The Jerome Levy Economics Institute of Bard College

Public Policy Brief

Public Infrastructure Investment: A Bridge to Productivity Growth?

Public Capital and Economic Growth
David Alan Aschauer

New Federal Spending for Infrastructure: Should We Let This Genie Out of the Bottle?
Douglas Holtz-Eakin

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SUMMARY

David Alan Aschauer, who was among the earliest researchers to quantify the statistical relationship between public infrastructure investment and private sector productivity, states that the slower rate of productivity growth since the early 1970s—coupled with an aging population, the declining share of workers to the total population, and other demographic factors—poses a dilemma for policy-makers interested in strengthening the long-term, relative position of the U.S. in an increasingly competitive global economic environment.

Aschauer regards public infrastructure (comprising streets and highways, mass transit, water and sewer systems, etc.) to be a factor of production. The public capital stock, which equaled 46.1% of GNP in 1960, amounted to less than 41% of GNP in 1990. Hence, the declining pace of capital accumulation may be responsible for explaining both "a very substantial portion of the productivity slowdown...and cross-country differences in productivity growth."

Critics charge that the magnitude of Aschauer's statistical correlation between public capital and private sector productivity is implausible. Moreover, he is accused of omitting variables that may better explain the productivity slowdown, and dismissing the prospect of reverse causation in his research. Aschauer responds by stating that the mere existence of other explanations does not inherently challenge the value of public capital: the inconsistent methodologies of other researchers (e.g., various definitions of "public capital" and the differing geographic scope of studies) make the critics' arguments less cogent.

Aschauer recognizes that he must extend his thesis to address the optimality of the public capital stock vis-à-vis maximizing private sector productivity. He provides evidence of the underprovision of public capital by citing a rate of return on public capital in excess of that to private capital. In fact, Aschauer claims that "as long as the returns to infrastructure investment exceed the growth rate of the economy, an increase in public investment will tilt the national consumption profile toward the future...and raise living standards in the next century."

In contrast, Douglas Holtz-Eakin dismisses the conventional arguments for a Federal infrastructure program. Holtz-Eakin asserts that:

- A large-scale public infrastructure program has no appreciable effect on productivity growth.
- In the current fiscal climate of scarce Federal resources, a Federal infrastructure is not consistent with the goal of deficit reduction.
- There are better infrastructure strategies than new spending and massive construction programs.
- Policies aimed at increasing private rather than public investment will have a more positive impact on U.S. competitiveness.

Holtz-Eakin cautions against a Federal infrastructure policy, stating that the "provision of infrastructure has been the province of state and local governments, on the grounds that local officials are better able to judge the needs and desires of their local constituents." Holtz-Eakin's critics charge that local decision-makers are unable to capture interstate productivity spillovers, but the author asserts that no empirical evidence suggests the existence of such spillover effects.

Rather than authorize new spending programs, Holtz-Eakin favors more efficiently pricing (e.g., user fees) the existing stock of infrastructure, and submits that infrastructure maintenance— not new construction—should be our focus. Given the deficit-reduction-driven political climate of fiscal restraint, all Federal expenditures are subject to being disguised as investments. Holtz-Eakin believes the distinction between expenditures and investment—at least in the debate over the return on public infrastructure—may be artificial.

Holtz-Eakin insists, though, that his results "do not imply that the large stock of infrastructure in the United States provides no benefits. Instead, the results say that a broad-based spending program for *additional* infrastructure is unlikely to augment economy-wide productivity growth." Hence, Holtz-Eakin would not necessarily quarrel with other justifications (e.g., social good) for increased infrastructure expenditures—just don't cite improved productivity as a rationale.

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Preface

The role of public capital has been widely discussed during the postwar period, with the emphasis on the cunning ability of legislators to secure pet projects (and constituents' votes) within their districts. However, the productivity slowdown in our country—which began in the early 1970s—has altered the way many Americans think about public capital. The debate now addresses the effects of public infrastructure investment on private sector productivity and, consequently, American competitiveness in the global economy.

The seminal work of David Alan Aschauer has been endorsed by many economists and policy-makers, but recent research conducted by scholars disputes the earlier empirical evidence. Many question the mere existence of a relationship between public capital and productivity: economics not being a science which can duplicate laboratory conditions, the skeptics allege that many unknown variables alter analyses which examine the reasons for the U.S. declining productivity trend (the recent gains notwithstanding). Others simply state that though a relationship may actually exist between public capital and productivity, it is impossible to quantify the magnitude or establish a precise level of correlation. Implicitly, the critics, represented in this *Public Policy Brief* by Douglas Holtz-Eakin, are suggesting that the inferences derived from the econometric results of the relationships previously described by Aschauer are not plausible.

In his first State of the Union address to Congress, President Clinton announced an economic program, which includes a fiscal stimulus package to aid the recovery in the near term. The president's focus, however, is clearly on creating meaningful jobs and enhancing the level of U.S. competitiveness in the next century. The long-term investment package outlined by the president supports the notion that public investment in infrastructure, human capital, R&D, and other growth channels will have significant benefits to the competitive position of the U.S. economy.

Dissenters of President Clinton's plan believe that although public infrastructure investment may contribute to the long-term competitiveness of this country, the current fiscal climate dictates that deficit reduction take precedence over any program which may expand the Federal budget deficit. In essence, these observers claim that deficit reduction and public investment are mutually exclusive strategies.

In this *Public Policy Brief*, both views of the effects of public infrastructure investment on the economy are presented. Our purpose at the Jerome Levy Economics Institute is to present balanced and academically rigorous research which provokes serious thought about the challenges that confront our nation, and makes a lasting contribution to the public policy debate while minimizing the damaging effects of political philosophy and ideology.

Dimitri B. Papadimitriou
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Public Capital and Economic Growth

David Alan Aschauer

Introduction

In the United States, there is an increasing interest in policies aimed at accelerating the pace of productivity growth. This interest is primarily due to two sets of factors. Looking backward in time, the long-term rates of growth of output and of productivity have fallen below that of the "golden age" of the 1950s and 1960s. Furthermore, the United States productivity growth rate has been substantially below that of some of its major economic trading partners for much of the post-World War II period, leading to the fear—rational or not—that these other countries pose a threat to the economic leadership position of the United States. Looking forward in time, the labor-force growth rate in the United States is expected to slip below the population growth rate soon after the turn of the century. In the decades ahead the number of workers relative to the population will decline, and the maintenance of the historical pace of improvements in living standards will require the typical worker to become steadily more productive.

While there are many potential mechanisms to raise productivity growth, most turn on boosting the rate of capital accumulation—either tangible such as plant and equipment, or intangible capital such as that generated by research and development expenditures. Traditionally, the role of fiscal policy in this process has been to encourage private savings and private investment through tax incentives or to raise national savings through reductions in the government budget deficit.

But the results of recent empirical research offer the possibility of a direct channel by which fiscal policy can affect national investment and national productivity growth. It has been recognized that the public infrastructure—streets and highways, mass transit, water and sewer systems, and the like—should be considered as a factor of production (along with labor and private capital) in the private sector production process. It has also been recognized that public infrastructure spending, as a share of total output, reached a peak in the latter half of the 1960s. The results of some of the empirical studies (e.g., Aschauer 1989a, Munnell 1990a) indicate that this reduction in the pace of public capital accumulation is capable of explaining a very substantial portion of the productivity slowdown. And other studies (e.g., Aschauer 1989c, Ford and Poret 1991) suggest that cross-country differences in productivity growth might also be partly explained by differences in levels of infrastructure spending.

These empirical studies, linking movements in private sector productivity to trends in public capital investment, raise a number of questions which demand further discussion. There are valid concerns about the statistical reliability of the results. At least four questions are pertinent here:

1. Is the strong correlation between public and capital productivity reflective of a true causal role for public investment spending?
2. Is the estimated magnitude of effect too large to be plausible?
3. Is the public capital stock merely acting as a proxy for other omitted variables such as population shares, exchange rates, or oil prices?
4. Finally, even if it were accepted that a strong causal relationship running from public capital to productivity exists, for public policy purposes it would still be necessary to answer the question: Is the public capital stock currently too low?

I begin by briefly discussing trends in the public capital stock over the last three decades, and then assess the potential impact of these trends on productivity growth. Here I assume that the public capital stock does act as an input to private production, and that the marginal product of public capital equals that of the private capital stock. Next, I discuss the statistical concerns which I just noted, paying particular attention to the magnitude of effect or to the output elasticity of public capital. Finally, I discuss the question of the optimality of the public capital stock.

Public Capital Trends and Potential Impact on Productivity

Table 1 shows the composition and behavior of the nonmilitary capital stock of the federal and state and local governments over the past three decades. (These public capital stocks are measured net of depreciation and in constant 1990 dollars.) The vast majority, or about 85%, of the nonmilitary public capital stock is owned by state and local governments—nearly $1.9 trillion of the total of almost $2.2 trillion. Of course, a large portion of the state and local capital stock has been funded by grants from the federal government. Just over half of the total public capital stock is composed of a "core infrastructure" (e.g., streets and highways, water supply, sewers, and publicly owned electrical and gas facilities), which might be expected to function as an input to the private production function more closely than does the total public capital stock. Of the categories of the core infrastructure, streets and highways represent some 61%, thus being the largest single category.

Table 1
Trends in Public Capital 1960-1990

	Percent of GNP				$ (billions)
	1960	1970	1980	1990	1990
Total	46.1	48.9	45.3	40.6	2,180.4
Federal	9.4	7.9	6.4	5.5	298.1
Core infrastructure	0.5	0.6	0.6	0.5	26.3
Highways	0.4	0.4	0.4	0.3	17.2
State and Local	36.7	41.0	38.9	35.1	1882.3
Core infrastructure	24.1	25.7	23.9	21.5	1143.0
Highways	16.8	12.9	12.4	10.6	693.6
Water supply	2.3	2.3	2.1	2.1	109.6
Sewers	3.0	3.0	3.5	3.5	184.1

Source: U.S. Department of Commerce, Bureau of Economic Analysis

The total public capital stock rose during the 1950s and 1960s, peaking in 1968, and has been falling thereafter. The public capital stock equalled 46.1% of GNP in 1960 and 48.9% GNP in 1970, but by 1990 amounted to less than 41% of output. As shown by Table 1, the fall-off in the ratio of public capital stock to output is concentrated in the streets and highways component, with water and sewer systems staying even with output.

Table 2
Contribution of Public Capital to Productivity Growth 1960-1989

	1960-69	1970-79	1980-89
[1] Growth in public capital (% per year)			
Total pubic capital	4.31	2.00	1.38
Core infrastructure	3.99	2.06	1.30
[2] Reduction in growth in public capital (% per year, relative to 1960-69)			
Total public capital		2.31	2.93
Core infrastructure		1.93	2.69
[3] Growth in productivity (% per year)			
Labor productivity	2.90	1.31	1.28
Total factor productivity	1.82	0.60	0.87
[4] Reduction in growth in productivity (% per year, relative to 1960-69)			
Labor productivity		1.59	1.62
Total factor productivity		1.22	0.95
[5] Contribution of public capital to productivity growth[a] (% per year)			
Total public capital	0.26	0.09	0.05
Core infrastructure	0.13	0.05	0.02
[6] Reduction in contribution of public capital to productivity growth (% per year)			
Total public capital		0.17	0.21
Core infrastructure		0.08	0.11
[7] Productivity growth slowdown explained by public capital (%)			
Labor productivity			
Total public capital		10.69	13.93
Core infrastructure		5.03	6.56
Total factor productivity			
Total public capital		12.96	22.11
Core infrastructure		6.79	11.58

[a] Measured as the product of the elasticity of output with respect to public capital (total and core infrastructure, respectively), η_{KG}, and the growth rate of public capital. In the calculations, the return to public capital is assumed to equal that of private capital, ranging from 12.73% in the period from 1960 to 1969 to 8.11% in the period from 1980 to 1989.

Table 2 details some standard growth accounting computations linking changes in investment in total public capital and core infrastructure capital to labor and total factor productivity growth. Line (1) of Table 2 shows that the growth rate of the total public capital stock was 4.31% per year in the 1960s, 2% in the 1970s, and 1.38% in the 1980s. The core infrastructure displays similar growth rates. Line (2) shows the reduction in growth rates in public capital for the 1970s and 1980s relative to the high growth rate of the 1960s. For the 1970s, the fall-off in growth of both the total and infrastructure capital stocks was in the range of 2 percentage points: for the 1980s, the fall-off was increased to between 2.67 and 3 percentage points. Line (3) shows the growth rates of labor productivity and total factor productivity, and line (4) shows the percentage point reduction in productivity growth. Relative to the 1960s, labor productivity growth fell by over 1.5 percentage points, while total factor productivity growth declined by around 1 percentage point. Most of the decline in labor productivity growth, then, is the result of a decline in multifactor productivity growth. While a slower pace of private capital accumulation relative to the labor force has been an important factor, it explains less than half of the slowdown in labor productivity growth.

One potential factor explaining a portion of the decline in total factor productivity growth and, thereby, labor productivity growth is the reduced rate of public capital accumulation. [See Appendix A for further discussion of this issue.]

The basic conclusion of Table 2 is that a non-negligible portion, perhaps around 10%, of the productivity slump can be explained by the lower rate of public capital accumulation during the 1970s and 1980s—even without making use of what some would term "implausibly high" elasticity estimates from the "flawed" aggregate studies.

The calculations in Table 2 show the potential *direct* contribution of public investment to labor productivity growth. But provided that public capital is complementary to private capital, infrastructure investment may *indirectly* contribute to labor productivity growth. An increase in public capital accumulation will raise the marginal product of private capital and, thereby, provide the incentive for a higher rate of private investment. The quicker pace of private capital accumulation will then contribute to an enhanced rate of labor productivity growth.

Table 3 shows how the trends in public capital accumulation may contribute to the movements in labor productivity in this indirect manner. [See Appendix B for a statistical presentation of this relationship.]

Table 3
Contribution of Public Capital to Growth in Private Capital and in Labor Productivity

	1970-79	1980-89
[1] Reduction in growth of private capital stock(% per year, relative to 1960-69)	0.58	1.28
[2] Reduction in growth of private capital stock explained by public capital[a] (% per year...)	0.04	0.45
[3] Indirect contribution of public capital to reduction in labor productivity growth[b] (% per year...)	0.14	0.16
[4] Direct contribution of public capital to reduction in labor productivity growth[c] (% per year...)	0.17	0.21
[5] Total contribution of public capital to reduction in labor productivity growth (% per year...)	0.31	0.36
[6] Labor productivity growth slowdown explained by public capital (%)	19.50	22.22

[a]Calculated from an investment model where: (i) the growth rate of the private capital stock depends positively on lagged growth of private capital, positively on the rate of return to private capital, positively on the capacity utilization rate in manufacturing, and negatively on the public investment rate, and (ii) the rate of return to private capital depends positively on time, negatively on the private capital–to–labor ratio, positively on the public capital stock, and positively on the capacity utilization rate in manufacturing. The model assumes that *the marginal product of public capital equals that of private capital* and that, given the rate of return to private capital, *an increase in public investment induces an equal reduction in private investment*. See the test for further detail.

[b]Measured as the product of the elasticity of output with respect to private capital, η_K, and the reduction in growth in the private capital stock explained by the reduction in growth of the public capital stock.

[c]From Table 2, line (7).

Meanwhile, the rate of return to private capital—which feeds into the investment equation—depends:

A. positively on time (proxying for technological progress)
B. negatively on the private capital–labor ratio (due to a diminishing marginal product of private capital)
C. positively on the public capital stock, and
D. positively on capacity utilization (capturing cyclical effects).

Consistent with previous set calculations, the model's parameters are set such that the marginal product of public capital equals that of the private capital. The model also assumes that *given* the rate of return to private capital, a one-dollar increase in public investment induces a one-dollar reduction in private investment. Only over time, as the rate of return to private capital rises with increase in public capital stock, does a higher rate of public capital investment bring forth an increase in national (public plus private) investment. [See Appendix C for a statistical discussion.]

Reverse Causation?

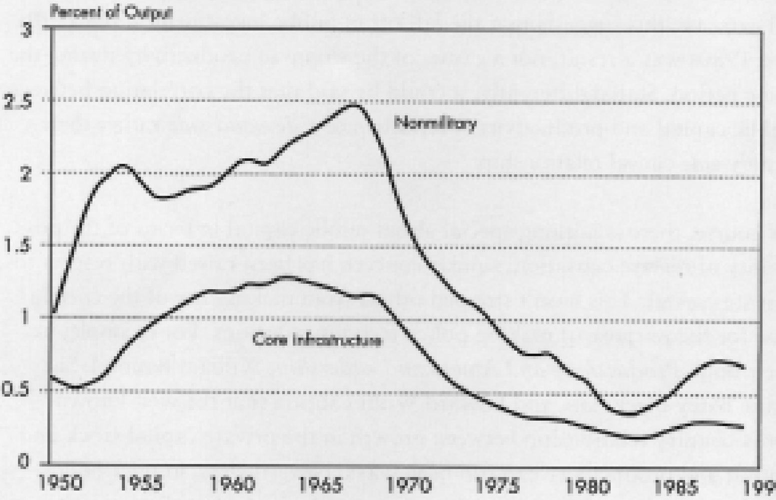
One reason for guarded optimism about the aggregate time series result is the problem of *reverse causation*. Certainly, a logical case can be made that public investment may well be responding to changes in private economy instead of initiating them. For instance, one could argue that slower growth in productivity, per capita income, and tax revenue induced the government at all levels to reduce spending on public capital projects. Pushed to its logical extreme, this suggests that the fall-off in public investment in the 1970s and 1980s was a result, not a cause, of the slump in productivity during the same period. Stated differently, it could be said that the correlation between public capital and productivity is reflective of a *demand-side* rather than a *supply-side* causal relationship.

Of course, there is nothing special about public capital in terms of the possibility of reverse causation; similar concern has been raised with respect to private capital. This hasn't stopped others from making use of the correlation for the purpose of making policy recommendations. For example, in their book *Productivity and American Leadership*, William Baumol, Sue Anne Batey Blackman, and Edward Wolff caution that the well-known cross-country relationship between growth in the private capital stock and output and productivity can run both ways. Nevertheless, in their policy conclusions, the authors assert that "it seems farfetched to discount altogether the association so tight as that between investment and economic growth..." and they subsequently estimate how it would be possible to achieve a particular productivity target—parity with major international competitors to the United States through the year 2020—by boosting the rate of growth of the private capital stock. Similarly, it would seem farfetched to discount, at least completely, the efficacy of lifting labor productivity growth through public capital accumulation.

Further, at a heuristic level, the demand-side reverse causation argument has its own problems. There are some economists who argue that in the United States the productivity growth slowdown began as early as 1965.

There are even some (e.g., Darby 1984) who take the position that the productivity slowdown is a result of a mismeasurement of factor inputs or of output. But these economists represent a distinct minority in the profession. Indeed, it seems safe to say that the consensus view of the economic profession is that the productivity growth slowdown is real and that it began *in the early 1970s*. But as seen from Figure 1, public nonmilitary investment spending, relative to gross national product, reached a peak in the period *between 1965 and 1968*. So while it is possible, perhaps even likely, that in the latter part of the 1970s and in the 1980s slow productivity growth hampered investments in public capital, it is unlikely that sluggish productivity growth represented the *initial* cause of decline in public investment expenditure.

Figure 1
Public Investment Trends



At a more formal level, there are a number of reasons to believe that the correlation between public capital and productivity is indicative of a true causal role for public investment. There is evidence that those functional categories of public capital which one would expect, on an *a priori* basis, to benefit the private economy the most—specifically, a core infrastructure of transportation facilities and of water and sewer systems—turns out to be the most important in the aggregate production functions. [See Appendix D for a technical discussion of these issues.]

Hence, the question arises: if these correlations are indicative of a reverse causation, why is it the case that the elasticity estimates are strongly positive for core infrastructure categories but negligible or even negative for other public capital? Specifically, why should the productivity slowdown have caused a reduction in capital investments in highways, water supply, and sewer systems but not in other capital such as office buildings, hospitals, and schools? Seemingly, this is an odd set of demand elasticities. [See Appendix E for a review of other relevant studies of reverse causation.]

Another strategy to minimize the likelihood of the estimated elasticities merely picking up a demand-side linkage between public capital and productivity would be to estimate cost functions rather than production functions. The purpose would be to obtain an estimate of the *shadow value* of public capital, a measure of the reduction in cost of production resulting from a given increase in public capital. The point I want to make is that the estimate of the shadow value of public capital will not directly involve any relationship between output and the public capital stock; instead, output is allowed to have a separate, distinct influence on costs of production. Here, the finding of a significant shadow value of public capital in the private sector would seem to undermine the demand-side argument. Specifically, if we are to believe that the correlation between public capital and private output merely evidences a demand-side budgetary link, then why is it that, when we hold fixed the level of output, an increase in the public capital stock reduces production costs?

[See Appendix F for technical presentation of the public capital–production costs relationship.]

Too Large an Impact?

Even if one accepts, on theoretical and empirical grounds, that public infrastructure partly determines private sector output, productivity, and costs of production, the concern remains that the estimated impact is too large. For example, the results in Aschauer (1989a) and Munnell (1990a) imply that a 1.0% increase in the public capital stock will increase private sector output by as much as or more than 0.33%—an amount which is seen by a number of well-respected economists as being "implausible" (Aaron 1990), "grossly inflated" (Schultze 1990), or which "strains credulity" (Montgomery 1990).

Of course, lacking alternative evidence on the impact of public capital on productivity and costs, it is difficult to say what is plausible or implausible. Indeed, those who argue that the estimated effect of public infrastructure is too large rarely, if ever, provide direct evidence to support their position. Those who do present such evidence refer to the results of cost-benefit studies which imply much lower average returns to public capital investments. But these low returns could just as conceivably be due to deficiencies in cost-benefit methods which tend to understate the true return to public capital accumulation. I have detailed these potential defects elsewhere. Among other factors, they involve the use of inappropriately high discount rates and the inherent difficulties in capturing general equilibrium effects in conventional partial equilibrium cost-benefit frameworks.

Others attempt to undermine the credibility of the aggregate estimates by arguing that while many empirical studies "have found statistical evidence that public capital influences private output," the magnitude of public capital's impact is "quite small" (*How Federal Spending for Infrastructure and Other Public Investments Affects the Economy*, 1991). However, what these analysts usually fail to recognize, or at least to communicate, is that adjustments often must be made to perform a proper comparison. After such adjustments are made, the various estimates turn out to be much closer in magnitude than a cursory view may suggest.

Three sorts of adjustment are necessary. First, it is not typically the case that the definition of the public capital stocks is the same across studies. In some cases, the public capital stock is limited to highways (Garcia-Mila and McGuire 1990), while in others it is more inclusive—perhaps a core infrastructure of highways but also mass transit, airports, and water and sewer systems (Aschauer 1989a). It is inappropriate to follow the lead of Jorgenson (1991) and compare elasticities of different types of public capital. If, instead, one were to correctly compare, say, the output elasticity of highway capital alone, one finds much closer estimates; for example, Garcia-Mila and McGuire (1990) estimate the highway elasticity to equal 0.04 while Munnell (1990b) estimates it to equal 0.06.

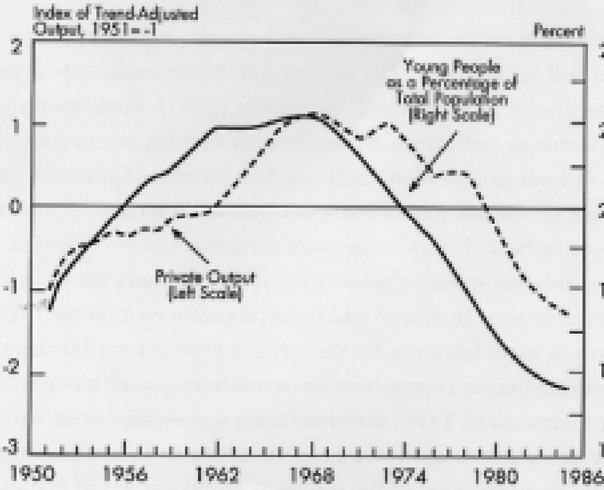
Second, it is necessary to adjust for differences in the geographic scope of the studies. The estimates of the output elasticities of public capital arising from production function studies using a similar definition of public capital show a fairly systematic relationship with the level of government. In particular, the estimates tend to be larger at the federal level than at the state level, and larger at the state level than the municipal level. This is to be expected since, to a certain extent, the benefits of infrastructure are likely to spill over jurisdictional lines. Munnell (1991) makes this point by stating that "because of leakages, one cannot capture all the payoff to an infrastructure investment by looking at a small geographic area."

Finally, while some studies involve the total private economy, others, such as Morrison and Schwartz (1991), involve only the manufacturing sector, and still others, such as Nadiri and Mamuneas (1991), involve only a subset of manufacturing industries. As the benefits of infrastructure can be expected to fall not just on manufacturing but across all industries, it is necessary to gross up the marginal benefits of public capital found in manufacturing in some fashion. For example, assuming that (on average) the rates of return to public capital in other sectors of the economy are the same as in the manufacturing sector, it would be appropriate to multiply the estimated returns in manufacturing by the ratio of total private business output to manufacturing output to compare the manufacturing estimate with the national estimates. As of 1991, manufacturing represented approximately 20% of private output so that, to a first approximation, this adjustment would require multiplication of the return to public capital in manufacturing by a factor of five. Thus, upon appropriate adjustment, rather small effects may, in fact, represent quite high aggregate returns.

Omitted Variables?

Another concern is that the correlation between public capital and productivity is actually due to public capital proxying for other variables. Economists at the Congressional Budget Office argue that one such data series would be a demographic variable such as the percentage of the population between five and fifteen years of age. As Figure 2 indicates, this population variable, too, "follows the same smooth path as the public capital stocks, rising through 1968 and falling thereafter." Further, these economists assert that when this series is used *in place of*—not *in addition to*—the public capital stock, "it appears to 'explain' private output in as statistically significant a fashion as does public capital." Since there is no reason to expect that the relationship reflects anything more than coincidence, it follows that "the association between private output and stocks of public capital may also be coincidental." Aaron (1990) makes use of a different data series—the yen/dollar exchange rate—to make essentially the same point.

Figure 2
Relationship Between Private Output and Young People as a Percentage of the Total Population, 1951-1985



Source: Congressional Budget Office using data from the Bureau of Labor Statistics; and *Economic Report of the President* (February 1991)

Note: Private output is measured by a three-year moving average of private business output per hour worked (adjusted for time trends). Young people are those between ages 5 and 15 years.

The method of argument employed by these researchers is clearly anti-scientific. It is my understanding that good empirical science proceeds by constructing a good theoretical model with refutable hypotheses—such as that the public capital stock positively influences private sector productivity—and then testing the theory by confronting the hypothesis with the available data. The method used by these researchers, on the other hand, is to search for data series which will attenuate the relationship between public capital and output without providing any theoretical justification for the relevance of such variables. Indeed, the lack of theoretical motivation is viewed as something of a virtue. Yet, without any theoretical rationale, *any* data series becomes admissible, and the ability of such researchers to find one or more data series to accomplish their goal will be constrained only by the extent of their desire to debunk a particular theory.

That having been said, it is also true that these researchers overstate their respective cases. It is true that various demographic variables —by themselves—perform in a manner similar to public capital in the statistical models. But what is also true is that when *both* the public capital and the demographic series are included in the models, the public capital series inevitably dominates; indeed, the demographic variables have no additional statistically significant explanatory power for output once public capital is included. It is also true that the yen/dollar exchange rate seems to "cause" productivity. But in order to eliminate the importance of the public capital stock for productivity, Aaron finds it necessary to not only include the yen/dollar exchange rate but *also* to convert to growth rates (thereby switching the focus from the long run to the short run) *and* to add dummy variables for 1966 and for 1974. It is hardly surprising that with this much effort it is possible to overturn a particular empirical result.

Other researchers have taken a better approach. Tatom (1991) argues that movements in the price of energy should be expected to have had an important impact on productivity over the post-World War II period: thus, he adds the real price of oil as an additional explanatory variable in the aggregate productivity model. Tatom presents empirical results which seem to indicate that the addition of the oil price variable completely eliminates the importance of public capital in the statistical model.

Yet a closer, technical look at Tatom's methodology reveals a contradiction within his theoretical model. The basic problem is that he uses a value added measure for his output variable, so that energy should not directly influence productivity. While there are other, indirect reasons why changes in energy prices might impact on productivity—such as induced capital obsolescence—he disallows those reasons by the constrained manner in which he introduces energy into his empirical model. If one recognizes the contradiction and relaxes the relative constraint, one finds that the public capital stock still carries important explanatory power for productivity.

Finally, most researchers who bring up the question of omitted variables seem to believe that the inclusion of other variables will work to eliminate the importance of public capital. Yet this is not always the case. Hulten and Schwab (1991b) use state-level data for manufacturing and find little role for growth in the public capital stock in determining growth in total factor productivity. Yet Nadiri and Mamuneas (1991) find that when the capacity utilization rate and growth in the stock of research and development capital are added into the empirical model, the elasticity of output with respect to public capital is estimated at 0.29 and is statistically significant. The addition of the capacity utilization rate is important since it captures movements in productivity over the business cycle. Moreover, the growth in the stock of research and development spending has been shown to be an important determinant of productivity growth in a large number of studies.

An Optimal Level of Public Capital?

Let's suppose that you're convinced of a strong causal relationship between public capital investment and productivity and output. From a policy perspective, it would still be necessary to go further and answer the question: Is the public capital stock at a level which maximizes private sector productivity? The time series results suggest that, at the aggregate level, there is underprovision of public capital, with the implied rate of return to public capital in excess of that to private capital. Yet, as discussed above, many would find the results in these studies unreliable. Hence, it is prudent to consider the results of other studies as well.

Munnell estimates an output elasticity of public capital of 0.15, while the output elasticity of private capital is 0.31; as the private capital stock is about twice the size of the state and local public capital stock, these results imply roughly equal returns to both types of capital, and it would appear that there is a nearly optimal level of public capital provision. Yet Munnell stresses that the existence of external effects—in particular, that the total benefits of a state highway will not be captured by that state's economy but will also spill over on adjacent and other states—"suggests that the United States has underinvested in public capital." Further research is called for to gauge the full extent of this type of spillover effect and see if it is large enough to explain a substantive portion of the difference between the state-level results and the national-level results.

[See Appendix G for a technical discussion of the relationship between public capital and manufacturing.]

There are grounds for believing that the rate of return on public capital may be as high or higher in other industries than it has been found to be in manufacturing. For example, in a study of the trucking industry, Keeler and Ying (1988) estimate that as much as three-quarters of the Federal Aid highway investments during the 1950s and 1960s can be rationalized *on the basis of reductions in trucking costs alone.*

Conrad and Seitz (1992) find that the rate of return to infrastructure is roughly equal in the manufacturing and trade and transport industries (0.056 and 0.055, respectively) and, while somewhat lower, is still substantial in the construction industry as well (at 0.031).

Putting these results together, it appears that the aggregate rate of return to infrastructure capital—once one adjusts for the inclusiveness of the public capital stock, for geographic spillover effects, and for the industry coverage—is at least as high as that of private capital. In my opinion, the returns to public capital are probably higher than that.

Finally, I want to address the commonly accepted notion that in recent decades the United States has been consuming too much and saving too little. In terms of the neoclassical growth model, the capital stock is well below the Golden Rule level, with the net marginal product of private capital in excess of the average growth rate of real output. Back-of-the-envelope calculations yield an estimate of the net marginal product capital of about 8%, compared to an average economic growth rate of around 2.5-3% per year.

In this setting, it is not necessary for the returns to public capital to be greater than—or even equal to—those of private capital in order to rationalize increased public investment. As long as the returns to infrastructure investment exceed the growth rate of the economy, an increase in public investment—financed through a reduction in either public or private consumption—will favorably tilt the national consumption profile toward the future. So, if it is true that the United States doesn't save and invest enough, then one way to partly overcome this deficiency is through appropriate investments in our infrastructure. A reorientation of public spending away from consumption toward investment is just as advisable as a reduction in the budget deficit to raise living standards in the next century.

Appendix A

Line (5) of Table 2 calculates the potential contribution of public capital to productivity growth. It is assumed that the marginal product of public capital is equal to that of private capital. Although some (maybe Paul Craig Roberts) would argue that this assumption overstates the returns to total public capital—and perhaps even to infrastructure capital—this represents a low rate of return when compared to some empirical results in the area. For now, my intent is only to provide a reasonable benchmark calculation and bypass the controversy about the larger aggregate elasticity estimates. As line (5) of Table 2 shows, by this type of calculation the contribution of the total public capital stock was just over 0.25% per year during the 1960s, just under 0.10% during the 1970s, and only 0.05% during the 1980s. The contribution of growth in the core infrastructure was over 0.10% per year during the 1960s, 0.05% during the 1970s, and negligible during the 1980s. Line (6) of Table 2 translates these results into percentage-point reductions in public capital's contribution during the 1970s and 1980s relative to the 1960s. The contribution of total public capital stock fell by around 0.20%, while that of core infrastructure declined by about 0.10%: in both cases, there was a somewhat larger decline during the 1980s than in the 1970s.

Line (7) of Table 2 shows that depending on the definition of productivity and public capital, between 5% and 22% of the productivity decline can be explained by the slowdown in public capital accumulation. Total public capital tends to explain more of the slowdown because of the larger implied output elasticity coupled with similar rates of growth of total and infrastructure capital. And more of total factor productivity is explained because, in percentage-point terms, the fall-off in labor productivity growth exceeded that of total factor productivity growth.

Appendix B

Line (1) of Table 3 shows the percentage-point reduction in the growth rate of the private capital stock of equipment and non-residential structures of over 0.50% per year in the 1970s and over 1.25% per year during the 1980s—both relative to the 1960s. Line (2) of Table 3 shows that for both decades, about 0.40-0.50% per year of this reduction can be explained by the slowdown in public capital accumulation. These amounts are calculated from a model which assumes that the growth rate of private capital stock depends:

A. positively on the rate of return to private capital and on the capacity utilization rate in manufacturing (as in Feldstein 1982), and
B. holding fixed the return to private capital, negatively on the public investment rate.

Appendix C

Line (3) of Table 3 calculates the indirect contribution of the reduction in public investment to the slowdown in labor productivity growth. This is the reduction in the growth rate of private capital of line (2) of Table 3 multiplied by the output elasticity of private capital of between 0.30 and 0.35. This yields an indirect contribution of public capital of just under 0.17% per year for both the 1970s and the 1980s. The direct contributions of nearly 0.20% in line (4) of Table 3 are taken from Table 2; when added together, the direct and indirect contributions are capable of explaining about 0.33% of the drop in productivity growth. By line (6) of Table 3, about 20% of the labor productivity slowdown in the 1970s and 1980s can thus be explained by the direct and indirect contribution of the reduction in growth in the total public capital stock.

By these calculations, then, the potential role of public capital in the productivity slowdown is certainly non-negligible. But if the results of the aggregate time series studies are to be believed, public capital may play an even larger role in the productivity slowdown. For instance, in my own work the output elasticity of public capital is as high as 0.39, so that the direct contribution of public capital could be some six times larger than that of Table 2 and explain as much as 60% of the slowdown in productivity growth. As stated before, though, there are a number of valid statistical concerns which need to be addressed.

Appendix D

For instance, Munnell (1990b) employs the data for the forty-eight contiguous states over the period 1970 to 1986 and estimates separate output elasticities for highways, water and sewer systems, and other public capital such as office buildings, hospitals, and schools. Table 4 presents her results. For the Cobb-Douglas production function, the output elasticity of highways equals 0.06, of water and sewer systems 0.12, and other public capital 0.01. For the translog production function, the direct output elasticity of highways equals 0.04, of water and sewers 0.15, and of other capital a negative 0.02. In a comment on Munnell's paper, Eisner (1991) provides supporting evidence along both the time series and cross-sectional dimensions. His direct elasticity estimates can be seen to range between 0.06 and 0.08 for highways, between 0.08 and 0.11 for water and sewers, and between a statistically insignificant 0.01 and a negative 0.12 for other capital.

Table 4
Disaggregated Public Capital and Output

	Munnell		Eisner			
			Time Series		Cross Section	
	CD	T	CD	T	CD	T
Highways	0.06	0.04	0.08	0.08	0.06	0.06
	(3.8)	(2.7)	(2.5)	(2.4)	(3.9)	(3.8)
Water and Sewers	0.12	0.15	0.08	0.07	0.12	0.11
	(9.6)	(10.9)	(5.2)	(4.8)	(9.3)	(10.7)
Other	0.01	-0.02	-0.12	-0.08	0.01	-0.03
	(0.7)	(-1.1)	(-6.3)	(-4.6)	(0.9)	(-2.5)

CD = Cobb-Douglas production function
T = translog production function
T-statistics in parentheses

Appendix E

Duffy-Deno and Eberts (1991) attempt to resolve the reverse causation argument in a different manner. They confront the issue by explicitly modeling the simultaneous relationship between public capital investment and economic growth for a sample of twenty-eight metropolitan areas in the United States during the first half of the 1980s. Although they make use of personal income data and do not directly estimate production function coefficients, their results indicate that a 1% increase in the public capital stock induces a 0.094% increase in personal income per capita.

Others have tried to determine the direction of causation between public capital and productivity by *Granger-causation* techniques. Using roughly the same aggregate data sets as in Aschauer (1989a), Holtz-Eakin (1988) looked at the association between public capital accumulation and private sector productivity growth and found that to a significant extent public investment spending Granger-causes a productivity growth. Holtz-Eakin, though, did find evidence of causation in the opposite direction as well.

Appendix F

Table 5 lists a number of recent studies which have used this approach to estimate the impact of public capital on costs of production. Morrison and Schwartz (1991) use U.S. state-level data for the total manufacturing sector over the period 1971 to 1987, and find a significant shadow share of public capital. Nadiri and Mamuneas (1991) use aggregate data on twelve manufacturing industries for the U.S. from 1970 to 1986, and find positive social rates of return on infrastructure capital. Using annual data over the period 1960 to 1988, Berndt and Hansson (1991) estimate an aggregate cost function for Sweden and obtain positive shadow share estimates. Conrad and Seitz (1992) find significant shadow values of public capital for three industries—manufacturing, construction, and trade and transport—in Germany over the period 1960 to 1988. Lynde and Richmond (1991) find that public capital significantly reduces average costs of production in the United Kingdom's manufacturing industries over the period 1966.1 to 1990.2 (quarterly data). Shah (1992) estimates a positive shadow value for public capital in a study of twenty-six Mexican manufacturing industries using data from 1970 to 1987. Finally, Takahashi and Maki (1992) use annual aggregate data for Japan's manufacturing sector, and find a significant shadow value of total and core infrastructure capital stocks.

Table 5
Public Capital and Costs of Production

Researchers	Geographical scope	Industrial scope
Morrison & Schwartz	State-level (U.S.)	Total manufacturing
Nadiri & Mamuneas	National (Sweden)	Private business Total manufacturing
Berndt & Hansson	National (Sweden)	Private business Total manufacturing
Conrad & Seitz	National (Germany)	Manufacturing Construction Trade and transport
Lynde & Richmond	National (U.K.)	Total manufacturing
Shah	National (Mexico)	26 manufacturing sectors
Takahashi & Maki	National (Japan)	Total manufacturing

Appendix G

Also using state-level data but focusing on manufacturing, Morrison and Schwartz (1991) generate an analogue to *Tobin's q* measure for private capital to assess the optimality of the provision of public capital by state governments.

Morrison and Schwartz find that their q variable—*the shadow value of public capital divided by the social cost of capital*—almost always exceeds unity over the period from 1971 to 1987. They conclude that "it appears that infrastructure investment has almost invariably been too low for social optimization." And as the authors recognize, these computations may significantly underestimate the social benefits of public capital since the shadow value pertains only to the manufacturing sector and ignores the benefits to other industries.

Nadiri and Mamuneas (1991), who consider the aggregate impact of public investment on twelve two-digit manufacturing industries, estimate a social rate of return to infrastructure capital of 0.068. While this is lower than the rates of return to private capital in these industries, they note that "these publicly financed capital services provide benefits to other producers in the economy…" and that "when appropriately measured, the economy-wide rates of return on these public capital services are likely to be larger." Indeed, the output of the twelve two-digit industries in their sample constitutes approximately three-quarters of total manufacturing output and only one-sixth of total private sector output; thus, if the returns to other manufacturing and other industries were, on average, equal to those in their sample, the social rate of return would equal 0.091 and 0.408 respectively. The former estimate would be rather close to the implied social rate of return in Morrison and Schwartz (1991), while the latter would be in the same range as the aggregate estimates in my own and Munnell's aggregate studies.

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New Federal Spending for Infrastructure: Should We Let This Genie Out of the Bottle?

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I. Introduction

Federal programs to increase spending on infrastructure figured prominently during the 1992 presidential campaign, attention which culminates a remarkable transformation in the debate over public capital spending. For the bulk of the postwar period, discussion about government capital budgeting decisions largely focused on their pork-barrel punch. In 1992, however, the public sector capital stock emerged as a potent force for improved macroeconomic performance. Proponents of large-scale infrastructure programs now argue that America's foundations are crumbling, impeding its ability to compete internationally, reducing the attractiveness of investments in the United States, and lowering the earnings of U.S. workers.

A careful reading of the evidence suggests, however, four truths that are at odds with the newly conventional wisdom: 1) a large-scale infrastructure spending program will not have *any* appreciable effect on productivity growth; 2) a *Federal* infrastructure program is at odds with the efficient use of scarce budget dollars; 3) there are *better* infrastructure policies than new spending programs; and 4) policies to increase *private* sector investment have a better chance to improve U.S. competitiveness. Understanding of these four realities should guide the development of infrastructure policies in the United States, and will argue against massive new Federal involvement. Stepping back a bit, it is worth noting that the currently fashionable emphasis on the productivity and competitiveness effects of public capital is misplaced. Given the size of the Federal budget deficit, one can understand the pressure to relabel any expenditure as an investment. Moreover, there are equally strong incentives to address U.S. trade performance. But infrastructure spending should not be decided by its public-relations value; instead it should be driven by the traditional principle of careful benefit-cost analyses for each proposed project.

1. *A large-scale infrastructure spending program will not have* any *appreciable effect on productivity growth.*

Recent interest in the productivity impact of public sector capital stems from the influential work of David Aschauer (Aschauer 1989a, 1989b). In his, and much of the subsequent, research, the center of attention is the relationship between productive inputs—private capital and labor, public capital—and economic activity, or output. These studies summarize this relationship with a "production function." [See Appendix A for a discussion of this statistical relationship.]

In early studies of the productivity effects of public capital, Aschauer (1989a), Holtz-Eakin (1988, 1989) and Munnell (1990a) examined annual, postwar data for the United States to estimate the parameters of such a production function. The results seemingly argue in favor of infrastructure accumulation as a key determinant of productivity growth. Unfortunately, the nature of the data makes it impossible to place faith in the estimates. During the 1950s and 1960s, the economy fared well and, as a result of programs like construction of the interstate highway system, public capital grew rapidly. In the early 1970s, however, productivity growth slowed dramatically. In the absence of large projects and with the maturation of the baby-boom generation, so did government capital spending. Mechanical application of statistical techniques might tempt one to conclude that there was a *causal* relationship running from slower public sector capital growth to slower productivity growth. More likely, however, is the reverse scenario. Deteriorating economic conditions tightened government budgets and reduced growth of the public capital stock. The result was similar movements in the two series. Indeed, almost every broad-gauged indicator of economic activity contains this sharp break in the early 1970s, and the underlying causes of the slowdown remain unclear.

Searching for convincing evidence, analysts moved to the "natural laboratories" of the U.S.: the states and their governments.[1] Initially, however, these studies largely produced controversy. On one hand, Munnell (1990b) and Garcia-Mila and McGuire (forthcoming) concluded that differences in the amount of state and local government capital was an important source of differences in states' economic performance. On the other hand, Hulten and Schwab (1978, 1991) found that "residual" state growth—that not accounted for by growth in firms' capital and labor—could not be attributed to state-local highways, roads, sewers, and other parts of public capital. Indeed, the residual was at odds with regional patterns of public sector investment.

In the past, I have argued that the apparent contradiction is easily reconciled. In making comparisons across states, one again runs the risk of reverse causality: successful states have greater resources available for all uses, including government capital outlays, leading to a positive association between government capital and productivity. If this were taken at face value, one might again mistakenly conclude that greater state and local government capital caused superior economic performance. Thus, statistical techniques used to investigate the productivity effects of infrastructure must be tailored to avoid this pitfall. The approach of Hulten and Schwab (1991) is tantamount to using such a technique. Moreover, direct application of the correct statistical approaches yields results that suggest no magic from public sector capital spending programs in boosting productivity growth. The third row of Table 2 shows estimates of the productivity effect of public capital. The first column repeats the conventional analysis (and finds a large, positive effect), while the remainder of the columns show corrected estimates (which are small or negative). [See Appendix B for a more detailed discussion of these issues.]

I hasten to stress that these results do not imply that the large stock of infrastructure in the United States provides no benefits. Instead, the results say that a broad-based spending program for *additional* infrastructure is unlikely to augment economy-wide productivity growth. This should hardly be surprising. On average, the U.S. has a superb system of highways and roads, modern utilities, and advanced telecommunications systems. The productivity effect of building, say, another interstate highway system could hardly be very great, and certainly not worth the expense.

Further, the very nature of the statistical analyses is to treat all public investments in all locations equally. In this way, they answer the hypothetical question: "What is the effect of randomly dropping another $1 of infrastructure, of any type, anywhere in the economy?" For an infrastructure-starved economy, the answer would be "A lot," but this is hardly the situation in the United States as a whole.

There is an old saying that there are three kinds of lies: lies, damn lies, and statistics. Skeptics may be tempted to relegate the argument thus far to the third category and push forward with a broad-based expenditure program aimed at the U.S. infrastructure. But even the most optimistic scenarios yield only marginal improvements in economic growth. Imagine that the U.S. devotes an additional $30 billion per year to infrastructure investment, an enormous commitment of resources in the current context: the public capital stock would grow just under 2 percentage points faster. At the extreme, one might guess that GDP growth would rise by one-quarter of this amount. Thus, even this large investment yields under one-half a percentage point increase in economic growth.

Now, over several decades, a one-half a percentage point increase in growth can make a large difference in living standards. The point is, however, that it takes decades for the effect to cumulate—there will be no dramatic turnaround in just a year or so—and that the underpinnings of even this calculation are extraordinarily optimistic.

2. A Federal *infrastructure program is at odds with the efficient use of scarce budget dollars.*

The preceding section argued against funneling significant new budget allocations toward infrastructure. As emphasized, however, the aggregate evidence does not mean that there are no capital expenditure projects that would survive a rigorous benefit-cost examination. When identified, however, these infrastructure projects should not be a Federal government policy concern. Provision of infrastructure has traditionally been the province of state and local governments, on the grounds that local officials are better able to judge the needs and desires of their local constituents. There is growing evidence that these governments react sensibly to the economic environment, both in their employment decisions (e.g., Freeman 1987, Holtz-Eakin and Rosen 1991) and in avoiding irrational swings in their capital spending (Holtz-Eakin and Rosen, forthcoming). Thus, additional resources will be less likely to be wasted if we adhere to the tradition of reliance on local decision-making.

Further, there is strong evidence that state needs differ greatly. Table 1 is drawn from Holtz-Eakin (forthcoming). It shows the ranking of states on the basis of the average annual growth rate of their public capital stock from 1961 to 1974, the value of the growth rate over that period, and the subsequent growth rate between 1975 and 1988. The table drives home the range of diversity in the states' experience. It is true—as has been widely noted—that there was a sharp decline in the rate of capital accumulation between the early and later years in the sample; a decline that the evidence presented above suggests is the result of poorer aggregate economic performance. The tendency to focus on the nation as a whole, however, hides the rather pronounced differences in the rate of capital accumulation across the states, with the highest (Alaska) exceeding the bottom end (California) by a factor of roughly 20. Even more interesting, there is little relationship between growth in the early period and growth in recent years. The notion that all parts of the U.S. have been subject to a uniform decline in infrastructure does not square with the facts.

Table 1 is persuasive evidence that a single national policy toward infrastructure accumulation would be unwarranted. Proponents might argue, of course, that a "Federal" policy need not imply a simplistic, equal-division approach. The politics of a large Federal program, however, certainly would lead to earmarking—in either an explicit or disguised fashion—some part of the budget for each state. This would be tantamount to implementing the hypothetical experiment envisioned above: randomly raining infrastructure funding everywhere in the economy, to little effect. The Federal government could fund additional state-local spending, of course, via grants-in-aid. To be effective, however, such a program need necessarily avoid restrictions on the use of Federal dollars. That is, an efficient Federal program must leave room for local officials to either cut local taxes or spend the aid to meet other objectives, and it is hard to imagine that these objectives—however sensible they may seem from a local perspective—would be well received in Washington.

Table 1
Growth Rate of State and Local Government Capital Per Capita
(percent per year)

		Annual Growth Rate	
Rank	State	1961-74	1975-88
1	Alaska	9.64	3.14
2	District of Columbia	6.89	4.01
3	Kentucky	5.88	0.80
4	Delaware	5.68	-0.62
5	Wyoming	5.01	2.28
6	South Dakota	4.92	1.22
7	Nebraska	4.81	1.64
8	Mississippi	4.65	0.30
9	Tennessee	4.63	0.26
10	West Virginia	4.56	0.90
11	North Dakota	4.47	0.75
12	Montana	4.20	0.59
13	Hawaii	4.08	0.90
14	Alabama	4.04	0.54
15	Maryland	4.00	1.44
16	Arkansas	3.98	0.63
17	Virginia	3.92	0.37
18	South Carolina	3.91	1.30
19	Texas	3.90	1.20
20	Missouri	3.80	0.33
21	Georgia	3.70	1.60
22	Iowa	3.59	1.15
23	Minnesota	3.58	0.80
24	Kansas	3.54	0.86
25	Wisconsin	3.52	0.05

Rank	State	1961-74	1975-88
26	Vermont	3.38	-1.18
27	Washington	3.36	0.97
28	Utah	3.34	1.87
29	Connecticut	3.33	-0.22
30	Louisiana	3.20	0.73
31	New York	3.13	0.52
32	New Mexico	3.10	0.91
33	Illinois	3.03	0.74
34	North Carolina	3.00	1.08
35	Pennsylvania	2.96	-0.05
36	Idaho	2.84	0.54
37	Arizona	2.78	1.81
38	Indiana	2.76	0.29
39	Rhode Island	2.70	-0.35
40	Ohio	2.57	0.46
41	Michigan	2.43	0.03
42	Oklahoma	2.32	1.00
43	Nevada	2.18	-0.51
44	California	2.12	-1.40
45	New Jersey	2.08	0.72
46	Massachusetts	2.05	0.63
47	Oregon	2.02	0.09
48	Florida	1.93	1.39
49	Maine	1.92	-0.14
50	New Hampshire	1.87	-0.57
51	Colorado	1.65	1.41
	United States	3.08	0.46

One common objection to reliance on local decisions for infrastructure spending is the notion that infrastructure benefits "spill over" from one state or region to its neighbors. Operating in isolation, policymakers fail to recognize these extra benefits, leading to underinvestment. The Federal government, the argument continues, is uniquely positioned to solve the problem of uncounted, external benefits by coordinating the investment activities of the sub-Federal governments.

The argument is one part of the textbook tension between the efficiency of a federalist system and the benefits of centralized policies. Unfortunately, when confronted with the data, the textbook argument gets cut short early: there is no evidence of large interstate productivity spillovers. Specifically, in the work discussed earlier (Holtz-Eakin 1992) I repeated the analysis summarized herein in Table 2, using instead data for eight U.S. regions. In the presence of significant cross-state spillover effects, one would expect that moving from the state level to the regional level would permit one to capture these benefits, thereby resulting in larger effects from public capital.[2] Instead, the estimates are virtually identical to those obtained at the state level, negating the importance of external effects.

Most recently, a new argument has been raised in favor of a Federal infrastructure spending program: that it would provide stimulus needed to recover from the most recent recession. This argument has *nothing* to do with the virtues of infrastructure *per se*. Instead, it relies solely on the merits of directly stimulating aggregate demand and employment. A full appraisal of the virtues of using fiscal policy for stabilization purposes would lead this discussion too far afield. However, it is worth noting that using infrastructure spending for such objectives will be inefficient. At the close of such a stabilization episode—regardless of its short-run stimulative success—there is the virtual guarantee of having wasted significant investment funds on the wrong types of capital in all the wrong places.

3. *There are better infrastructure policies than new spending programs.*

The newly conventional wisdom hinges on anecdotes of outdated infrastructure that is badly in need of repair and overly congested. Of course, one might argue that this is exactly what to expect when infrastructure—or anything else—is free to use, and when there is no incentive to maintain past investments appropriately. From this perspective, the best infrastructure program does not focus on new spending. Instead, the top priority should be to "get the prices right" where feasible by charging user fees for infrastructure services. User fees would serve to reduce excessive demands on the infrastructure and at the same time would provide a secure flow of funds for purposes of maintenance and modernization.

User fees are not the answer to all infrastructure problems, but are the most promising path in the most high-profile of problems: airports, water supply, port facilities, landfills, waste treatment, bridges, and highways. Technological advances in scanners and sensing mechanisms have eliminated the concern that user fees are impractical and have served to make user fees administratively feasible. It is no longer the case, for example, that charging tolls to control peak congestion automatically backfires by causing endless delays at toll booths. There also has been concern that reliance on user fees would be unnecessarily hard on the poor, but the "fairness" of user fees should be compared to the alternative. Small (1983) points out that highway tolls can make *all* income classes better off, if the revenues are used to lower property taxes, or replace registration and fuel taxes.

Pricing the use of our existing infrastructure efficiently is best viewed as an essential part of any infrastructure spending program. To determine the appropriate size of a project, one must forecast use of the facility, and this is integrally related to the price charged. By revealing the intensity of demand for services provided by public capital, user fees may improve the planning process. Further, when user fees are dedicated to maintenance and modernization, funds will be available for repairs at the appropriate time in the life-cycle of roads, bridges, sewers, and other facilities.

In the past, there has been little or no accounting made for maintenance expenditures, making it impossible to reward timely maintenance, which is typically more cost-effective than new construction. Even worse, for much of the postwar period, Federal policy (via matching grants, especially for highways and water treatment plants) subsidized new investment relative to maintenance. Local governments responded predictably to these perverse incentives with insufficient maintenance and excessive construction plans. While there has been progress on this front in recent years (in, for example, the recent Federal surface transportation bill), a widespread move toward the use of efficient infrastructure prices remains a promising avenue for reform.

4. *Policies to increase* private *sector investment have a better chance to improve U.S. competitiveness.*

At one level, the argument is simple. If additional infrastructure will have negligible productivity effects, private investment simply *has* to be better.

Indeed, public investment is even more costly than it might appear because by transferring $1 of investment from the private sector to the public sector, one gives up a productive private investment for nothing in return. Viewed from this perspective, a case can be made for "budgeting" additional investment by reducing the Federal deficit and thereby freeing up additional capital for use by private firms, rather than by spending on Federal programs. Importantly, the "zero effect" discussed above is not the key to this argument. Instead, the guiding rule is that the return on private investment exceeds that on public investment, a result consistent with all but the most extreme studies of infrastructure effects. [See Appendix C.]

II. Conclusion

The threads of the argument may now be spun together. First, the statistical foundations cannot support the claim that public capital is the key to faster productivity growth in the United States. Second, to the extent that there are infrastructure needs in the U.S., they differ greatly across the country. Such needs are best addressed in the traditional fashion by state and local governments, and to the extent that the Federal government provides aid, it would be wasteful to embody mandates or other restrictions on its use. Indeed, the most appealing policy toward infrastructure does not focus on new spending at all. Instead, it would focus on the efficient use of our existing public capital stock through user fees and other pricing schemes. Finally, most of the evidence suggests that private investment spending would have more beneficial productivity effects than new public capital spending. Indeed, even some of the evidence used in favor of an infrastructure program is best interpreted in this way. In sum, the case for a big, new Federal program for infrastructure is weak.

At the same time, the current fixation with the productivity and competitiveness effects of public capital is misplaced. Should the government pursue policies conducive to more rapid economic growth, improved international competitiveness, and higher real earnings for workers? Where possible, of course. Should these goals be the metric by which we judge the desirability of each and every dollar of capital spending by our governments? No, of course not. It is an axiom as old as the field of public finance itself that public sector projects should be judged by comparing their benefits to their costs. If the difference is positive, the project is worthwhile and merits funding.

Measuring benefits appropriately is very difficult. Investment projects are by definition long-lived, so benefits in both the present and future must be counted. Infrastructure projects affect the population as a whole, so benefits received by many individuals and firms must be calculated and added up on a consistent basis. The list of pitfalls goes on and on. It is safe to say, however, that no one would argue in favor of drawing the line at greater productivity. If subways are safer and cleaner, and the public happier as a result, this too should count as a benefit. If better roads reduce commuting times and the result is the *same* work but more leisure, this should count as a benefit. In general, the *consumption* value of the services produced by infrastructure and other capital should count just as much as increased productivity.

Thus, some projects may be worthwhile even though public capital spending is a poor candidate to resolve the productivity problem in the United States. Projects of sufficient value will pass a routine examination of the pros and cons. With equal force, a great many projects will fail reasonable benefit-cost comparisons. Each capital project should undergo such scrutiny by those best equipped to evaluate it.

In their haste to get on with spending, proponents of the "infrastructure crisis" view of the productivity slowdown will likely circumvent this type of detailed policy analysis. The outcome will be unnecessarily large and (by definition) wasteful expenditures. In the end, a large infrastructure spending program at the Federal level is not the magic solution to U.S. economic woes. It is a genie best left in the bottle.

Appendix A

The production function is written:

Equation 1

$$q_t = \beta_{0t} + \beta_1 k_t + \beta_2 l_t + \beta_3 g_t + \varepsilon_t$$

where q_t is the logarithm of private output, k_t is the logarithm of private capital inputs, l_t is the logarithm of labor inputs, g_t is the logarithm of public sector capital, and ε_t is the residual, unexplained output. The parameters of the production function (β_1, β_2, β_3) measure the contribution of each of the inputs to the productive process. For example, if $\beta_3 = 0$, then investments in public capital have no effect on output or productivity. Further, by entering the variables in logarithms, the β's may be interpreted as elasticities. To give another example, if $\beta_3 = 0.05$, a 10 percent increase in government capital would result in a one-half percent increase in private output. At the heart of the claim that infrastructure spending is the key to faster productivity growth is the notion that β_3 is both positive and large.

Appendix B

To see the argument clearly, modify Equation 1 to keep track of states (s) and permit each state to have a different underlying productive ability (f_s). These differences stem from such natural sources as location, climate, and mineral endowments, as well as such inherited features as the pattern of industrialization. The result is a slightly modified production function that looks like:

Equation 2

$$q_{st} = \beta_{0t} + \beta_1 k_{st} + \beta_2 l_{st} + \beta_3 g_{st} + f_s + \varepsilon_{st}$$

Consider now Table 2, which is drawn from Holtz-Eakin (1992).[3] Column (1) contains the results of the conventional (ordinary least squares) statistical approach to estimating the β's in Equation 1. For purposes of this discussion, the key result is that the estimated β_3 is 0.20. Thus, boosting the growth of the public capital stock by 5 percentage points would increase productivity growth by a full percentage point. However, this result is an artifact of using inappropriately simple techniques.

The problem stems from ignoring the f_s: states with a "big" f_s will have more output and greater incomes (directly from [2]). They are also likely to spend more public programs, leading to a greater g_{st}. (They are also likely to be better places to live and invest, affecting k_{st} and l_{st} at the same time.) What one "sees" is the positive association between g_{st} and q_{st}, which is mistakenly transformed into a prescription for spending on g_{st} in order to raise q_{st}.

The remainder of the columns of the table are devoted to determining how well this result stands up to closer scrutiny by trying different means to circumvent the presence of the f_s in Equation 2. Column (2) shows the results of focusing on *changes* in both sides (2) between 1969 and 1986. Notice that by using changes, the f_s are eliminated. That is, changes over time in each state depend only on the growth of inputs and the parameters, and are independent of (unchanging) differences across states. To the extent that public-sector capital is an important determinant of long-run productivity growth, it seems reasonable to expect that it manifest itself over a period of nearly two decades. What is the result? Looking at column (2), the estimate of the impact of public capital (β_3) is now negative. However, because of the large standard error, one is best left with the conclusion that β_3 is essentially zero.

Columns (3) through (6) aim progressively greater extremes of statistical firepower toward the goal of discerning the correct value for β_3. Without belaboring the details, two important conclusions emerge. First, a formal, statistical test strongly supports the presence and importance of the f_s—states really are different, and these differences complicate the analysis of their economies.[4] Second, and more to the heart of the debate, the single best estimate of the productivity impact of public capital is zero. Indeed, another way to look at the results in this table is that there is only *one* way to get the "big effect" answer. Any other cut at the data suggests that any "smoking gun" in the death of productivity growth does not lie in the hands of infrastructure policy.

Appendix C

Most studies of infrastructure focus only on whether public capital has productivity effects at all, not whether these effects are larger than those for private capital. In terms of the production function in (1), the ratio of the productivity effect of public versus private capital is given by:

Equation 3

$$\frac{\textit{Public Capital Output Effect}}{\textit{Public Capital Output Effect}} = \frac{\beta_3}{\beta_2}\left(\frac{\textit{Private Capital}}{\textit{Private Capital}}\right)$$

In the research discussed earlier, I estimate that the mean ratio of non-residential fixed capital to state-local capital in the states is in the vicinity of 2. This implies that the estimate of β_3 need be at least one-half that of β_2 for the pure productivity effect of public capital to be larger than that of private capital.[5] Notice that even the upward-biased estimate of β_3 just barely makes the grade. Thus, for the data to reveal a need for greater increasing infrastructure, it is not enough to show a positive productivity effect. Instead, the estimated value of β_3 must meet this more stringent test, which is likely for only the most implausibly optimistic estimates.

Table 2*
Estimates of State Production Function

Variable	(1) OLS	(2) LONG	(3) FIX	(4) GLS	(5) IV	(6) HNR
	Dependent Variable: Log Private Gross State Product					
Log Labor	0.497 (0.0144)	0.643 (0.137)	0.691 (0.0262)	0.659 (0.0225)	0.542 (0.0747)	0.911 (0.0530)
Log Private Capital	0.359 (0.0112)	0.504 (0.142)	0.301 (0.0302)	0.361 (0.0233)	0.472 (0.0653)	0.106 (0.0253)
Log Public Capital	0.203 (0.0190)	-0.115 (0.126)	-0.0517 (0.0267)	0.00770 (0.0235)	-0.0150 (0.0660)	-0.102 (0.0606)
Log Private Capital/Lab or	—		—	—	—	—
Log Public Capital/Lab or	—		—	—	—	—
Time Effects	Yes	No	Yes	Yes	Yes	Yes
State Effects	No	No	Fixed	Random	No	Differences

*For definitions of variables, see Holtz-Eakin (1992). "OLS" is ordinary least squares, "LONG" is long-differences: 1986 values minus 1969 values, "FIX" is conventional fixed effects estimation, "GLS" is conventional random effects estimation, "IV" is an instrumental variables estimator using other states' data as instruments, and "HNR" is an instrumental variables estimator of a first-differenced equation.

Notes

1. Other studies looked at cross-national comparisons of productivity growth (e.g., Aschauer 1989b), but the difficulty in finding comparable data and correcting for vast differences in governmental structures has made for rather unstable parameter estimates (see Tanzi 1990).
2. It is also possible for the effects to be smaller as one looks at larger geographic areas. One pitfall of local development strategies is that they may attract businesses and workers largely at the expense of neighboring jurisdictions. The right measure of the effect on overall economic growth is the *difference* in productivity in the two jurisdictions, not just the economic growth experienced in the chosen jurisdiction. There have been many careful studies using regional and municipal data (see, e.g., Duffy-Deno and Eberts 1989 and Eberts 1986, 1990a, 1990b). One must be careful in interpreting in these studies in order to avoid overstating the impact of public capital at the national level.
3. See Holtz-Eakin (1992) and Holtz-Eakin (forthcoming) for a more extensive discussion of the underlying data and statistical techniques.
4. The test, due to Hausman and Taylor (1981), compares the parameter estimates from the fixed effects estimator to those from the random effects, or generalized least squares (GLS), estimator.

5. This overstates any preference for public investment because it ignores the distortionary costs of raising revenues to finance public capital outlays.

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