

## Cato Institute Policy Analysis No. 196: Paved with Good Intentions: The Mythical National Infrastructure Crisis

August 12, 1993

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### Executive Summary

Several recent studies have developed the view, central to the Clinton administration's economic program, that this nation's infrastructure is crumbling and in crisis. They suggest that the public-sector capital stock has declined since the 1970s and that the decline has reduced productivity, with a corresponding decline of the nation's standard of living. According to that view, increased spending on infrastructure is an urgent national priority.

The evidence reviewed here indicates that the view presented in those studies is based on a superficial reading of infrastructure trends and on a faulty view of the benefits of public capital formation. While public capital formation slowed in the 1970s, the slowing was concentrated in areas where demand for public capital was reduced by demographic and energy price changes, as well as by other economic influences. The slowing occurred at the state and local levels, not in federal government capital formation. The federal government provides little of the nation's infrastructure, and there has been little change in the per capita stock of federal nonmilitary capital since 1947.

More important, the statistical basis of the claim that crumbling infrastructure has reduced the nation's productivity is seriously flawed. When the flaws are corrected, there is no evidence that an increase in public capital raises private productivity. There is a meaningful relationship between the two, but it indicates that higher productivity boosts the demand for infrastructure. Finally, a recent private-sector poll and recent voting behavior show no evidence of an infrastructure crisis.

### Introduction

A central pillar of President Clinton's economic program is to substantially boost spending on "investment." Over the next five years some \$100 billion of that new funding would be targeted for infrastructure projects-- building roads, bridges, transit systems, airports, environmental projects, and even a national computer network.

To be sure, for millions of Americans the state of the nation's public capital infrastructure is of paramount concern. Two congressional commissions' reports and several other studies have inflamed public opinion by fostering the notion of an infrastructure crisis.[1] Proponents of that notion suggest that the nation's infrastructure is crumbling. They point to a decline in the rate of growth of the public-sector capital stock that began in the 1970s. That decline, they argue, caused U.S. productivity growth to stagnate and the nation's standard of living and its international competitiveness to decline. In their view, infrastructure is the nation's "third deficit," a companion to the budget deficit and the international trade deficit; they conclude that increased infrastructure spending is an urgent national priority that will

yield high returns.

The evidence suggests, however, that the perception of an infrastructure crisis is the product of two false premises: (1) that spending on public infrastructure has been declining and (2) that the reduction in public capital investment has lowered private-sector productivity.[2] The truth is that there is no shortage of infrastructure funding. Since 1948 the real level of federal capital stock per person (1987 dollars) has remained virtually constant at \$1,500. The real capital stock at all levels of government rose from \$6,000 per person in 1948 to \$10,500 in 1970 and has remained at that level since. The leveling off of infrastructure spending since 1970 is almost entirely attributable to the completion of the interstate highway system and a reduction in spending on school construction as the percentage of the population that is of school age has declined.

Studies that purport to show the economic benefits of increased spending on infrastructure have distorted the role of public capital formation and its contribution to private-sector performance. The level of infrastructure spending has been more a consequence than a cause of economic growth in the United States.

Infrastructure is often narrowly defined to include highways, mass transit and rail systems, aviation facilities, and water supply and wastewater treatment facilities.[3] That practice is followed here because proponents of the infrastructure-crisis view use such measures. More realistically, however, infrastructure includes the relatively large physical capital facilities that are fundamental to the organization of communities and their economic development along with the communities' organizational, informational, and technological frameworks. Hence, infrastructure includes education systems; public health systems; water treatment and distribution systems; garbage and sewage collection, treatment, and disposal systems; public safety, legal, and corrections systems, including fire and police protection and communications systems as well as utilities and transportation systems.[4]

In a highly developed market economy like that of the United States, much of the infrastructure is privately provided and managed. Most electric and gas utilities in the United States are privately held ventures as are the telephone and cable companies, the airlines, and thousands of private schools and colleges. In fact, local governments have recently begun increasing private-sector involvement in infrastructure by mandating that to obtain necessary government approvals for development, real estate developers provide public water and sewer structures; mains and hookups; and streets, sidewalks, street lighting, highway access, and overpasses.[5]

The trend toward privatization is also at work in other countries where traditionally much more of the infrastructure has been in the public sector.[6] Mexico, for instance, has privatized its telephone companies and its airline. East European nations are privatizing their infrastructure activities, and West European nations have proposed privatizing their railroads, airlines, and communications systems. In the 1980s Britain alone privatized more than \$100 billion worth of public housing and state-owned enterprises. Only in the United States is there such a strong push for greater public investment in physical capital.

Ironically, the call for increased public investment in the United States is often couched in terms of developing the world's best communication, transportation, and environmental systems. That is ironic because it has been America's private sector that has provided the technological innovation and enterprise that have already achieved those objectives in large part. In the early 1970s, for example, few workers had a computer or fax machine at their disposal. Two decades later, virtually every workplace in America uses both those technologies routinely--without new public-sector infrastructure.

Although the information revolution may have been the most important improvement in the nation's transportation and communication networks in history, its source, its success, and its impact are often ignored in the debate over the condition of the nation's infrastructure. For example, proponents of a federally provided nationwide fiber-optic network and of a national computer communication network fail to recognize the extensive private capital already in the communication sector and the advanced state of the U.S. networks compared with those of foreign competitors. Indeed, a national fiber-optic communications network and a nationwide computer network (Internet) already exist.

### **Trends in Infrastructure Spending: Is There a Crisis?**

The nation's public-sector stock of nonmilitary fixed capital grew steadily from 1947 to 1991 as measured in constant

1987 dollars (Figure 1).[7] But that growth slowed sharply in the 1960s and early 1970s. Proponents of an infrastructure crisis focus on that trend toward slower growth. By measuring the public capital stock relative to private-sector employment, they show that capital stock per worker began falling in the mid-1970s.

Figure 1  
Net Stock of Nonmilitary Public Capital  
(Graph Omitted)

Taking a broader view of the situation can be helpful. Taxpayers do not invest in public capital to benefit only workers. Public capital benefits everyone, especially children and the aged. Measuring the combined federal, state, and local public capital stock in terms of all Americans reveals that capital stock per person roughly doubled between 1949 and 1971, then remained about the same for the next 20 years, averaging about \$10,400 per person in constant 1987 dollars.[8] As Figure 2 shows, however, federal nonmilitary capital has been about \$1,500 per person (1987 dollars) since 1948. There has been essentially no upward (or downward) trend, either before or after the early 1970s. Contrary to popular mythology, the federal government has not shirked its duty in public capital formation.

Further undermining the argument that an infrastructure crisis exists and that it is a federal problem requiring a federal solution[9] is the fact that about 86 percent of the nation's public capital stock is held by state and local governments. It is those units of government that must decide whether to spend more on infrastructure (Table 1 and Figure 2).

Figure 2  
Real Nonmilitary Government Capital Stock per Person  
(Graph Omitted)

Table 1 Composition of the Public Capital Stock, 1991 (Billions of Current Dollars)				
	Federal	State and Local	Total Dollars	Percent*
Nonmilitary structures	\$242.8	\$1,791.3	\$2,034.1	90.7%
Highways & streets	16.9	708.0	724.9	32.3
Educational buildings	1.2	318.8	320.0	14.3
Other buildings	33.7	224.3	258.0	11.5
Hospital buildings	11.7	50.0	61.7	2.8
Water supply facilities	--	110.7	110.7	2.8
Sewer systems & structures	--	184.8	184.8	4.9
Conservation & development structures	143.4	35.9	179.3	8.0
Industrial buildings	25.7	--	25.7	1.1
Other structures	10.1	158.7	168.9	7.5
Nonmilitary equipment	61.0	146.6	207.6	9.3
Total nonmilitary structures & equipment	303.8	1,937.9	2,241.7	100.0
Military equipment	393.3	--	399.3	
Military structures	114.8	--	114.8	
Total nonmilitary & military structures & equipment				
	817.9	1,937.9	2,755.8	
	36.5*	86.4*	122.9*	

Note: Components may not add to total due to rounding. \* Percentages of total expenditures on nonmilitary structures and equipment (\$2,241.7 billion)

Table 1 shows the components of public capital at the end of 1991 (the latest year for which data are available).(10) Two of the largest components of the nation's public capital stock are highways and streets (about 32 percent of the total at the end of 1991) and educational buildings (about 14 percent). Highways and streets are closely related to the notion of infrastructure, though they are only one part of a much larger, generally private, set of capital goods involved in the provision of transportation. Educational buildings are less related to the infrastructure concept and also have a large private-sector counterpart. Those two components--highways and streets and educational buildings--account for most of the slowing in the growth of public capital. Figure 3 shows those two components of state and local public capital per person. As the "other" line on the figure indicates, when those two components are excluded, public capital formation has not slowed.

Figure 3  
State and Local Net Capital Stock per Person  
(Graph Omitted)

There were sound reasons for reduced growth in public investment in highways and streets and educational buildings. First, the post-World War II baby boom's temporary surge in population growth played a major role in increasing investment in highways and streets, especially roadways surrounding cities. The interstate highway system, begun in the mid-1950s and largely completed by 1975, also accounted for a temporary surge in public capital formation. Changes in the price of driving also have played an important role in reducing road capital formation. Following sharp in-creases in the price of oil and gasoline in 1973-74 and again in 1979-80, the growth of passenger-miles traveled perperson dropped very sharply. As the growth of highway and street use slowed, so did the growth of capital spending on roadways

The baby boom had an even greater influence on growth of spending on educational buildings. The school-aged population (ages 5 to 24) rose from about 31 percent of the total U.S. population in 1949 to about 37.5 percent in 1971, then fell steadily to less than 29 percent in 1990. Not surprisingly, public educational buildings per person peaked in 1974.(11)

A third factor influencing public capital formation for streets and highways, educational buildings, and other purposes is the prices of capital goods.(12) From the early 1950s to the early 1960s the prices of public capital goods fell relative to the prices of private capital goods. As a result, public capital grew much faster in quantity than private capital goods over the period. Since then, and especially since the late 1960s, the relative price of public capital goods has climbed sharply; not surprisingly, the demand for, and the quantity of, public capital has declined relative to private capital.(13)

Private capital formation decisions also are instructive in the case of highways and streets. Although most highway and street use is not commercially related, proponents of increased infrastructure point to street and highway infrastructure as an important source of private productivity gains. Figure 4 shows highway and street capital per person along with the stock of private trucks, trailers, and buses, the principal commercial users of highways and streets. Were highway and street infrastructure geared solely to serving those commercial interests, one indication of a shortage of highway capital could be a rise in private capital for road use without a corresponding rise in the stock of roads. In fact, however, the level of commercial capital demand does not suggest that highway capacity has constrained commercial road use. Trucking and bus capital per person showed little growth from 1974 to 1983 and subsequently rose only little. Like other public-vs.-private capital comparisons, developments in public highway and street capital formation appear to reflect, to a degree, the same pattern as related private-sector developments.

Figure 4  
Business Trucks, Trailers, and Buses per Person and Highways and Streets per Person  
(Graph Omitted)

Two of the three factors depressing public capital formation began to reverse in the 1980s. First, the price of gasoline generally declined after 1980, falling dramatically in 1986, which boosted road travel. As a result, the decline in highway and street capital per person has slowed (as was also the case for trucks and buses, according to Figure 4). Second, the growth of the school-aged portion of the population had nearly bottomed out as well. Not surprisingly, school districts all over the nation responded to the baby boomlet in the mid-1980s by building new schools. As a result of those two factors, from 1984 to 1991, the stock of highways and streets and educational buildings per person declined at a rate of 0.3 percent, much less than

the 1.5 percent rate of decline from 1975 to 1984.

In fact, the lower price of gasoline and the size of the school-aged population have contributed to a resumption of growth in the overall stock of public capital per person since 1984. During the period of decline, 1975 to 1984, the total stock rose at only a 1.1 percent rate, so the per capita total public stock fell at a 0.5 percent rate. From 1984 to 1991, the growth of total public capital stock accelerated to a 1.7 percent rate, and that of per capita stock rose to a 0.7 percent rate. If an infrastructure crisis existed, as measured by declining public capital per person, it ended in 1984.

**Federal Infrastructure Spending Is Crowded Out at the State and Local Level**

While the federal government plays a minor role in decisions concerning the acquisition of public capital and manages relatively little of the stock, it does play a role in financing part of state and local government capital formation. Nevertheless, it is difficult to see a federal financing role as contributing to the past state and local slowing. Federal transfer payments to state and local governments rose from less than 1 percent of the nation's gross domestic product (GDP) in the period 1947-56 to a peak of about 3.5 percent of GDP in 1975-78.(14) The share of public capital investment in GDP peaked at about 3.5 percent from 1966 to 1968 and then declined to near 2 percent in 1984. Thus, the share of public investment had been declining sharply for nearly a decade before federal transfers peaked in 1978. Indeed, most of the decline in the share of public investment in GDP occurred before the share of federal grants to state and local governments peaked. The share of public investment showed a further slight decline from 1978 to its 1984 level of about 2 percent of GDP, and then it rose to about 2.2 percent of GDP from 1985 through 1991.

Federal transfer payments to state and local governments ballooned during the Bush administration years, rising from 2.2 percent of GDP in fiscal year 1989 to 3.0 percent in FY92. In dollar amounts, those expenditures rose from \$116 billion in FY89 to \$169.3 billion in FY92 (a 45.9 percent increase). Those years showed a sharp rise in federal infrastructure outlays. Table 2 shows that, over the period 1989 to 1993, total federal infrastructure outlays expanded by 32 percent.(15) Indeed, in 1991 Congress passed a \$150-billion highway reauthorization bill, the most expensive public works legislation in U.S. history. Had the increase in transfer payments simply kept pace with the growth in GDP, they would have climbed to only \$131.5 billion. Despite the \$37.8-billion extra boost in funds available to state and local government, public-sector investment as a share of GDP did not change. Hence, the overall boost in funds from the federal government was fully offset by reduced funding at the state and local level.

Table 2 Growth of Federal Infrastructure Spending, 1989-93 (Billions of Dollars)			
	1989	1993	Increase
Airports	\$1.3	\$1.8	38%
Environmental protection	6.0	6.9	15%
Highways	15.6	18.5	19
Housing and urban development	16.5	25.0	52
Prisons	1.8	2.3	28
Transit	3.1	3.8	23
Total	44.3	58.3	32

Such a substitution in funding is not unusual.(16) Earlier attempts by the federal government to boost state and local

employment by providing subsidies for new employees failed and were abandoned because of such funding substitutions. State and local governments, in effect, used federal funds for new employees who would have been hired anyway and also switched existing employees to new programs covered by the federal subsidies. Moreover, according to the Congressional Budget Office, local capital spending (in 1984 dollars) for wastewater treatment peaked at \$5 billion in 1972, the year before federal grants were made available. As federal Environmental Protection Agency wastewater grants increased, real local capital spending on wastewater treatment fell to \$1 billion annually.<sup>(17)</sup> The experience showed that it is difficult to ensure that targeted assistance, whether for job creation or public capital formation, will result in net increases in outlays for those activities. New federal funding for state and local government capital spending is likely to be consumed by projects that would have been undertaken in any case. State and local governments would then use the savings those federal grants generate to finance current operating expenses.

### **Infrastructure Spending and Productivity**

The principal damage done by the alleged infrastructure crisis is said to be the stagnation of private-sector productivity, which began at nearly the same time public capital formation slowed. Statistical estimates by David Alan Aschauer of Bates College and by Alicia Munnell at the Federal Reserve Bank of Boston indicate that the public capital stock has an unusually large effect on private-sector output, given the use of fixed amounts of private-sector resources.

Those estimates have been widely criticized as implausible because of their sheer magnitude. As Henry J. Aaron notes, Aschauer's estimates imply a real rate of return to public capital "of about five times that of private capital."<sup>(18)</sup> Moving a dollar of private investment spending to public investment would boost output by about \$1.15 per year. Closer inspection reveals that the estimates arise from an elementary statistical fallacy called "spurious regression." In this case, the result is a slight twist on the familiar fact that if two wholly unrelated measures or series have similar time trends, they can exhibit a statistically significant relationship when none, in fact, exists.

Consider a more extreme example of the spurious regression problem. After World War II, hours worked per employee in the U.S. business sector declined about 17 percent by the end of the 1980s, as workers took part of their real income gains in increased leisure. A statistical analysis of the relationship of the level of business output and the level of hours per worker indicates that there is a statistically significant negative relationship between those two measures. That suggests that the nation can raise its output by cutting the average weekly hours worked, certainly a desirable outcome that, if correct, would be readily agreeable to workers and their employers. An analysis of the growth rates, however, indicates that those two measures are actually strongly and statistically significantly positively related, not negatively so. Of course, that would be expected if workers were efficiently employed. Such an extreme case of a spurious result is easily detected, without sophisticated statistical diagnostic work. For example, simply accounting for a possible trend in their relationship, or for strongly related errors in the estimated relationship, reveals the correct positive sign. Not all examples are so easy, however.

Another example concerns the relation of money to the level of prices or of money growth to inflation. Some analysts have borrowed from the theoretically expected positive relation to study the relation of a broad measure of monetary assets, called M2, and prices. They find that there is a significant link in levels, or in growth rates, suggesting that control of M2 would control the level of prices. In fact, even the growth of M2 and inflation do not have the statistical properties necessary for such a conclusion. Like the trend case, M2 growth and inflation are not statistically related when the data are appropriately differenced or tests of a long-run relationship are conducted. Of course, such a breakdown does not occur for the growth of the M1 measure of the money stock and inflation.

Figure 5 shows business-sector output per worker and the public capital stock per worker to illustrate the problem. Private productivity and the stock of infrastructure (per private-sector worker in this case) both showed relatively strong upward trends from the late 1940s to the early 1970s. Then each trend declined. From 1948 to the early 1980s, each series has a "broken trend" with the "break" occurring near the same point in time, which gives an even stronger appearance that the two series are related. Supporters of the infrastructure crisis thesis conclude that if productivity growth and capital spending declined together, they will rise together; hence, increased capital spending will boost economic growth.

Figure 5  
Output per Worker and Public Capital Stock per Worker  
(Graph Omitted)

After 1982, however, evidence is considerably weaker. Indeed, private productivity accelerated sharply, rising at a 1.9 percent annual rate from 1982 to 1987; the stock of public capital per worker, however, actually decreased more sharply, falling at a 1.3 percent annual rate from 1982 to 1989, down from a 0.2 percent rate of decline from 1971 to 1982.<sup>(19)</sup> Moreover, beginning in 1989, public capital per worker rose, climbing at a 2.4 percent rate until 1991, while private productivity actually fell at a 0.4 percent rate over the same two-year period. Thus, the two measures were strongly negatively related from 1982 to 1991. In 1992 both measures rose.

Well-known statistical methods can assess whether the spurious regression problem is present and can remove its influence on statistical results. In some cases, such as those that show a significant public capital stock effect, simply "first-differencing" the data is sufficient to eliminate the problem. That means that the effect is estimated using data on changes (growth rates) in private-sector productivity and in public capital stock, along with growth rates of other factors influencing the level of private-sector productivity. When that is done, however, the estimated effect of public capital formation on private-sector productivity growth declines substantially, but more important, the effect is not statistically different from zero at conventionally acceptable confidence levels.

The problem is easily verified by observing that the level of business output per worker and of public capital per worker are strongly and positively correlated from 1947 to 1992; the correlation coefficient is 0.95, consistent with a strong, but potentially spurious, relationship. The correlation between the growth rates of the two series is not statistically significant, however consistent with the spurious relation. The correlation coefficient for the growth rates is nearly zero (0.06). Thus, even simple correlation analysis illustrates the rejection of the hypothesis that a rise (or fall) in the amount of public capital per worker raises (or lowers) business-sector productivity.

Other evidence suggests that private productivity and the stock of public capital per worker are positively related, however. For example, Robert Eisner has noted that regions with relatively high productivity have relatively more infrastructure. He suggests that that reflects an effect of income on the demand for and quantity of public capital.<sup>(20)</sup>

A simple statistical test of whether higher productivity causes more public-sector capital formation, or the reverse is true, is to examine "Granger causality." Such a Granger causality test is described in more detail in the appendix.<sup>(21)</sup> Because correlation does not necessarily imply causality, the purpose of the test is not really to discover what is causing what. Instead, it examines whether there are statistically significant temporal sequences between one development and another. Thus, for example, the test might help answer the question, does rain cause umbrellas to open or do open umbrellas cause rain? It is possible, in principle, for each measure to "cause" the other, for neither to "cause" the other, or for only one measure to "cause" the other.

The test's results indicate that neither the growth rate of the public capital stock nor the level of public-sector investment "causes" total factor productivity growth. On the contrary, the growth of private-sector productivity "causes" both measures of public capital formation--the direction of influence expected by Eisner and precisely the opposite of that expected by proponents of the infrastructure crisis theory.

One of the advantages of that approach is that it explicitly looks for statistically significant relationships between public capital formation and subsequent private-sector productivity growth, and the reverse, between productivity growth and subsequent changes in public capital formation. However, it finds only the reverse relationship to be statistically significant. That is, economic growth causes more infrastructure spending, but more infrastructure spending does not cause more economic growth.

### **Does the Public Want More Infrastructure Spending?**

Despite the attention devoted to the infrastructure problem, evidence on public opinion does not support the view that an infrastructure crisis exists; apparently, proponents of that view have aroused public concern, but they have not been successful in convincing voters of the existence of such a crisis. While, to some extent, people should be expected to complain about the inevitable inadequacy of the services that are freely offered by public capital, the evidence is not

strong that alleviating the inadequacy is a major priority. A 1992 Wall Street Journal/NBC News poll indicated that increased spending on infrastructure, such as transportation and communication systems, ranked last among four possibilities for the "most important aspect of the Clinton economic program." (22) Only 13 percent of respondents chose infrastructure spending as most important, while 41 percent chose reducing the deficit, 22 percent chose tax cuts for the middle class, and 19 percent chose business tax breaks to encourage investment.

Another indicator of public opinion is voter behavior. In the November 1992 elections, voters approved 62 percent of \$11.7 billion in bond issues on their ballots. (23) Although that percentage is relatively high (and much higher than in several previous years), one would expect that more such spending would have been favored if respondents had perceived a crisis. Californians, for example, rejected a \$1-billion issue for upgrading the state's rail system; Seattle voters rejected \$695 million in school bonds; Oregonians rejected a \$250-million issue for parks and a \$200-million issue for land acquisition; and New Yorkers rejected an \$800-million program to create more jobs to repair sewers, roads, and other infrastructure. Taxpayers are discriminating, however. Californians approved \$900 million in statewide school bonds, and Angelenos passed a \$1.5-billion issue to upgrade the sewer system. San Franciscans approved \$350 million for earthquake safety measures but disapproved \$158 million for prison renovations. Those recent votes clearly illustrate the fact that infrastructure decisions are often made directly by the populace or by a level of government very close to the voters who are the ones who directly benefit from and pay for public capital changes. In sum, there is little reason to believe that voters are getting less public capital goods than they desire.

## **Conclusion**

The purported infrastructure crisis is largely a myth that has distorted the public discussion of the role and determinants of public capital formation. President Clinton and other supporters of the infrastructure crisis theory seem more intent on rebuilding government spending than on "rebuilding America." (24) Although public capital formation slowed in the 1970s, the slowing was concentrated in two components: highways and streets and educational buildings. Those components were hard hit by demographic and energy price changes that reduced the demand for those goods.

The slowdown in public capital formation was concentrated at the state and local levels. The federal government provides little of the nation's infrastructure, and the per capita stock of federal nonmilitary capital has changed little since 1947. Moreover, the trend reversed direction in the mid-1980s. The stock of public capital per person has grown steadily since 1984.

The greatest cause for alarm raised by the publicists for the infrastructure crisis is their claim that crumbling infrastructure has reduced the nation's productivity, its standard of living, and its economic competitiveness. But the statistical basis for those claims is seriously flawed. When the flaws are corrected, there is no evidence that an increase in public capital raises private productivity. There are reasons the two are related, but the relationship is one of demand and indicates that faster productivity growth boosts voters' desire for, or at least purchases of, infrastructure investment.

The mythical infrastructure crisis has diverted national attention from real economic challenges. Decisions about public capital investment are made largely at the state and local level by voters who receive the benefits and pay the cost of such decisions or by their representatives who share in the costs and benefits and are more closely accountable for their decisions than are federal decisionmakers. Thus, it is difficult to conceive how voters' demands for public capital could have been ignored over the past 20 years or, perhaps more precisely, over the 1975-84 period.

The drive for more infrastructure spending may be based on good intentions, but it will, nonetheless, lead us down the road to bigger government and less money for private capital investment. Ultimately that trade-off will make America poorer.

## **Appendix: Public Capital Formation and Private-Sector Productivity Growth--Some Causality Evidence**

Many researchers have noted that regions of the United States and countries that have relatively high income and productivity have relatively more public capital per worker and per person. Such an observation suggests that infrastructure boosts private-sector productivity, but others view that observation as simply confirmation that higher income voters normally demand more of all goods, including the services of public capital stocks. As noted in the body

of this analysis, estimates of private-sector production functions, when appropriately derived, indicate that no statistically significant positive relationship exists between the nation's public capital stock and private-sector productivity. It is conceivable, however, that the effect of public capital formation on productivity occurs with some time lag, so that the estimates of production function do not take a long enough perspective.

A standard method for assessing whether there is a causal linkage between one factor and another is to test for "Granger causality." Such a test investigates whether a statistically significant link relates changes in one of two variables to past changes in the other. A significant temporal sequence from a change in one variable to a subsequent change in another is referred to as Granger causality.

If an increase in public capital leads to a subsequent change in productivity growth, then public capital would be said to cause productivity; if an increase in productivity leads to a subsequent change in public capital formation, then productivity causes public capital. It is possible for causality to be "bidirectional," in which case statistically significant relationships exist from each measure to the other. Causality can involve negative or positive relationships between the two measures, but the two hypotheses examined here involve positive ones. An advantage of the testing framework is that it explicitly examines whether lagged or past information is systemically important (i.e., statistically significant) for one measure or the other. That is especially important for the infrastructure debate because it is possible that public capital only boosts productivity over time, rather than immediately. Causality tests explicitly look for such lagged relationships.

To test for Granger causality, as many as four lags of public capital productivity growth were examined for any statistically significant impact on formation and on the other measure. A conventional 5 percent significance level was used for the tests. Public capital formation is either measured as the continuously compounded growth rate, the change in the logarithm of the constant-dollar net nonmilitary public capital stock ( $\_1\text{NPK}$ ), or as the pace of public capital investment (LPI), the logarithm of the constant-dollar (1987) flow of public capital investment. Productivity (TFP) is measured here by business-sector total factor productivity, which is output divided by a weighted average of labor and private capital services employed in the business sector. Both the productivity and the public capital data are prepared by the U.S. Department of Commerce. The data used are for the period 1948 to 1990, the latest year available, for TFP and 1948 to 1991 for public capital.

The lagged value of each variable is added to the best time series equation for the other variable. For total factor productivity growth ( $\_1\text{NTPF}$ ), no lags of productivity growth are statistically significant when considered alone. When lags of  $\_1\text{NPK}$  or LPI are included on the righthand side, the closest statistical significance (7.8 percent) for any lag is found with only one lag of LPI for the period 1949 to 1990:

$$\_1\text{NTPF}_t = 0.094 - 0.019 \text{ LPI}_{t-1} \quad (1)$$

(2.11) (-1.81)

—

$R^2 = 0.05$  S.E. = 1.93% D.W. = 1.79

The numbers in parentheses are t-statistics; the summary statistics are  $R^2$ , standard error of estimate (S.E.), and Durbin-Watson statistics (D.W.). In this estimate, public investment has a negative, but statistically insignificant, relationship to total factor productivity growth.<sup>(25)</sup> Thus, there is no evidence that public capital formation causes the growth of total factor productivity.

The best time series model for the growth of public capital relates it to three past values of itself. When lags of productivity growth are added to this model, two lags are statistically significant:

$$\_1\text{NPK}_t = 0.001 + 1.057 \_1\text{NPK}_{t-1} + 0.109 \_1\text{NPK}_{t-2}$$

(1.11) (7.31) (0.48)

$$- 0.266 \text{ _lnPKt-3} + 0.059 \text{ _lnTFPt-1} + 0.060 \text{ _lnTFPt-2} \quad (2)$$

$$(-2.19) \quad (2.59) \quad (2.73)$$

—

$$R^2 = 0.97 \quad \text{S.E.} = 0.24\% \quad \text{D.W.} = 1.85$$

The estimate indicates that total factor productivity growth in the business sector causes public capital formation; moreover, the statistically significant relationship between productivity growth and public capital formation is positive, as expected.

When public capital investment is related to its own past values, it is found to depend upon two lags of itself. Two lags of total factor productivity growth are statistically significant when added to the public capital investment equation.(26) For the period 1951 to 1991, the estimate is as follows:

$$\text{LPI}_t = 0.173 + 1.169 \text{ LPI}_{t-1} - 0.209 \text{ LPI}_{t-2}$$

$$(1.42) \quad (8.15) \quad (-1.54)$$

$$+ 0.893 \text{ _lnTFPt-1} + 0.732 \text{ _lnTFPt-2} \quad (3)$$

$$(2.58) \quad (2.17)$$

—

$$R^2 = 0.972 \quad \text{S.E.} = 3.78\% \quad \text{D.W.} = 1.98$$

Thus, total factor productivity growth causes public capital formation, according to this estimate as well as to Equation 2.

The Granger causality tests are consistent with production function estimates in that they reject the hypothesis that public capital formation raises business-sector productivity. Such evidence is especially important because it explicitly allows for a lagged relationship of up to several years for the effect of public capital, yet it finds no such relationship. The tests do confirm, however, that there is a statistically significant causal relation between public capital and private productivity; it is a reverse causality relationship, however. That is, a rise in total factor productivity has a positive and statistically significant causal relationship to public capital formation.

## Notes

[1] The most influential proponents include Professor David Alan Aschauer, who developed the argument in two articles in the *Journal of Monetary Economics* in 1989. Subsequently, Alicia H. Munnell of the Federal Reserve Bank of Boston, now assistant secretary of the Treasury for economic policy, published supporting evidence in the January-February 1990 *New England Economic Review*; the bank also sponsored a conference on the infrastructure crisis in the summer of 1990. Another proponent, Secretary of Labor Robert Reich, outlined his argument for the existence of an infrastructure crisis in "The REAL Economy," *Atlantic*, February 1991, pp. 35-52. Studying the effects of infrastructure on private-sector performance has become the latest growth industry in economics as conferences and dissertations on the subject have multiplied. At least seven papers presented at the American Economic Association's annual meetings in January 1993 addressed the subject.

[2] This article draws heavily upon the author's earlier work: "Should Government Spending on Capital Goods Be Raised?" *Federal Reserve Bank of St. Louis Review*, March-April 1991, pp. 3-15; "Public Capital and Private Sector Performance," *Review*, May-June 1991, pp. 3-15; "Is the Infrastructure Crisis a Myth?" *Construction Business Review*, March-April 1993, pp. 62-65; and from his testimony, "A Perspective on the National Infrastructure Crisis" before the Congressional Commission to Promote Investment in America's Infrastructure, November 19, 1992.

[3] A May 1992 study by the Congressional Budget Office, *Trends in Public Infrastructure Outlays and the President's*

Proposals for Infrastructure Spending in 1993, defined "infrastructure" to include highways, mass transit, rail, aviation, water transportation, water supply, and wastewater treatment facilities. The study indicated that other areas could also be considered infrastructure, however.

[4] The most important infrastructure, the defense establishment, is neglected here, as it is in the popular discussion. National defense capital expenditures climbed sharply from the late 1970s through the late 1980s.

[5] Edward L. Hudgins and Ronald D. Utt, *How Privatization Can Solve America's Infrastructure Crisis* (Washington: Heritage Foundation, 1992).

[6] A common criticism of U.S. infrastructure policy is that major foreign competitors have more infrastructure than the United States. The criticism ignores the relatively large U.S. private-sector holdings of what abroad is held by the public sector, especially in transportation, communications, and heating and lighting.

[7] A built-in bias favors overinvestment in public capital facilities in the United States. The bias occurs because the public sector is not taxed on the return or benefits from public capital formation as the private sector is on the benefits from private-sector capital formation. More important, public capital formation is often financed by the sale of tax-free bonds, which means that those projects face a taxpayer-subsidized, lower cost of capital than does private capital formation. As a result, public decision makers tend to invest in projects with benefits that are worth less than their cost to taxpayers. In that sense, the nation "overinvests" in public capital.

[8] Bruce Seely suggested that a comparison with the earlier infrastructure trend, especially that of the 1960s and early 1970s, overstates the decline. In particular, he referred to the earlier period as the "golden age of infrastructure development in the United States." He cited the creation of the U.S. Department of Transportation (1968) and of the Environmental Protection Agency (1969) and the passage of three new laws, the Solid Waste Disposal Act of 1965, the Urban Mass Transit Act of 1970, and the Water Pollution Control Act of 1972, as the sources of the boom. See Seely, "A Republic Bound Together," *Wilson Quarterly* (Winter 1993): 19-39, especially 37-39.

[9] Heywood T. Saunders has suggested that it is a popular myth that there is a "pervasive national problem that requires a solution at the federal level." Saunders, "What Infrastructure in Crisis?" *Public Interest* (Winter 1993): 7.

(10) The collection of public-sector physical plant and equipment that typically is referred to as infrastructure includes a broad range of capital goods that are only loosely thought of as infrastructure and are not related to activities that are typically the special functions of government.

(11) The subsequent decline in educational buildings per person was smaller in the public sector than in the private sector.

(12) Seely gave another reason for the end of a "golden age of infrastructure development." He argued that Americans "lost faith in experts" and began to seriously criticize the direct effects and side effects of infrastructure development, including population displacement, urban sprawl, suburban congestion, and environmental change.

(13) Tatom, "Should Government Spending on Capital Goods Be Raised?" pp. 12-14.

(14) Federal grants to state and local governments include funding for other programs besides capital outlays. Indeed, such grants are nearly four times as large as federal grants for state and local government spending on infrastructure capital. About 60 percent of federal infrastructure spending occurs through such grants.

(15) Stephen Moore, "Clintonomics Test Run Record," *Washington Times*, December 17, 1992; and idem, "Crisis? What Crisis? George Bush's Never-Ending Domestic Budget Build-Up," *Cato Institute Policy Analysis* no. 173, June 19, 1992.

(16) The Congressional Budget Office provided strong evidence of such substitutability in the June 1986 study, *Federal Policies for Infrastructure Management*. Also see the September 1988 study, *New Directions for the Nation's Public Works*, and Randall W. Eberts, "Public Infrastructure and Regional Economic Development," *Federal Reserve Bank of*

Cleveland Economic Review (Quarter 1, 1990): 15-27, for discussion of this phenomenon.

(17) Congressional Budget Office, Efficient Investment in Wastewater Treatment Plants, June 1985, pp. 4-5.

(18) See Henry J. Aaron, "Discussion," in Is There a Short fall in Public Capital Investment? ed. Alicia H. Munnell, Federal Reserve Bank of Boston Conference Series no. 34, p. 54.

(19) Although the capital stock per person rebounded after 1984, the capital stock per worker did not begin to rise until later. That reflected the faster growth of the labor force than of the total population until the end of 1988. (20)20. See Robert Eisner, "Infrastructure and Regional Economic Performance: Comment," New England Economic Review (September-October 1991): 47-58.

(21) The tests use annual data (1949 to 1991) on the public capital stock or public-sector investment and on the private sector's total factor productivity (as measured by the Bureau of Labor Statistics). Total factor productivity is output per unit of a weighted-average bundle of both private capital and labor resources.

(22) See Wall Street Journal, December 18, 1992, p. A6.

(23) See Anne Newman, "Voters Give Their Approval to 62% of \$11.7 Billion in State, Local Bonds," Wall Street Journal, November 5, 1992, p. C12.

(24) "Rebuild America" is the label chosen by the Clinton campaign for its infrastructure investment program in Bill Clinton and Al Gore, Putting People First (New York: Times Books, 1992), pp. 9-11, 143-45. The theme continued in the administration's A Vision of Change for America (Washington: Government Printing Office, 1993).

(25) When lags of the growth of the public capital stock are tested, the Durbin-Watson statistics have relatively low values, which suggests autocorrelation of the error terms. The tests of those lags include a correction for first-order autocorrelation.

(26) The second lag of public capital investment becomes statistically insignificant in this case. Omitting it has no effect on the statistical significance or sign of the two lagged productivity growth terms. The overall descriptive statistics are not altered appreciably either.