value of variables for the period 1970 to 1988. After controlling for initial per capita income in 1960, human capital, and political stability, they find public investment in transportation and communication has a significant impact on long-run economic growth. They also find that total public investment has a negative impact on growth. The authors conclude that this latter result reflects the negative effect of public-enterprise investment on growth. The results in this study suggests that countries are better off in growth terms leaving production of goods and services to the private sector, rather than turning them over to a publicly owned enterprise.

The initial aggregate infrastructure studies by Aschauer and Munnell produced overly optimistic results. The work that followed, using different models and econometric techniques, suggest additional infrastructure investment has only a modest impact on aggregate output in the U.S. and abroad.

Regional Production-Function Studies

Although Aschauer and Munnell used aggregate data to investigate the impact of public capital on the economy, many of the infrastructure

studies use regional data. Researchers have taken this path for two reasons. First, in the U.S., approximately 70 percent of the public capital stock belongs to state and local governments. Second, the variation in data across states and over time improves the statistical properties of the tests.

The best known of the early regional studies is Munnell.⁽¹¹⁾ Munnell estimates Cobb-Douglas and translog production functions using data for the lower 48 states covering the period from 1970 to 1986. Munnell finds investment in public capital to have a significant positive impact on gross state product. Her results suggest a one percent increase in public capital results in a .15 percent increase in state output. While smaller than the aggregate results, these results appeared to confirm the positive and significant impact of incremental public investment.

Estimation of a production function has been the most common method used to examine the impact of public capital on output at the aggregate or state level. An important issue at the state level is whether the production technology is the same across different regional economies. Luger and Evans have shown that production functions differ across regions of the United States, even within the same industry.⁽¹²⁾ In Munnell's regional study, she estimates state production functions with ordinary least squares. For this to be valid, production technology must be the same. Given the results from Luger and Evans, Munnell's results are likely to be biased and alternative techniques which correct for these differences must be used.

Different procedures exist to control for these differences in production functions. The most common is the fixed-effects model. It estimates the equation using ordinary least squares, but includes a separate dummy variable for each state to control for state differences. Alternatively, the differences between states can be treated as random. Then, the production function differences are captured as a random component of the error term. Generalized least squares is used to estimate the equation.⁽¹³⁾

Holtz-Eakin also examines the impact of public capital on gross state product.⁽¹⁴⁾ A key difference in his paper, however, is the use of estimation methods which control for differences in production functions across states. Using a different data set than Munnell, he estimates a Cobb-Douglas production function for the period 1969 through 1986. He finds a negative relationship between total public capital and gross state product.

Evans and Karras estimate both Cobb-Douglas and translog production functions using Munnell's data set, but they remedy the flaw in Munnell's work by controlling for differences in production functions across states.⁽¹⁵⁾ They do not find a significant positive relationship for between infrastructure and gross state product. But Evans and Karras' results are difficult to interpret as they include explanatory variables – various

measures of public investment – which are likely to be correlated with one another and public capital. Multicollinearity between different explanatory variables make interpretation of results difficult.

Garcia-Mila, McGuire and Porter report results similar to those in Holtz-Eakin.⁽¹⁶⁾ Using a sample period from 1970 to 1983, Garcia-Mila et al. estimate models with infrastructure broken down into its narrower components. They find highways and streets, along with water and sewage systems, to have a small significant positive effect on gross state product. The buildings and structures category of public investment has a negative impact.

The problem in this literature is that each paper typically makes a major departure from Munnell's original regional paper so that comparisons are difficult. We cannot be sure if the significance (or lack of significance) is due to the use of different data, estimation technique or type of production function.

In an attempt to resolve these issues, Krol estimates both Cobb-Douglas and translog production functions controlling for state differences, using Munnell's original data set.⁽¹⁷⁾ Using a Cobb-Douglas production function, and controlling for state differences in production functions, total public capital appears to have a significant negative impact on gross state product. Next, Krol reestimates the model with public capital broken down into components – highways and streets, water and sewage systems and buildings and structures. These results indicate that marginal investments in water and sewage systems have a significant positive effect on gross state product, but marginal expenditures on buildings and structures have a significant negative effect. The coefficient of the highways and streets variable was not significant. In the translog results, total public capital and buildings and structures have negative marginal products, while highways and streets and water and sewage have positive marginal products. These results are comparable to the Cobb-Douglas results. Finally, labor is a significant substitute for total public capital, and two components, highways and streets and buildings and structures. Private capital is a significant substitute for buildings and structures, but a complement with respect to highways and streets and water and sewage systems.

Sectorial Cost-Function Studies

Some researchers have estimated cost functions to determine the impact of additional infrastructure investment on manufacturing costs and efficiency.

Nadiri and Mamuneas estimate cost functions for 12 U.S. industries for the period from 1956 to 1986.⁽¹⁸⁾ What is interesting about this study is that it includes traditional infrastructure as well as publicly financed R & D expenditures as a measure of “knowledge capital”. Nadiri and Mamuneas find that both kinds of public capital have a small negative and significant impact on industry costs. An increase in infrastructure reduces the demand for labor and capital, but increases the demand for intermediate inputs. R & D capital tends to reduce the demand for capital and material inputs, but raises the demand for labor. This latter effect may reflect the increased demand for skilled labor, a complement to R & D capital.

Feltenstein and Ha apply the same approach to Mexican data.⁽¹⁹⁾ They look at 16 sectors for the period from 1970 to 1990. Surprisingly, they find electrical and communications infrastructure lowers private production costs, but transportation infrastructure *increases* costs. This latter result is puzzling. It may reflect the serious congestion problems on Mexican highways. They find electrical public capital is a substitute for labor and a complement for private capital. Communication capital is a substitute for both labor and private capital, while transportation capital is a complement to labor and a substitute for private capital.

In a study closely related to Feltenstein and Ha but using less aggregated data, Shah examines 26 Mexican industries for the sample period 1970 to 1987.⁽²⁰⁾ Shah also finds increases in infrastructure reduces variable costs. Infrastructure is a weak substitute for intermediate inputs and a complement to labor and capital (only in long-run). These results differ from Feltenstein and Ha due to the more aggregated measure of infrastructure used by Shah. He finds the estimated return on infrastructure is less than the opportunity cost of funds due to congestion and unreliable service.

Seitz and Licht estimate manufacturing cost functions using West German regional-level data for the period 1971 to 1988.⁽²¹⁾ Seitz and Licht find that public capital has a significant negative affect on manufacturing costs. Public capital turns out to be a complement to both types of private capital (buildings and machinery) and a substitute for labor.

Infrastructure and Taxation

A major problem with the studies discussed so far is that they fail to take into account the marginal cost associated with raising funds for public investment projects. Taxes distort economic incentives resulting in a less efficient use of resources in an economy. Any benefit that comes from additional infrastructure investment must be weighed against the dead-weight losses associated with taxation.⁽²²⁾

Ballard, Shoven and Walley estimate that the welfare costs associated with the taxes imposed by all levels of government in the U.S. range between 17 and 56 cents per dollar of incremental revenue.⁽²³⁾ Jorgenson and Yun⁽²⁴⁾ provide estimates consistent with Ballard et al. This potentially large inefficiency resulting from the taxation of economic activity will offset – partially or fully – any positive impact of public capital investment has on output.

For example, suppose a city spends \$100,000 from tax revenues for an infrastructure project with an anticipated benefit of \$115,000. Simple benefit/cost analysis which ignores the welfare costs of taxation would conclude positive net benefits and lead officials to approve the project. However, taking into account the welfare costs of taxation would raise the cost estimate to at least \$117,000, suggesting the project generates negative net benefits. In the latter calculation, the project should not be approved.

Morrison and Schwartz carefully address this issue by comparing the benefits of additional infrastructure, as measured by lower manufacturing costs, with the distorting marginal costs associated with raising funds through taxation.⁽²⁵⁾ They estimate manufacturing cost functions and factor demands with data for the period 1970 to 1987 grouping the lower 48 states into four regions – northeast, north central, south, and west. The estimated cost function is designed to include both variable and fixed costs of production. Variable costs include production labor, non-production labor, and energy. Private and public capital are viewed as fixed factors. The optimal private capital stock is achieved when the shadow value of additional capital equals user cost. Shadow value is measured by the decline in costs that results from an increase in capital. The optimal public capital stock is determined in the same manner. However, in the public capital case, the user cost takes into account the marginal cost of public funds, which is usually greater than one.

Morrison and Schwartz find public investment tends to significantly lower costs in manufacturing in all regions and time periods. This implies additional infrastructure improves manufacturing efficiency. The saving was higher in the south, suggesting a greater marginal product from additional investment. The impact of an increase in private capital is greater, implying a greater return from private investment. They use regional dummy variables to control for differences in production technology, so it is not subject to the same criticism of the other papers.

Next, Morrison and Schwartz take into account the deadweight loss associated with the taxes needed to pay for the public capital. Estimates on the marginal cost of public funds exceed a dollar and range as high as \$1.56. Once you factor in the marginal cost of public funds as part of the user cost

of capital, the costs generally exceed the firm's cost savings. Based on this study, public infrastructure investment fails the cost-benefit test.

The regional and sectorial studies indicate that additional infrastructure has only a small impact on gross state product. This is especially true once you control for differences in state production technologies. There is evidence that additional infrastructure investment lowers manufacturing costs and improves efficiency. However, once the marginal cost of raising public funds through taxation is taken into account, the average net social benefit from extra infrastructure is small or negative.

ECONOMIC AND POLITICAL FACTORS THAT EFFECT INFRASTRUCTURE

Economic Factors

Much of the recent popular concern about public investment stems from the slower accumulation of public capital that characterized 1970s and 1980s. In a series of papers, John Tatom convincingly argues that the U.S. slowdown was efficient, and that it was caused by changes in the supply and demand for public infrastructure.⁽²⁶⁾

The basic premise behind Tatom's work is that the socially optimal and efficient quantity of infrastructure is that which balances the cost of additional public capital with the additional benefits. When the marginal cost of public capital exceeds the marginal benefit, there is too much public capital. If the reverse holds, then there is insufficient public capital.

In order to understand how changes in demographics and relative prices altered infrastructure investment decisions, we start by assuming the public capital stock reached its optimal level by the early 1970s. As Tatom points out, a series of changes occurred that altered this equilibrium. On the demand side, the percentage of the population between 5 and 24 started to decline. In 1971, the share of the under 24 population peaked at around 37.5 percent and has steadily declined since then reaching 29 percent in 1990. As a result, the service benefits associated with building new schools declined.

The second important development was the real increase in the price of oil in the 1970s. This significantly altered driving habits. The average number of miles driven per capita fell, leading to a decline in service benefits associated with building new highways. In addition, the interstate highway system was completed at around this time, so additional highway construction was subject to diminishing returns. The point being, while the interstate highway system provided substantial benefits, an additional highway system would not.

Next, the relative cost of public construction started to rise at this time. Tatom shows that the implicit price deflator for public nonmilitary investment compared to the private nonresidential fixed investment price deflator increased by 20% during the 1970s. The higher relative cost makes economic justification for incremental public investment more difficult.

Given these developments, by the mid-1970s, the marginal cost of public capital would have exceeded the marginal benefits flowing from additional U.S. infrastructure investment. According to this view, the slowdown in public investment was an efficient response to changing economic and demographic conditions. It did not reflect shortsighted decision making on the part of government officials.

The real price of crude oil declined substantially during the 1980s. As a result, driving has increased, raising the benefits associated with road usage. Correspondingly, additional highway investment may make more economic sense in the 1990s. The most current data indicates a rise in highway infrastructure, consistent with Tatom's argument. In addition, the large cohort of children of baby boomers is making its way through the schools. Assuming there is little excess capacity, the benefits of additional schools may rise causing an increase in school building.

Some observers have suggested that the decline in state and local infrastructure spending is the result of a reduction in federal grants-in-aid. Tatom examines this possibility and rejects it for two reasons.⁽²⁷⁾ First, most of the decline in infrastructure spending occurred before the reduction in federal grants-in-aid to state and local governments. Second, the increase in federal grants-in-aid in the Bush and Clinton administrations has not dramatically changed the trend in infrastructure spending by state and local governments.

Political and Institutional Factors

Recently, Crain and Oakley examined the impact of political institutions on infrastructure investment.⁽²⁸⁾ They use a strategic model of fiscal policy. Suppose future officials are expected to have policy preferences that differ from those of current officials. Because current elected officials do not have a direct means to enforce policies in the future, they take actions to indirectly constrain or limit the choices of future elected officials.

Glazer makes the same point with respect to voters.⁽²⁹⁾ Because voters cannot enter into contracts with future voters, one option is to choose durable capital projects which limit future choices. A key testable implication is that political institutions which increase policy "durability" should result in lower capital spending. For example, gubernatorial term

limits reduce policy durability resulting in more capital spending, and would be expected to lead to an increase in state level capital spending.

Crain and Oakley develop a cross-sectional test using data for the lower 48 states covering the period from 1978 to 1988. They try to explain per capita state government capital investment using variables which describe characteristics of state political institutions which influence policy durability. Also included are a set of variables which control for differences in state economic conditions. The control variables included in the model are welfare spending as a share of the state budget, per capita gross state product, per capita private capital and the state-bond rating.

The political variables have the following interpretation. The absence of gubernatorial term limits increases policy durability, which is expected to result in less public capital. The stability of majority party control in the state legislature increases policy durability reducing public capital, while volatility of the state electorate increases uncertainty about future voter preferences, which should increase the public capital stock. Initiative power allow voters to directly propose capital spending, which should increase capital spending. Finally, a biennial rather than an annual budget cycle increases policy durability reducing public capital. The existence of a separate capital budget tends to increase public capital investment.

The results indicate that political institutions have a significant impact on public capital investment decisions. In almost every case, the estimated impact is consistent with the theory. Political institutions which increase policy durability tends to reduce public-capital investment.

James Poterba examines the impact of a separate capital budget on per capita non-highway capital spending for the 48 lower states in 1962.⁽³⁰⁾ The paper tests an implication of the median-voter model which suggests that institutional arrangements should not influence voting and, therefore, the spending behavior of the government.

Separate capital budgets are likely to influence capital spending a number of ways. First, a separate capital project bureaucracy is created, with incentives to lobby for increased capital spending. Second, it may allow special-interest groups with a particularly strong preference for capital spending to more efficiently influence results. Finally, if voters are more willing to pay for capital spending over general-operating expenditures, government officials might begin to call operating expenditures capital expenditures.

Another important factor is the influence of pay-as-you-go capital expenditure rules. These budgetary rules require capital expenditures to be funded out of current revenues. These rules should tend to reduce capital spending. However, if debt financing is thought to be cheaper, the pay-as-you-go rules are less likely and capital spending should be higher.

The results show that separate capital budgets and pay-as-you-go finance rules significantly influence capital spending. After controlling for other economic and political factors which might influence capital spending, Poterba finds that states with separate capital budgets spend about one-third more on non-highway capital than states without capital budgets. Furthermore, states with pay-as-you-go capital financing rules reduce non-highway capital spending by about 20%.

At the local level, Dalenberg and Duffy-Deno examine whether ward election systems influences the level of public capital.⁽³¹⁾ They reason that ward elections provides incentives for council members to provide public goods and services with geographically concentrated benefits, but with costs spread out over the entire city. Infrastructure projects provide local benefits that are visible and durable, but are usually paid for by the entire city.

They estimate a model which includes a wide set of city demographic and economic variables. Also included is a dummy variable which takes on a value of one if there are ward elections, and is zero otherwise. The sample includes 30 cities for the period 1960 to 1981. On average, they find that cities with ward election systems have public capital stocks which are 1% higher. They also find that ward cities experience a larger increase in public capital than public employment. These results support their hypothesis that council members in ward election systems focus more on their wards than on the city as a whole.

POLICY IMPLICATIONS AND OPTIONS

Given the uncertain and probably low return associated with additional public investment, Policymakers should consider some alternative options in order to promote the efficient use of public infrastructure and economic development. Suggested policy changes include giving maintenance greater priority, elimination of the construction bias in U.S. federal grant programs, ending the U.S. federal tax exemption on state and local borrowing, and charging user fees to improve the infrastructure efficiency.

The Congressional Budget Office⁽³²⁾ has shown that the rate of return on maintenance exceeded the return associated with new construction during the 1980s. It also appears to be the case that the return on urban highway construction is greater than for rural highway construction. The policy implication is that urban highway construction and road maintenance should be given a higher priority in transportation budgets. Clearly, funds should be reallocated toward increased maintenance.

In the context of developing countries, Hulten compares the economic growth impact of additional public investment with simply increasing the effectiveness of the existing public capital stock.⁽³³⁾ He defines effectiveness in terms of electricity system loss, road-condition index, telephone faults, and locomotive availability. Even in developing countries, he finds an annual 1% increase in effectiveness has a seven times greater impact on economic growth than an annual 1% increase in public investment. Hulten's results suggest that, in many circumstances, it is not the lack of infrastructure that matters, but how it is maintained and managed.

For a number of reasons, federal grants in the United States are generally biased toward construction rather than toward funding maintenance. Gramlich argues that federal grant priorities should shift toward maintenance, rather than construction.⁽³⁴⁾ Furthermore, despite strong incentives to the contrary, highway construction funds need to be reallocated away from areas in economic decline to areas that are expanding. The marginal return from additional public investment in expanding areas exceeds the return from investing in declining areas. Politically, the reverse probably occurs because officials view infrastructure projects as a means of promoting economic development. Since the evidence doesn't support this policy, it represents an inefficient allocation of scarce infrastructure funds.

Tatom argues the current tax code is biased in the direction of favoring public infrastructure investment relative to private investment.⁽³⁵⁾ There are two reasons for this bias. First, the return to public investment project is not taxed, while the return to a private sector project is taxed. Second, and perhaps more important, state and local governments have access to tax subsidies in raising funds. Bonds used to finance state and local projects are exempt from federal corporate and personal income taxes. This allows public entities to borrow at below market rates, a subsidy which lowers the cost of public capital. As a result, many public projects look economic due to the tax subsidy, but may not be worth the investment.

Most economists think that the infrastructure systems could be used more efficiently if the means of financing shifted from broad-based taxes, such as the gasoline tax, to a direct user fee. Gramlich points out that there would be substantial benefits associated with this change.⁽³⁶⁾ Tolls or user fees are based on the principle of willingness to pay. Furthermore, the collected tolls would represent a useful guide to government officials as to how the public values alternative infrastructure projects and how future revenues should be allocated.

A recent study by Boarnet argues that it is the service flow from infrastructure, rather than the stock, which leads to improved private-sector performance.⁽³⁷⁾ Congestion reduces the positive productivity impact

derived from infrastructure service flows. Boarnet examines the impact of additional highway construction and congestion on output. He constructs a measure of highway congestion for each county in California from 1977 to 1988. His results indicate reducing congestion has a significant positive impact on county output while building additional roads does not. Boarnet concludes transportation policy should focus on reducing congestion as much as building new roads.

Furthermore, work by Small, Winston, and Evans⁽³⁸⁾ and Winston⁽³⁹⁾ among others, suggest that user fees would cause the existing infrastructure to be used more efficiently. The improved efficiency would greatly reduce the need for greater infrastructure investment would avoid future infrastructure problems.

They recommend a number of changes in highway infrastructure pricing policy. First, charge for pavement wear. Pavement damage is a function of weight per axle, not total vehicle weight. The fees charged to truckers should reflect this fact. As a result, trucks would gradually be built with a greater number of axles, reducing pavement damage and extending the life of the highway. The current gasoline tax works just the opposite. It creates an incentive to have less axles, improving gasoline mileage but increasing highway damage. Combined with thicker highway pavement, Small et al. estimate that such a road policy change would result in an estimated benefit-to-cost ratio of approximately four.

A second major recommendation would be to use peak-load pricing for both highways and airports. This would amount to charging higher user fees during periods of time when highways and airports are congested. This would provide infrastructure consumers with an incentive to reduce use during peak hours. The incentives provided by peak-load pricing would cause individuals to shift less essential trips to off-peak hours, encourage use of mass transit, and car pooling. Elimination or reducing the severity of congested highways and airports would reduce the need to build additional infrastructure. They also estimate net benefits from peak-load pricing of about \$6 billion per year, primarily in time saving.

CONCLUSION

This paper investigated the impact of public infrastructure investment on the economy. Concern about infrastructure issues grew because of the decline in U.S. public capital stock during the 1970s. Policy makers and the early research linked the decline in infrastructure investment with lower productivity growth.

Much of the infrastructure research effort has been directed at quantifying the impact of additional public capital on output, productivity, or cost. Estimates of production and cost functions at the aggregate, regional, and sectorial levels suggest the return on additional infrastructure investment is low. Once the marginal cost of raising the funds is included in the calculation, the return is close to zero. The case has also been made that the decline in the public capital stock was an efficient response to changing economic and demographic factors.

Studies also suggest that policy makers should direct their efforts at increasing maintenance of the existing infrastructure stock. In addition, shifting to peak-load pricing will reduce congestion and increase the benefits derived from existing roads and airports. While politically less popular, these policies will yield a higher return for each tax dollar than simply more construction. Finally, decisions on new infrastructure projects should be based on careful cost/benefit analysis.

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