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# **Public Investment and Private Sector Growth**

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**The Economic Benefits  
of Reducing America's  
"Third Deficit"**

David Alan Aschauer

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Economic Policy Institute

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## Executive Summary

This report demonstrates the importance of *public* investment in physical infrastructure (roads, bridges, mass transit, electric power, sewers, etc.) to the stimulation of *private* sector productivity, profitability, and investment. Specifically the report argues that the slow-down in spending for infrastructure over the past 25 years has been a major cause of the U.S. economy's poor performance since 1970.

More than half of the decline in our productivity growth over the past two decades can be explained by lower public infrastructure spending, which has dropped to less than one-half of one percent of total output. The shortfall between our present stock of public capital and our public capital needs is often described as "America's Third Deficit."

The report presents an economic model showing that if the average level of public infrastructure investment (relative to GNP) between 1950 and 1970 had been maintained for the succeeding twenty years:

- the rate of return to private capital would have averaged 9.6 percent instead of its actual value of 7.9 percent;
- private investment would have averaged 3.7 percent of the private capital stock rather than 3.1 percent;
- the average annual rate of private sector productivity growth would have been 2.1 percent instead of 1.4 percent—a 50 percent increase in the average rate of expansion of our productive capacity

The model is based on statistical studies of the effects of public investment on the economy using historical data for the aggregate U.S. economy, state-led economies, and comparisons among major industrialized countries.

From these studies, it is estimated that a one percent increase in the level of core infrastructure will increase GNP by as much as 0.24 percent. Moreover, after four years or so, each additional dollar of public investment in infrastructure will *raise* private investment by 45 cents, contradicting the notion that a dollar of public investment merely "crowds-out" and therefore reduces, private investment.

The basic reason why public capital improves private sector efficiency, profits, and investment is that public facilities provide productive services to firms, such as an effective transportation system of airports, highways, and mass transit. These public facilities are as necessary to the production process as a firm's own capital equipment.

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*More than half of the decline in our productivity growth over the past **two** decades can be explained by lower public infrastructure spending.*

Moreover, because public capital comprises over a third of our total physical capital, the services it generates can be expected to have an important effect on macroeconomic, or aggregate, economic performance. For every dollar of private capital in place there is 56 cents of public capital.

The report shows that today public infrastructure investment is a higher economic priority than private investment; the pay-off in GNP growth from an extra dollar of public capital is estimated to exceed that of private investment by a factor of between two and five.

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***The pay-off in GNP growth from an extra dollar of public capital is estimated to exceed that of private investment.***

Public investment in infrastructure has dramatically declined. Over the last two decades, non-military public investment, as a fraction of GNP, was only 65 percent of its average level during the preceding two decades, falling from 3.7 percent to 2.4 percent. When depreciation is taken into account, the rate of non-military public investment in the 1980s was only half that of the 1970s and just one-fourth that of the 1950s and 1960s.

Public investment is critical to general economic growth, but because we live in a dynamic economy which changes constantly in response to technological progress, foreign competition, and changes in the labor force, infrastructure needs in the future may not necessarily be the same as they were in the past. As we move toward the 21st Century the definition of infrastructure may have to be broadened to include such investments as communications networks or energy development.

This report encourages a reconsideration of federal budget policy so as to facilitate the growth of the public capital stock. Current policies entail severe, untimely constraints on public investment for the foreseeable future. The U.S. economy needs to be prepared for the challenges of the future, and public investment should be a tool of first resort.

## Introduction

**In** the past few years, a number of tragic incidents have focussed attention on the disrepair of the nation's public infrastructure. Examples include:

- a bridge collapses on the NY State Thruway, taking the lives of ten motorists;
- a dam bursts in Georgia, flooding a bible school and drowning a number of school-aged children;
- medical debris washes up on the shores of Long Island, posing a health risk to millions of people.

Concern has also grown over the less dramatic but pervasive congestion of our streets, highways, and air routes: mounting delays in a transportation network that is apparently insufficient to meet the needs of a growing economy. Indicators of the congestion problem include:

- The U.S. Department of Transportation has estimated that in 1985 total vehicle delays on the highways exceeded 722 million hours: it is projected that this alarming number will skyrocket to 3.9 billion hours by the year 2005 if improvements to the nation's freeway system are not forthcoming.
- As these cars and trucks were stuck in traffic, nearly 3 billion gallons of gasoline were wasted, almost 4 percent of annual consumption in the United States. The total cost of this congestion was estimated at \$9 billion.
- Within Los Angeles County alone, traffic congestion is estimated to result in \$507 million worth of lost time and 72 million gallons of wasted fuel each year.
- According to the Federal Aviation Administration, air travel delays in 1986 resulted in \$1.8 billion in additional airline operating expenses and 53.2 billion in time lost by travellers.

Underlying these headlines, anecdotes, and cost estimates is a larger question: to what extent has the decline of investment in public infrastructure affected the performance of the U.S. economy as a whole?

In recent research, I and other economists have been attempting to get a broad picture of the importance of the public infrastructure to our economic prospects, to our ability to produce profitably and efficiently, and to our international competitiveness.

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*To what extent has the decline of investment in public infrastructure affected the performance of the U.S. economy as a whole?*

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***The reduction of public investment spending in the U.S. over the past 25 years played a central role in a number of our long-term economic ills.***

In this paper I survey the results of that research. I conclude that the reduction of public investment spending in the U.S. over the past 25 years played a central role in a number of our long-term economic ills. My study suggests that if the U.S. had continued to invest in public capital after 1970 at the rate maintained for the previous two decades, we could have benefited in the following ways:

- Our chronically low rate of productivity growth could have been up to 50 percent higher—2.1 percent per year rather than the actual rate of 1.4 percent;
- Our depressed rate of profit on nonfinancial corporate capital could have averaged 9.6 percent instead of 7.9 percent;
- Private investment in plants and equipment could have increased from the sluggish historical rate of 3.1 percent to 3.7 percent of the private capital stock.

These results indicate that close attention should be paid to the critical role played by public infrastructure in augmenting overall economic performance.



## Infrastructure and the Economy: Trends

As is well-known, a number of signs indicate that the United States' economy has not performed as well in recent years as in the so-called "golden-age" of the 1950s and 1960s.

We have seen a *continuing slump in the growth rate of economic productivity*, measured either conventionally as output per labor hour (labor productivity) or alternatively as output per unit of combined private labor and private capital services (called total factor or multifactor productivity). Beginning sometime in the early 1970s—the specific date is much debated—productivity growth fell by some 1.4 percent per year. In the case of labor productivity, the drop was from 2.X percent to a much lower 1.4 percent. This was clearly an important development. It meant that labor productivity would no longer double every 26 years; under the new trend we could only expect labor productivity to double once every 51 years. This implies that on a per capita basis, our future income must rise much more slowly, thereby generating a wide variety of concerns on issues such as the viability of our national social insurance programs & our national security.

Low productivity growth was reflected in a 3.3 percent decrease in the real average hourly wage between 1979 and 1987. Annual average wages and salaries only held up in this period because people were working 5.8 percent more hours per year. The typical worker in the factory, on the construction site, and behind the check-out counter increasingly feels the bite as wages fail to keep up with inflation.

Not only has productivity growth fallen over time in the United States, it has been low for the past three decades relative to our major international competitors. For example, from 1965 to 1985, Japan and West Germany achieved labor productivity growth rates in excess of 3 and 2 percent per year, respectively (see Figure 1). One reflection of our low productivity growth, when coupled with persistently high consumption growth, is the yawning trade deficit and the switch, during the 1980s, from our nation's position as the world's largest creditor to the world's largest debtor.

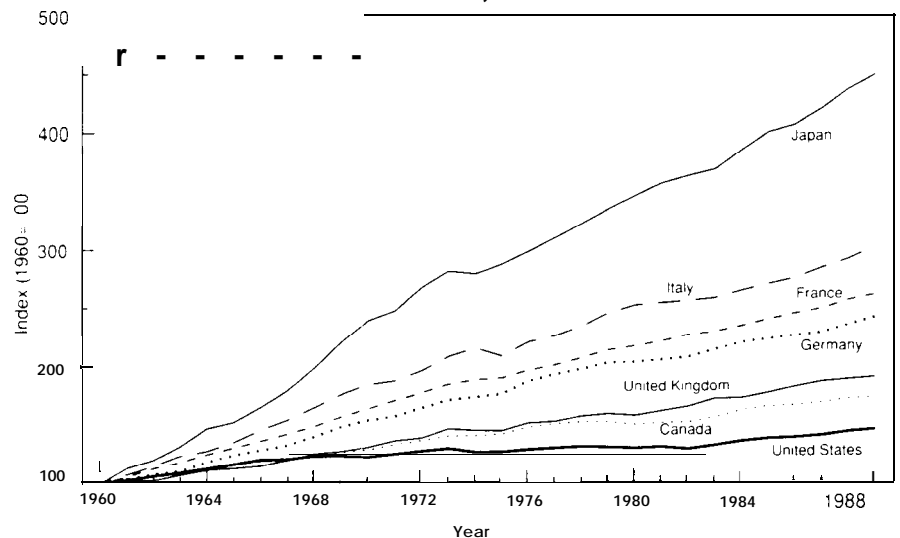
A second dimension of poor economic performance which is related to low productivity growth is 3 *low profit rate*. During the 1970s and 1980s the profit rate was depressed to a considerable amount below its level in the 1950s and 1960s—from about 11 percent to about 8 percent.<sup>1</sup>

A third indicator of poor economic performance which is closely linked to the fall-off in the profit rate is a *low rate of net private investment*. For instance, the growth rate of the private capital stock (the value of capital assets) has been about 3 percent per year in recent years, down from about 4 percent in the 1950s and 1960s.<sup>2</sup>

---

*We have seen a continuing slump in the growth rate of economic productivity.*

**Figure 1**  
**Trends in Real GDP per Employed Person,**  
**Selected Countries, 1960 to 1989**



(Sources: Alicia Munnell, Federal Reserve Bank of Boston; Bureau of Labor Statistics.)

*Although the United States still leads in the level of output per worker, we have been far outpaced in the rate of growth of that measure of productivity since 1960.*

#### INDICATORS OF SAGGING U.S. ECONOMIC HEALTH IN THE 1970s and 1980s

- ☒ Productivity growth rates are lower by a yearly average of 1.4 percentage points.
- ☒ Productivity growth has been much lower than that of Japan and West Germany.
- ☒ Private profit rates have dropped by three percentage points.
- ☒ Net private investment, as a fraction of output, has declined by three percentage points.
- ☒ Average hourly wages, adjusted for inflation, were 3.3 percent lower in 1987 than in 1979, and real average weekly earnings were lower in 1989 than in 1967.

# Solving the Mystery

The reasons for our low productivity growth, our low profit rate, and our low net investment rate—in general, our state of economic “malaise”—have so far resisted explanation by economists. Many obvious culprits have been brought to trial in the economics literature and, for one reason or another, all have been found largely innocent.

For example, the Bureau of Labor Statistics came to the conclusion that at most one-half of the total fall-off in productivity growth can be explained by obvious suspects such as oil price hikes during the 1970s, a decline in research and development spending after the mid-1960s, and mismeasurement of labor input (U.S. Department of Labor, 1983; Fischer, 1988; Griliches, 1986, 1987; Olson, 1988; Romer, 1987).

In this paper, I bring another suspect before the bench by asking: what role might movements in the amount of public infrastructure capital have played in the evolution of the macroeconomy over the past forty years?

To be potentially important for explaining shifts in the performance of the aggregate economy, the public capital stock must be large relative to the private capital stock, and it must display variable trends over time. Table 1 provides 1987 data on the levels of total, private, and public stocks of fixed reproducible capital. It can be seen that of the total physical capital stock of 6.5 trillion dollars, 2.3 trillion dollars—36 percent—is held by the public sector. For every \$2 of private capital, there is \$1 of public capital.

*The reasons for our low productivity growth ... have so far resisted explanation by economists.*

TABLE 1  
Private and Public Capital Stock, 1987

Capital Stock	Billions of Dollars	Percent of Total
Total	\$6,487.3	100%
Total Private	4,142.8	64%
Nonfarm Business	3,974.6	61
Farm	168.2	3
Total Public	2,344.5	36%
Military	457.7	7
Nonmilitary	1,886.8	29
Core Infrastructure	1,195.7	18
Education, Hospital, &		
Other Buildings	535.9	8
Conservation & Development	155.2	2

Source: Bureau of Economic Analysis

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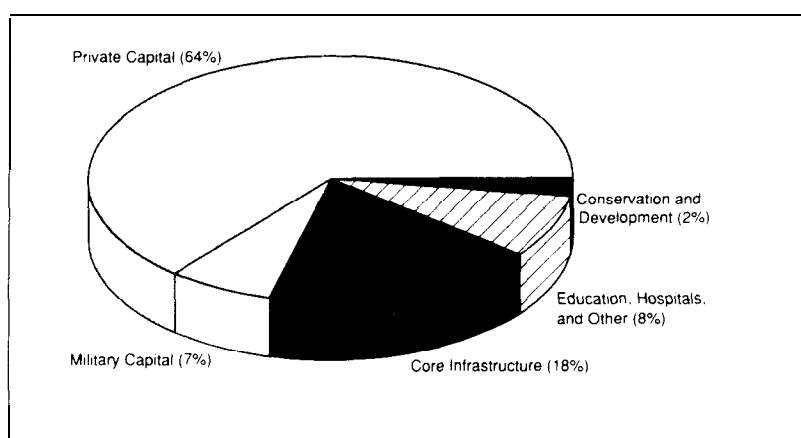
***Elements of core infrastructure are intrinsic to most every sector of private production.***

While military capital makes up the bulk of the federal capital stock, it only amounts to 7 percent of the nation's total (public and private) stock of capital. Nonmilitary capital accounts for 29 percent of the national stock of tangible capital. Finally, the stock of "core infrastructure capital" (streets and highways, water and sewer systems, mass transit, airports, and electrical and gas facilities) comprises nearly 20 percent of the nation's stock of physical capital (see Figure 2). Moreover, it could be expected that because the elements of core infrastructure are intrinsic to most every sector of private production, they are especially influential in the determination of total national economic output. Clearly, the public capital stock has sufficient magnitude to influence the behavior of the private economy in a meaningful way.

It may not be fully appreciated that, setting military spending to one side, the bulk of the public capital stock resides in the state and local government sector. For instance, in 1985 the total federal net stock of public capital, excluding military equipment and facilities, was \$247,125 million in 1985 dollars. But the state and local counterpart to this amount was \$1,518,736 million. Thus, the state-local component of total civilian public capital was roughly 86 percent (Bureau of Economic Analysis, 1987).

---

**Figure 2**  
**Private and Public Capital as**  
**Percent of Total U.S. Capital in 1987**



(Source: Bureau of Economic Analysis)

*In 1987, publicly-owned structures and equipment providing services in the areas of national defense, transportation, education, health care, conservation, and development constituted 36 percent of the total U.S. capital stock*

---

Not only is the public capital stock large, but it also has evolved in a marked pattern over the post-World War II period. As Table 2 reveals, the level of nonmilitary public investment generally rose during the 1950s and 1960s—reaching some 3.9 percent of GNP in the latter decade—and then fell during the 1970s and the early 1980s (see Figure 3). While in recent years public investment has rebounded slightly, it remains far below levels attained during the mid-1960s. This striking pattern prevails for nearly all

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***Public investment ...  
remains far below levels  
attained during the  
mid-1960s.***

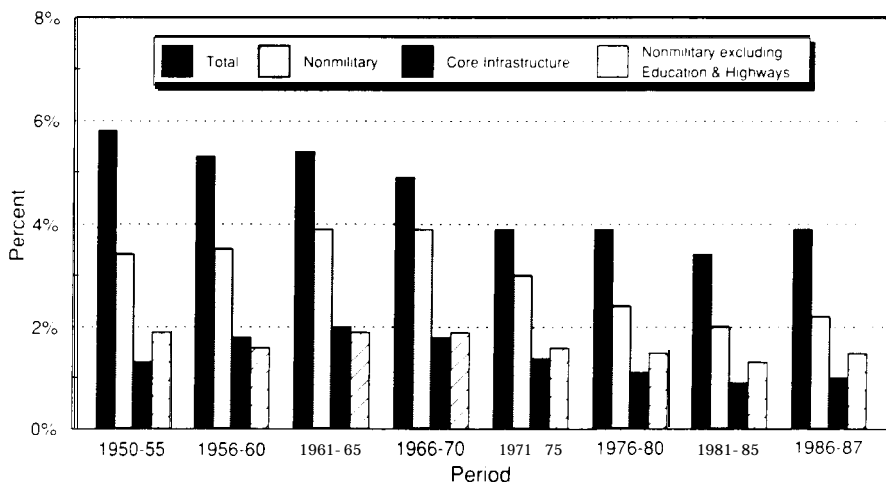
**TABLE 2**

**Trends in Public Investment Relative to GNP**

	Total	Nonmilitary	Core Infrastructure	Nonmilitary Minus Education and Highways
1950-55	5.8	3.4	1.3	1.9
1956-60	5.3	3.5	1.8	1.6
1961-65	5.4	3.9	2.0	1.9
1966-70	4.9	3.9	1.8	1.9
1971-75	3.9	3.0	1.4	1.6
1976-80	3.4	2.4	1.1	1.5
1981-85	3.4	2.0	0.9	1.3
1986-87	3.9	2.2	1.0	1.5

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

**Figure 3**  
**Trends in Public Investment Relative to GNP**  
**1950 to 1987**



(Source: Bureau of Economic Analysis)

*Measured as a share of GNP, civilian public investment and its components have all declined since the late 1960s.*

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***By 1982 net public investment in core infrastructure had nearly ground to a halt in the United States.***

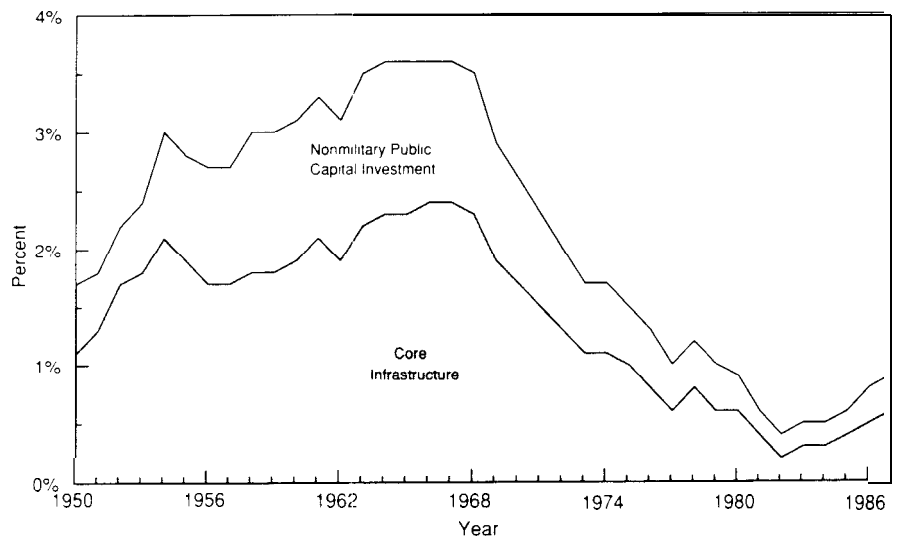
functional categories of public capital investment. Relative to output, the level of investment in core infrastructure peaked within a year of the peak in nonmilitary public capital spending, and it has risen only modestly in the last half decade.

As indicated in the last column of Table 2, nonmilitary public investment minus spending on educational structures and highways displays similar trend behavior.

It should also be noted that these figures pertain to gross investment in nonmilitary capital; no deduction has been made for the physical wear and tear on the nation's total stock of public capital, so the figures cited in Table 2 understate the problem. Once the public stock is adjusted for depreciation, the negative trend becomes even more disturbing. As shown in Figure 4, by 1982 *net* public investment in core infrastructure had nearly ground to a halt in the United States, coming in at less than 0.5 percent of total output. This means that the U.S. was not doing much more than replacing the existing public capital stock; very little was being added, the needs of the growing private economy notwithstanding.

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**Figure 4**  
**Net Public Investment Relative to GNP**  
**1950 to 1987**



(Source: Bureau of Economic Analysis)

*Public investment in core infrastructure, relative to GNP, has dwindled to less than 0.5%; other types of public investment have barely exceeded that level. The precipitous drop since 1968 is well below average performance during the 1950s.*

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Figure 5 shows that this fall-off in public investment is reflected in a similar fall-off in the amount of infrastructure capital available to each worker in the economy. After climbing from around \$8,500 per worker in 1950 to \$15,000 per worker in the early 1970s, the public capital stock tumbled to some \$13,000 per worker by the end of 1987.

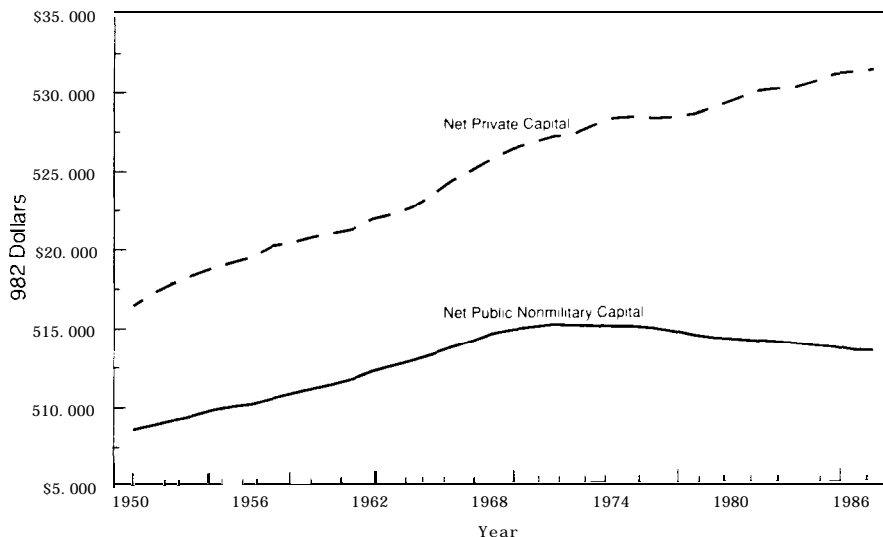
At the same time, the dollar value of private plants and equipment per worker has continued to climb throughout the post-World War II period, from about \$16,000 in 1950 to roughly \$34,000 by the end of 1987. Thus, while the *private* sector has largely—though not completely—been doing its job in equipping workers with adequate tools and work environments, the public sector has been negligent in providing the appropriate amount of infrastructure, the necessary foundation to the private economy.

It is common for economists to talk about the “twin deficits” of the 1980s: the federal government budget deficit and the trade or current account deficit. But in a sense, the last decade has also witnessed a third deficit: a deficit in spending on vitally needed public works. Indeed, the fundamental thesis of this paper is that this third deficit is central to some of our most important long-term economic difficulties: our declining private profit rate on machinery and structures; our overall failure to invest adequately in our future; and our sluggish growth in productive efficiency.

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***The last decade has also witnessed a third deficit: a lack of spending on vitally needed public works.***

**Figure 5**  
**Private & Public Nonmilitary Capital Per Worker**  
**1950 to 1987**



(Source: Bureau of Economic Analysis)

*Net public nonmilitary capital per worker has clearly fallen off since 1970. The rate of increase for net private capital has changed little in forty years, which is remarkable in light of changes in the U.S. economy and the strenuous efforts to stimulate private investment.*

## Infrastructure and the Economy: Concepts

Economists describe goods and services used to produce other goods and services as “factors of production.” These consist of land (and associated natural resources), labor (considered in terms of time expended and skill level, among other things), and capital (chiefly equipment and structures).

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*Without a good infrastructure, private production would be much more costly, in certain cases prohibitively so.*

*If* a private company builds a road from one of its buildings to another, or digs a well to obtain water, we would classify these items as private capital investments. If that same company were to move goods or obtain water as part of the production process by means of public roads and water supply, *we* would be remiss in not acknowledging the effect of the services of public capital on private production.

The delivery of an overnight package by Federal Express, for example, requires labor (truck drivers, airline pilots, mail sorters) and physical capital (the associated trucks, airplanes, and the “Octopus”-Federal Express’s mechanical mail sorting machine). Oddly standard procedure for economists is to limit the physical capital concept to *private* capital and to neglect public capital such as roads, airports, and other public infrastructure facilities. As the chosen example should make clear, however, this is an unfounded omission. For what kind of product would Federal Express have were it not for the streets on which it drives its trucks, or the airports where its planes land? What profits would Federal Express generate without such things as public highways and airports?

So the basic connection between infrastructure and the economy is simple. The stock of public highways, bridges, and other infrastructure capital is essential to the profitable and efficient production and distribution of private sector goods and services. While the choice of Federal Express as an example is admittedly not fortuitous, a moment’s reflection should convince the reader that infrastructure capital directly or indirectly affects nearly every productive unit in the economy. Consider, for example, the variety of ways that infrastructure might be important to a clothing producer in a major city. Mass transit provides the firm with access to an extensive pool of inexpensive and productive labor. The washing and dyeing of fabrics requires a steady source of water and a reliable sewer system. Good streets and highways serve the dual purposes of just-in-time inventory management and easy shipment to national and international markets. Without a good infrastructure, private production would be much more costly, in certain cases prohibitively so.



The potential importance to the macroeconomy of trends in infrastructure spending can be discussed by utilizing the theoretical framework in Arrow and Kurz (1970) and Aschauer and Greenwood (1985). These authors expand on the standard neoclassical production function, expressed in labor-intensive form, to show that private sector output is a function of both private capital and the public infrastructure capital

$$y = f(k, k^g) \quad (1)$$

Here  $y$  = private sector output,  $k$  = private capital, and  $k^g$  = public infrastructure capital (all expressed per unit of labor employed).

This type of analysis has a number of important implications. First, an increase in the stock of public capital would be expected to directly raise the level of private sector output of goods and services. In the example given above, Federal Express would be able to make more deliveries per year (produce more output) with 3 given number of workers, planes, and trucks if the nation's stock of airport and highway facilities was expanded or improved. In this sense, public capital directly abets private sector production. Second, under certain circumstances, public capital and private factors of production—labor and private capital—may be “complementary inputs” so that an increase in the stock of public capital increases the productivity of private factors of production and thereby generates increased demand for labor and private capital investment goods. The decision by the government to improve the nation's transportation network might well encourage Federal Express to buy more planes and trucks, to hire more pilots and delivery personnel, and perhaps to make better use of their own capital.

Thus, one obvious implication of including public capital in our depiction of the process of private production is that it may play 3 direct role in promoting private sector productivity:

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***An increase in the stock of public capital would be expected to directly raise the level of private sector output of goods and services.***

## Evidence for the Hypothesis

---

*A one percent increase  
in the stock of  
infrastructure capital will  
raise productivity by  
**0.24** of one percent.*

Recent empirical evidence indicates that the public capital stock is an important factor of production; the slowdown in public investment can help explain a significant portion of the slump in productivity growth in the past two decades. For example, in Aschauer (1989a) I present historical statistical (i.e., time series) evidence for the post-World War II period in the United States which indicates that a “core infrastructure” of streets and highways, mass transit, airports, water and sewer systems, and electrical and gas facilities bears a substantially positive and statistically significant relationship to both labor productivity and multifactor productivity. Table 3 contains estimated output elasticities for various categories of public capital.<sup>4</sup> As can be seen in this table, the core infrastructure category has the largest output effect (i.e., the largest elasticity estimate) and is the most statistically significant of the various categories of public capital. A one percent increase in the stock of infrastructure capital, by this estimate, will raise productivity by 0.24 of one percent.

Figure 6 illustrates the close relationship estimated between total factor productivity and the nonmilitary public capital stock. To highlight the link between longer-term movements in productivity and the public capital stock, the measures of total factor productivity and the public capital stock have been adjusted for business cycle effects.<sup>5</sup>

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TABLE 3

Public Capital by Type and Productivity (1949-1985)

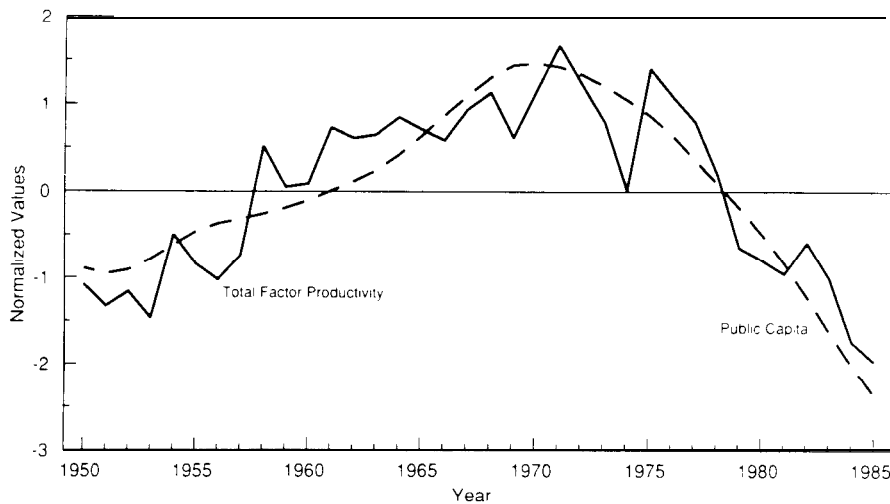
Type	Coefficient Estimate*	T-statistic	Percent of Total	F
Core Infrastructure (highways, mass transit, airports, electrical and gas facilities, water and sewers)	0.24	(5.07)	55%	0.16
Other Buildings (office buildings, police and fire stations, courthouses, garages, and passenger terminals)	0.04	(1.57)	7	0.01
Hospitals	0.06	(1.62)	3	0.33
Conservation & Development	0.02	(0.92)	4	0.01
Educational buildings	0.01	(-0.18)	16	0.99

\* The coefficient is the percentage change in total national output given a one percent change in the particular type of public capital.

Source: Author's calculations

---

**Figure 6**  
**Public Capital and Productivity**  
**1950 to 1985**



(Source: Author's calculations.)

*Changes in total factor productivity are closely associated with movements in the size of the public capital stock, after accounting for short-term fluctuation in productivity attributable to the business cycle.*

The graph shows how that portion of total factor productivity which *cannot* be explained by technological progress<sup>5</sup> (proxied by time) or by the state of the business cycle (proxied by the capacity utilization rate) *can* be explained by movements in the public capital stock. One can see the close association between changes in productivity and public capital; indeed, the empirical estimates in my 1989 paper suggest that of the total 1.4 percent annual fall-off in productivity growth during the 1970s and 1980s, fully 57 percent—or 0.8 percent per year—can be attributed to the downturn in public investment spending. The levels of productivity and public capital stock peaked in the late 1960s to the early 1970s and during the mid-1960s, respectively.

Certain refinements of my 1989 paper by Munnell (1990a) entailed adjusting the standard Bureau of Labor Statistics measure of labor input to account for changes in the age/sex composition of the labor force and updating the sample period to 1987. Munnell obtained strong parallel results on the importance of public capital in private sector production.

*One can see the close association between changes in productivity and public capital.*

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***A shift from private to  
public investment would  
increase GNP  
substantially.***

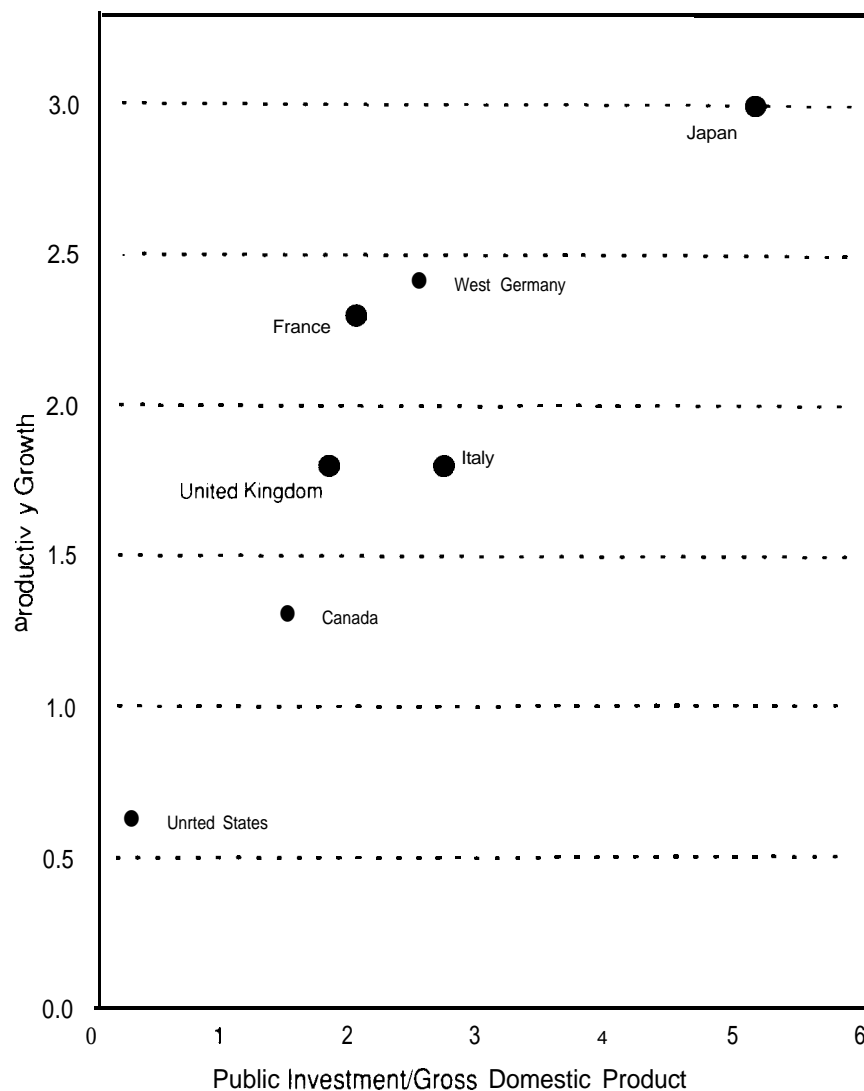
Munnell also computed adjusted measures of multifactor productivity growth and found that after accounting for changes in the quality of the labor force and for changes in the growth rate of the core infrastructure capital stock, the fall-off in multifactor productivity growth during the 1970s and 1980s relative to the 1950s and 1960s was "much more in line with expectations" and that "[much] of the drop in published multifactor productivity numbers may reflect the omission of public capital from the calculations of inputs rather than a decline in technological innovation" (Munnell, 1990; p. 19).

Of course, from a policy standpoint it would not be prudent to rest such strong conclusions solely on the basis of aggregate historical data from one country. It should be very instructive to examine cross-sectional evidence by comparing either states, industries, or countries. In fact, additional empirical results buttressing the case for expanded public spending on infrastructure are available.<sup>6</sup>

In Aschauer (1990d), I present evidence that public investment in streets, highways, and water and sewer systems is an important factor in explaining the variation in levels of productivity across states, and that the level of such public spending is lower than would be chosen by optimizing governmental bodies. Indeed, the inefficiency of our existing allocation of investment resources is underlined by the finding that increases in GNP resulting from increased public infrastructure spending are estimated to exceed those from private investment by a factor of between two and five. This means a shift from private to public investment would increase GNP substantially; it reflects the dearth of resources presently committed to infrastructure. Munnell (1990b) estimates the sizes of state-area public capital stocks and finds that public infrastructure capital is an important factor of production determining the level of state-area productivity. The categories of public capital bearing the most importance for private productivity turn out to be streets and highways and water and sewer systems; other public capital facilities have little or no explanatory power in private sector output regressions.

In Aschauer (1989c) I employed comparative historical data (i.e., pooled time series data) using evidence from national comparisons for the Group of Seven nations (Canada, France, Germany, Italy, Japan, Great Britain, and the U.S.) over the period 1965 to 1985. I found that upon controlling for private investment and employment growth, public nonmilitary investment bears a significantly positive relationship to growth in gross domestic product per employed person (see Figure 7).

**Figure 7**  
**Cross-Country Comparison of Productivity Growth**  
**and Public Investment to GDP Ratio**



(Source: Author's calculations.)

*A cross-country comparison of average annual growth rates of labor productivity with the ratio of public investment to gross domestic product indicates that over the period 1973–1985, nations which invested more in their public capital stocks saw productivity gains as well.*

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***The rate of return to private capital in the nonfinancial corporate sector is positively affected by changes in the stock of public capital per worker.***

This is a noteworthy result because a number of researchers have pointed out that the productivity slump was not a disease unique to the United States; to the contrary it had epidemic-like proportions, affecting nearly all industrialized economies. In the words of Stanley Fischer, the explanation for the productivity slowdown “is unlikely to lie ‘in the special circumstances of a single country’” (Fischer, 1988:p.3). In that regard, it is interesting to note that public investment spending as a share of gross domestic product fell during the late 1960s and early 1970s in five of the seven countries in the sample. Furthermore, the ratio of public investment to total government spending declined during this period in all the Group of Seven countries.

Summing up the evidence for the first major finding highlighted at the outset of this paper, the size of the public capital stock is an inescapable feature of the explanation for national productivity trends. This conclusion holds when considering the evolution over time of productivity in the U.S.; it holds when comparing disparate productivity levels in the states; and it holds when comparing the productivity performance of major industrial nations.

As stated above, a second implication of including public capital in the production technology is that changes in the *public* capital stock may influence the marginal productivity of *private* factors of production. For example, a better transportation network would allow Federal Express to make better use of additional trucks and airplanes which, in turn, would raise profit rates on such private capital goods. In Aschauer (1988), I present an historical statistical analysis (i.e., aggregate time series) which suggests that the rate of return to private capital in the nonfinancial corporate sector is positively affected by changes in the stock of public capital per worker. Employing data on manufacturing firms over the period 1970 to 1978, Deno (1988) finds similarly strong effects from public capital—highways, sewers, water facilities—as well as the total of these. In particular, he finds evidence of a complementary relationship between public and private capital. In short, public capital is “profitable” because it boosts the returns to private capital. While Eberts (1986) also finds that the public capital stock makes a positive and significant contribution to manufacturing output, the magnitude of his effect is considerably smaller than that indicated by Deno’s results. Deno (1988) reconciles the difference by arguing that his own approach is more flexible, as it allows for responses to changes in public capital by firm output supply and by factor demands.

The evidence appears overwhelmingly in support of the proposal that public infrastructure directly augments private sector production. Therefore, a valid case can be made for a significant increase in public investment spending. But a crucial question must then be asked: what impact would an increase in public capital spending have on private investment? If the public investments were merely to displace private investments in plant and machinery—economists call this a complete “crowding out” of private capital accumulation—then national investment (private plus public) would be left unchanged and relatively minor productivity gains could be expected.

There are two basic effects operating on private investment activity when public investment is increased. As discussed above, an increase in the public capital stock can be expected to have a positive effect on the profitability or the rate of return to private capital. The theory of the firm suggests that firms will respond to heightened profit rates by expanding the pace of capital investment. But if we assume that the private sector profit rate remains constant, then greater public capital investment can also be expected to reduce private investment as national investment (private plus public) is pushed beyond the level which optimizing agents would choose. Historical data for the United States suggest that both types of effects of public investment on private investment may well be operative (Aschauer, 1989b). More specifically, I present results which indicate a nearly one-to-one “crowding out” of private by public investment (holding fixed the rate of return to private capital) as well as a “crowding in” of private investment by public investment—as the rate of return to capital responds over time to the increases in the public capital stock which are brought about by higher public investment. In the long run—in this case four or five years—the “crowding in” effect dominates and overall private investment is stimulated; indeed, for every dollar increase in public investment, private investment rises by approximately 45 cents.

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*An increase in the public capital stock can be expected to have a positive effect on the profitability or the rate of return to private capital.*

## What If We Had Invested More in Public Infrastructure?

*The simulation exercise depicts an increase in the level of public nonmilitary investment by one percent of the private capital stock during the period from 1970 to 1986.*

It is instructive to bring together some of these empirical results to consider how large an effect public investment has on crucial dimensions of economic performance: investment, profits, and productivity. This is accomplished by utilizing the aforementioned empirical estimates to construct a minimal model capable of simulating the effect of higher public investment on the aggregate economy. The increase in public investment hypothesized for the purpose of the simulation is consistent with what the U.S. would have experienced if the actual historical rate of public investment from roughly 1950 to 1970 (as shown in Figures 3, 4, and 5) had held up for the following two decades, rather than falling off as it did.

More specifically, the simulation exercise conducted below depicts an increase in the level of public nonmilitary investment by one percent of the private capital stock during the period from 1970 to 1986, an amount 125 percent greater than the actual level of public investment in this time period, so that the rate of public investment since 1970 is comparable to that of the 1950s and 1960s. By incorporating the effects of the greater public investment, Table 4 provides data on actual and simulated levels of the rate of return to private nonfinancial corporate capital, on net private investment in nonresidential structures and equipment, and on private business sector productivity growth.<sup>7</sup>

TABLE 4  
Simulated impact of Public Investment on Private Economy

	Return to Private Capital (%)		Private Investment (% of Private Capital Stock)		Productivity Growth (% Per Annum)	
	Actual	Simulated	Actual	Simulated	Actual	Simulated
1953-69	10.7	—	3.8	—	2.8	—
1970-74	a.7	10.7	3.9	3.9	1.5	1.9
1975-79	a.5	9.9	3.2	4.2	1.3	2.2
1980-84	6.7	a.4	2.7	3.0	1.1	1.9
1985-88	7.8	9.6	2.8	3.8	1.8	2.7
1970-88	7.9	9.6	3.1	3.7	1.4	2.1

Source: See Appendix and Aschauer (1989a, 1989b) for details of simulation methodology



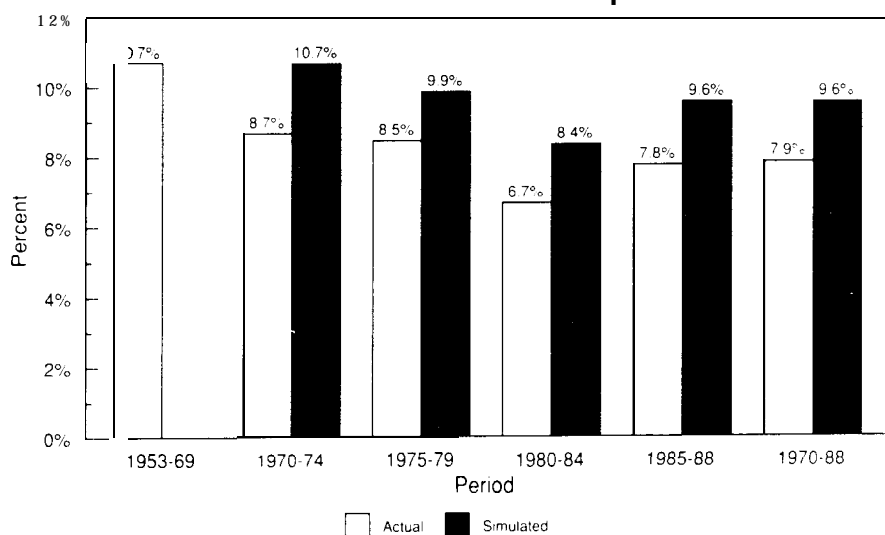
The actual data document that between 1970 and 1988, inferior economic performance was experienced relative to the 1953-1969 period, along with a lower rate of return to private capital (7.9 percent as opposed to 10.7 percent), lower private investment (3.1 percent of the private capital stock rather than 3.8 percent), and lower labor productivity growth (1.4 percent per annum as opposed to 2.8 percent).

The simulation data also reveal relationships between public nonmilitary investment, private profitability, private investment, and private sector productivity growth. In the first five years of the hypothetical expansion in public investment, the rate of return to capital rises by 2 percentage point.<sup>5</sup> over its actual level, remaining at its 1953 to 1967 level of 10.7 percent instead of falling to 8.7 percent (see Figure 8). This is due to the cumulative positive effect of the rising public capital stock on the productivity of private capital.

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*In the first five years of the hypothetical expansion in public investment, the rate of return to capital rises by 2 percentage points over its actual level.*

**Figure 8**  
**Actual and Simulated Impact of**  
**Rate of Return to Private Capital**



(Source: Author's calculations.)

*The light bars reflect actual historical levels of the return to private capital in the U.S. The dark bars reflect the rates of return that could have been achieved if the commitment to public investment had not lagged after 1970.*

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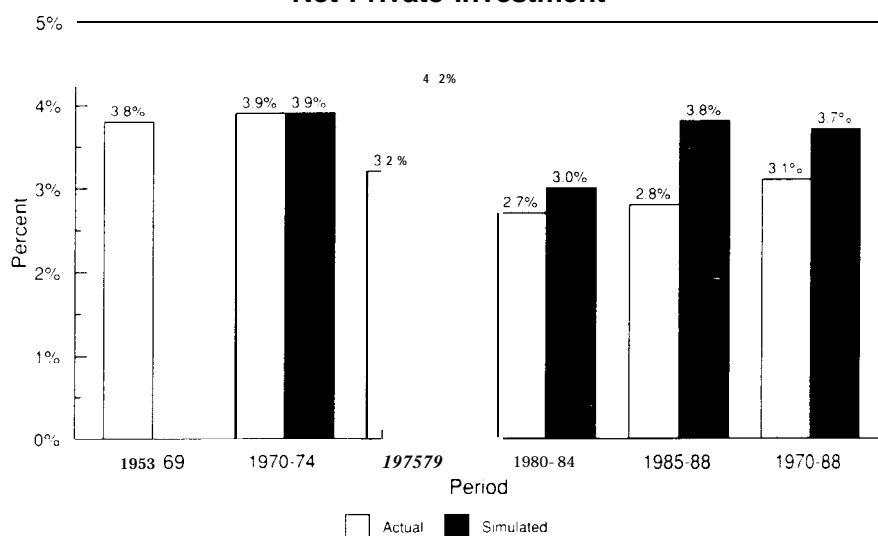
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***Private sector  
productivity growth is  
enhanced by 1.5 to 1.9  
percent per year.***

During the same period, the private investment rate averages 3.9 percent of the private capital stock, the same as in the actual data (see Figure 9). This reflects two offsetting forces: in the first three years of the higher public investment, private investment is pushed lower due to the direct crowding out effect of higher public investment, while in the next two years private investment is brought above its historical level by the higher rate of return to private capital. In the same period, private sector productivity growth is enhanced by 1.5 to 1.9 percent per year (see Figure 10). As the private investment rate (as a percent of the capital stock) is seen to remain steady this enhancement of productivity growth reflects the direct, positive effect of a growing public capital stock on the productivity of labor.

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**Figure 9**  
**Actual and Simulated impact on**  
**Net Private investment**

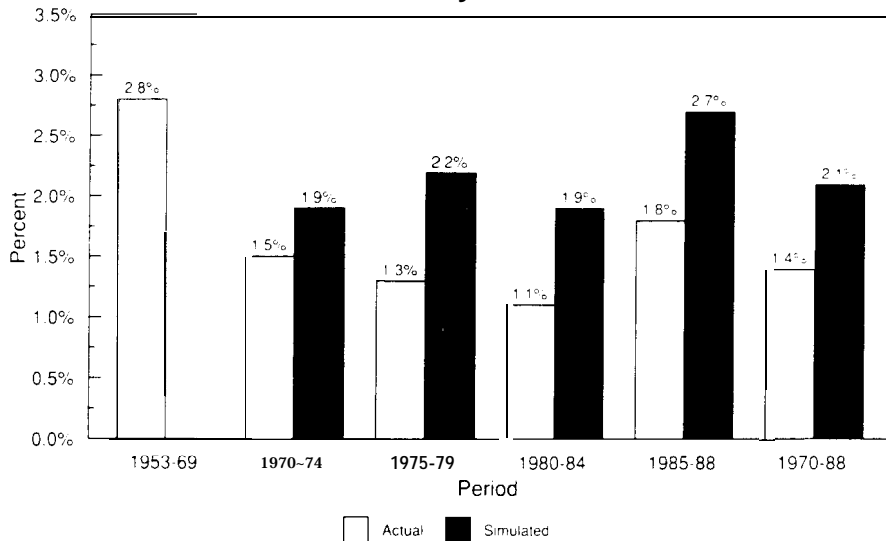


(Source: Author's calculations.)

*The simulation suggests that net private investment could also have been augmented after 1975 if public investment rates had not decreased after 1970.*

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**Figure 10**  
**Actual and Simulated Impact on**  
**Productivity Growth**



(Source: Author's calculations.)

*Productivity growth could have been significantly higher than actual performance after 1970 under a regime of increasing public investment.*

In the later years of increased public investment, the simulation results show that the rate of return to private capital could have held up to between **one** and two percentage points more than the historical levels. This issue arises because the private investment rate climbed to one percentage point higher than the historical level, and the consequent negative effect on the rate of return to private capital of the growing private capital stock roughly offset the positive effect of the expanding public capital stock. Productivity growth would then rise by a more substantial amount (nearly one percent per year above historical values) because the direct effect of growth in the public capital stock is augmented by the indirect effect of a higher return to capital, raising private investment which, in turn, stimulates productivity growth.

On the whole, the simulation exercise suggests the possibility that the performance of the economy might have been greatly improved by an increased investment in public facilities. Comparing the 1970-1988 period to the 1953-1969 period, the rate of return to private capital could have been only 1.1 percentage points lower (instead of 3.8 percentage points); private investment could have been only 0.1 percentage points lower (rather than 0.7 percentage points lower); and annual productivity growth could have been 0.7 percent per year lower (instead of 1.4 percent lower).

*The rate of return to private capital could have held up to between one and two percentage points more than the historical levels.*

## Criticisms and Rebuttal

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*Those functional categories of public capital which one would expect, on an a priori basis, to be the most productive- turn out to have the strongest statistical significance in estimated productivity relations.*

As was mentioned above, there are a number of reasons why these results might be interpreted with some caution. One reason for guarded optimism about the ability of public investment to improve private sector economic outcomes is that a logical case can be made that rather than being exogenous, public investment may well be responding to changes in the private economy instead of initiating them. In other words, one could argue that slower growth in productivity, per capita income, and tax revenue induced the government to reduce spending on public capital projects. Pushed to its logical extreme, this suggests that the fail-off in public investment in the 1970s and 1980s was a result, not a cause, of the slump in productivity growth during the same period.

This argument can be answered by reference to the simple facts mentioned above: public nonmilitary investment expenditure, relative to output, reached a peak in the period between 1965 and 1968, and the usual dating of the onset of the productivity decline is around 1973. While some argue that the productivity slump began as early as 1965, and others deny its very existence (Darby, 1981), such economists are in a decided minority.

As demonstrated in Aschauer (1989a), those functional categories of public capital which one would expect, on an *a priori* basis, to be the most productive—in particular, a core infrastructure of surface and air transportation facilities, water and sewer systems, and electrical and gas facilities—turn out to have the strongest statistical significance in estimated productivity relations. Holtz-Eakin (1988) looked in some detail at the statistical association between public capital accumulation and private productivity growth and found that a substantial portion of the correlation reflects a causal role for the public capital stock and a passive role for productivity, rather than the converse. This means that public investment is the active causal factor in stimulating GNP growth and refutes the suspicion that GNP growth merely finances public spending of questionable value.

A second objection could be made that the estimated impact of public capital on productivity—one key parameter in the simulations above—is unreasonably large. Montgomery (1989) asserts that “the importance ascribed to government investment simply strains credulity” (Montgomery, 1989, p. 2). Also, in a contribution to *Setting National Priorities: Policy for the Nineties*, Schultze (1990) writes that the regression results in Aschauer (1989a) “imply that a \$1 increase in the stock of public infrastructure adds about as much to productivity as a \$-t increase in the stock of private business capital” which, in his eyes, implies “grossly inflated estimates of the returns to infrastructure investment” (Schultze, 1990, p. 63).

My own judgement is that public infrastructure capital—which is valuable precisely because of the myriad ways in which it simultaneously raises productivity jointly, across industries—may well be *four times* as potent in affecting the macroeconomy as private investment. More importantly, however, the plausibility of such large impacts of public capital has been estimated by Baster and King ( 1770 ), who used theoretical simulation techniques to generate output paths resulting from changes in public investment. The authors conclude that “our analysis of the effects of public investment supports Aschauer’s [1989a] view that variations in publicly provided capital have important macroeconomic effects. In particular, the decline in public investment could potentially account for the recent decline in private factor productivity” (Baxter and King, 1990; p.29).

It is true, however, that the elasticity estimates contained in Aschauer (1989a) yield an estimate of the rate of return to public capital in the range of 50 to 60 percent. And while rates of return to public investment in the 50 percent range are high relative to those estimated by conventional cost-benefit techniques, this could conceivably be due to deficiencies in cost-benefit methods which tend to understate the true return to public capital investments. Such defects in cost-benefit analysis could include:

(A) *The use of an inappropriate rate of discount for public projects.* Ogura and Yöhe (1977) demonstrate that in a setting with a distortionary tax on private capital, if public capital and private capital are complementary inputs to the private production function, then the correct discount rate for public projects lies below the rate of time preference. This is because the completed public investment project will raise the marginal productivity of private capital and induce more aggregate savings and private investment than would arise without the complementarity. As we have seen, empirical evidence of such complementarities has been found in Aschauer ( 1988, 1989b), Deno ( 1988 ), and Eberts ( 1986).

(B) *The inherent difficulties involved in capturing general equilibrium effects in partial-equilibrium cost-benefit analysis.* In the words of the authors of a research project currently being funded by the Transportation Research Board, the spur which public investment provides

to labor productivity and growth is not fully captured in Benefit-Cost analysis, either because of limitations in the theoretical framework or because of benefit estimation methodologies. The growing suspicion among transportation policymakers and engineers is that either one or both is indeed the case; and that as a result even the most proficient use of Benefit-Cost analysis creates the risk that ‘the sum of all infrastructure decisions taken according to the strict rules of net present value maximization will fail to achieve the level and mix of transportation investments that maximize productivity, national economic growth, and welfare (Hickling, 1990; p. 72).

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***My own judgement is that public infrastructure capital may well be four times as potent in affecting the macroeconomy as private investment.***

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*Traditional disequilibrium  
macroeconomic models  
stipulate a direct,  
demand-side effect of  
government spending on  
output and capacity  
utilization.*

A clear example of the validity of such reasoning can be found in Quarmby (1989), which considers a detailed example of the possible cost reductions to a food retailer resulting from a road improvement. The cost savings arise as time savings to the retailer's vehicles (traditional user's benefits) and as "restructuring benefits" as the retailer is able to capture economies of scale by reducing the number of food depots. The quantitative significance of the restructuring benefits leads Quarmby to the conclusion that "[i]t is doubtful whether current methods of cost/benefit assessment fully account for the benefits of network improvements, which may include structural changes in distribution logistics" (Quarmby, 1989; p. 84). This is merely one example of the way in which infrastructure investment may help improve the productive "atmosphere" (Meade, 1952), thereby allowing the capture of increasing returns to scale and productivity gains. It seems plausible that in the aggregate such spill-overs could have significant effects on private sector production: indeed, they would seem to offer as much potential for explaining the stylized facts of economic growth as do the knowledge spill-overs discussed by Romer (1986, 1987).

*(C) The actual process of project selection.* In many cases, cost-benefit analysis is not even undertaken. To cite one example, it is stated that "methods of assessing the costs and benefits of pollution control have not generally been applied by the states on any regular, continuing basis" (Environmental Protection Agency, 1985; p. 27). When cost-benefit studies are undertaken, in actual practice the analysis is often performed with the use of relatively high real discount rates. The Office of Management and Budget, for instance, requires the use of a 10 percent discount rate for evaluating federal projects.<sup>8</sup> Also, rather than separate projects being evaluated individually and being funded if they pass the cost-benefit test, it is often the case that the parties responsible for choosing projects have a fixed amount of resources to allocate, leading to the possibility that a number of projects which are justifiable on cost-benefit grounds are left unfunded.

A third concern about the simulation exercise is that the model is simplistic. It assumes, for instance, that movements in employment and capacity utilization are independent of changes in public investment spending. It might be expected that public spending increases the general employment level through some kind of Keynesian "demand-side" effect.

In response to this I would reiterate that the focus of this exercise is on forces operating on the supply side of the economy, not the demand side. Traditional disequilibrium macroeconomic models stipulate a direct, demand-side effect of government spending on output and capacity utilization. Even equilibrium macroeconomic models can allow for significant positive output effects of public investment, at least in the long run. Raster and King (1990) show that a unit increase in public investment spending may result in sizeable output multipliers, substantially in excess of unit:

Aschauer (1990b) provides evidence that public nonmilitary investment has much more stimulative impact on output than do either public consumption or military investment; the output multipliers attached to the former type of expenditure lie in the range of four while those associated with the latter two types lie well below unity.

The upshot is that these theories may posit an alternative transmission mechanism for the effect of public investment on GNP, but they do not contradict the basic direction or magnitude of the effect underlying the simulation exercise, the immediate purpose of which, after all, is simply to estimate potential GNP which the U.S. has lost for lack of an adequate commitment to the public capital stock.

While a variety of objections could be made to these exercises, it is striking how closely the simulation results match those obtained by other researchers in simulations of purely theoretical representative agent growth models (Raster and King, 1990).<sup>9</sup>

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*These theories may posit an alternative transmission mechanism for the effect of public investment on GNP, but they do not contradict the basic direction or magnitude of the effect underlying the simulation.*

## Conclusion

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*The Administration's proposed level of spending on nonmilitary equipment and structures, relative to total output, is 26 percent below the 1960 level and 24 percent below the 1980 level.*

President George Bush, Secretary of Transportation Samuel Skinner, Budget Director Richard Darman, and Council of Economic Advisors Chairman Michael Boskin are all well aware of these arguments for the importance of a sound infrastructure to our economic vitality. In his introduction to Secretary Skinner's recent report on the nation's transportation needs, President Bush said that "our competitive success in the global economy depends [on preparing] our transportation system to meet the needs of the 21st Century" (U.S. Department of Transportation, 1990). Similarly, in the President's proposed Fiscal 1991 Budget, Richard Darman wrote that "it is intuitively apparent that some public investments—particularly those of infrastructure such as streets, highways, airports, and water and sewer systems—provide direct productive services and are complementary with private capital. Comparisons over time and across countries seem to indicate that some relationship may exist between additions to such capital and growth." (Office of Management and Budget, 1990; p. 36). In the most recent *Economic Report of the President*, Michael Boskin asserted that "inadequate government infrastructure can impede improvements in productivity growth" and that "taking advantage of productive opportunities to maintain and improve the infrastructure is an important part of federal, state, and local government policies to raise economic growth." (Council of Economic Advisers, 1990: p. 133).

These sentiments notwithstanding, the Administration's proposed level of spending on nonmilitary equipment and structures, relative to total output, is 26 percent below the 1960 level and 24 percent below the 1980 level. Grants to state and local governments for physical investment purposes, relative to total output, will be left 40 percent under the 1960 level and 43 percent below the level in 1980. Likewise, the proposed level of total federal investment—in physical capital as well as in research and development and education—will lie 33 percent below its 1960 level and 10 percent under its 1980 level.

Of course, it is highly unlikely that the ~~mis~~ and level of public investment spending which was ~~chosen~~ over the past forty years ~~n~~-ill be preferred in the future. Even if, for instance, it were established beyond a shadow of doubt that the Interstate Highway System was a key determinant of productivity growth in the 1960s and 1970s, such a discovery would not necessarily imply that a similar effect on productivity would be obtained from the construction of another 40,000 miles of controlled access highways. We live in a dynamic economy which ~~changes~~ constantly in response to technological progress, foreign competitive pressures, and alterations in the demographic characteristics of the domestic workforce. In the future, infrastructure needs may well shift from surface to air transportation, from the transport of goods to that of ideas, and from a national to an international focus. Potentially large efficiency gains are to be expected, therefore, from improved air and seaport facilities and from telecommunications networking, among other things.



The evidence surveyed in this paper, along with the related simulation results, suggest that the benign neglect of the quality and quantity of our nation's infrastructure facilities will act as a severe drag on our overall economic performance. Unless we address our public capital needs immediately we can expect a continuation of lackluster productivity growth, low profit rates on the existing private capital stock, stagnant real wages, and sluggish private net investment.

The collapse of Communism and the associated reduction in Cold War tensions now offers an unanticipated opportunity to rechannel some of the nation's resources from military spending into more productive areas. Many would argue that reductions in military spending should be utilized to reduce the budget deficit, in the hope that lower government borrowing would push down interest rates and, indirectly, stimulate private investment. I claim, however, that at the present time the best use of the extra resources is to directly augment the nation's public capital stock through a surge in infrastructure investment. Following this course will help equip the nation to compete effectively in the international arena and, at minimum, it offers some hope for a partial reversal of our sliding economic fortunes.

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*The benign neglect of the quality and quantity of our nation's infrastructure facilities will act as a severe drag on our overall economic performance.*



## Appendix: Simulation Methodology

The simulation results reported in the text were obtained using the following methodology. The empirical results from Aschauer (1989a, 1989b) were used to parameterize the following simple model:

$$(X.1) \quad \Delta k/k = -.04 + .60 \cdot \Delta k(-1)/k(-1) + .79 \cdot r - .99 \cdot \Delta kg/k$$

$$(A.2) \quad r = 2.52 + .006 \cdot \text{time} - .27 \cdot \log(k/n) + .09 \cdot \log(kg/n) + .19 \cdot cu$$

$$(A.3) \quad \Delta y/y - \Delta n/n = .008 + .26 \cdot (\Delta k/k - \Delta n/n) + .39 \cdot (\Delta kg/kg - \Delta n/n) + .43 \cdot \Delta cu/cu$$

where:  $k$  = net fixed private capital stock

$r$  = net rate of return to private capital stock

$kg$  = net fixed public nonmilitary capital stock

$n$  = labor force

$y$  = private business sector output

$cu$  = capacity utilization rate

$\Delta x$  = absolute growth in variable  $x$ .

The first equation shows the growth rate of the net private capital stock as dependent upon its own lagged value (due to increasing costs of adjusting the capital stock), the rate of return to capital, and investment in public nonmilitary capital. The second equation shows that the rate of return to private capital is dependent upon time (due to neutral technological progress), the private capital to labor ratio (negatively due to a diminishing marginal product of private capital), the public nonmilitary capital to private labor ratio (positively due to the services of public capital in private production), and the capacity utilization rate (positively due to shocks to supply or demand). The model also contains two identities to convert investment rates into growth rates of capital stocks.

The parameterized model was used to obtain simulated values for  $\Delta k/k$ ,  $r$ , and  $\Delta y/y - \Delta n/n$  during the period 1770 to 1988 taking levels and growth rates of the labor force and capacity utilization as given exogenously.

## Endnotes

These data refer to the profit rate on nonfinancial corporate capital structures and equipment.

Darby (1984). Of course, there is much controversy about the validity of these facts as well as about their appropriate interpretation. For instance, there are some, like Michael Darby, who argue that there has been no true productivity slowdown; instead, what we have chosen to see in this regard is “a case of statistical myopia.” Others, such as Martin Feldstein and Lawrence Summers, would argue that there is really no long-term downtrend in the corporate profit rate. And there is much controversy about whether investment really has been depressed during the 1980s. Individuals like Paul Craig Roberts choose to emphasize gross, as opposed to net, investment rates, and gross investment has been relatively stable during recent years. Finally it is necessary to be careful about interpreting movements in productivity profit rates, and investment-or, for that matter, other variables such as the current account deficit-as indicators of economic malaise. The appropriate, or optimal, rates of national savings, investment, and productivity growth are inherently unobservable and may well be changing over time. It seems clear, nevertheless, that the economy has not been performing well as of late and that the typical person in the street is rightly concerned about our long-term economic prospects.

An output elasticity of public capital is defined as the percentage change in total national output given a one percent change in the stock of public capital.

“Total factor productivity” or “multi-factor productivity” is a statistical measure of the “joint” productivity of all inputs in the production process: labor, private capital, and public capital. Munnell’s findings (1990a, b) emphatically support the conclusion that the shortfall in public investment spending played a large role in diminishing the productivity of the private economy, over and above the separate influence of the changing labor force. The dependence of productivity on the level of utilization of the private capital stock has also been estimated and subtracted from the measure of total factor productivity. Productivity is commonly believed to move in conjunction with the business cycle: when unemployment is low, productivity is high, and vice versa. This has been attributed to the tendency of business firms to refrain from some layoffs when business is slow in order to ensure the retention of experienced workers, with the result that firms are somewhat overmanned in such circumstances and output per worker declines.

This refers to technological progress in the sense known by economists as “neutral.”

Munnell (1990b) and Aschauer (1990d)

The rate of return to private nonfinancial corporate capital is defined here as the ratio of corporate profits net of depreciation plus net interest received to the total value of the net capital stock. The rate of return to net private investment in non-residential structures and equipment is defined as the ratio of net profits and net interest to the stock of non-residential structures and equipment. The rate of return to capital in terms of productivity is defined in terms of the growth in output per labor hour.

This represents a high discount rate because in the present value calculations the future benefits are expressed in real, inflation-adjusted terms. Consequently the ten percent discount is best interpreted as a ten percent real discount rate.

The model employed by Baxter and King (1990) is a representative agent model with a production structure similar to equation (1) in the "Infrastructure and the Economy: Concepts" section of this report. The model imposes the discipline of general equilibrium: that is, there are no involuntarily unemployed resources at any time. Still, public investment policy has important effects on the economy by altering productivity as well as factor returns (wages, profits) which, in turn, change the pace of employment and capital stock growth.

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