March 1, 1995

ECONOMIC COMMENTARY

Federal Reserve Bank of Cleveland

Is Public Capital Productive? A Review of the Evidence

by Kevin J. Lansing

Many analysts and policymakers are calling for increased infrastructure spending to help spur output and productivity in the U.S. economy. However, economic research provides conflicting evidence on the magnitude of public capital's productive effect. While certain aspects of the data suggest that expanding infrastructure investment would boost private output, it is unclear just how large the effect would be or whether the economic benefits would outweigh the attendant costs.

In recent years, analysts and policymakers have voiced concern that public investment in the United States may be too low. In response, the Clinton administration's original economic strategy emphasized a plan to expand investment in public infrastructure.[1] Now, however, the Republican-controlled Congress is looking for ways to achieve a balanced budget by the year 2002. When the budget ax falls, will infrastructure programs be among those targeted for cuts? In making such decisions, policymakers need to consider the evidence regarding the productive effects of public capital on the U.S. economy.

What Is Public Investment?

Before examining the relationship between public capital and private-sector production, it is necessary to define what is meant by public investment. Investment can be defined as the expenditure of current resources to produce some future benefit. In contrast, consumption expenditures yield immediate benefits. By these definitions, we would classify public investment as any type of government outlay that provides economic benefits beyond the current budget cycle.

Although it is often difficult to quantify the benefits of government programs, there are basically three types of public outlays that can clearly be labeled as investment: physical infrastructure programs, human capital programs, and government-funded research and development (R&D). Infrastructure programs support the stock of physical public capital, such as transportation and environmental facilities. Human capital programs are aimed at increasing the skills and productive knowledge that people bring to their jobs. And government-funded R&D helps to expand the body of basic knowledge that drives technological progress. This wealth of knowledge can be viewed as the nation's stock of intangible capital.

The Rationale for Public Investment

There are various ways of rationalizing public investment programs. The standard "public good" argument states that the government should provide goods and services that would otherwise be underproduced by the private sector. For example, a private road-building firm may undertake too little highway construction because it fails to consider the economic benefits that accrue to communities outside the immediate vicinity of the road. Such logic has also been used to argue that highway construction should be funded at the federal government level, as opposed to leaving these decisions to state or local governments.

Another rationale is that the government has an advantage over individual firms in its ability to manage the risk associated with certain types of investment. The high-risk nature of R&D projects, for example, may cause private firms to devote fewer resources to this activity than is socially desirable. Finally, public investment programs may be rationalized as a means of achieving various social goals. Job training, for instance, can be viewed as a way to help reduce income inequality, since it improves the prospects of higher-paying jobs for the poor.

The Role of Public Capital in Production

While all three categories of public investment are quantitatively significant in the U.S. economy, this article will focus on the productive effects of physical public capital.[2] In the United States, the stock of physical public capital is about one-third the size of the private capital stock. The "core" infrastructure, which represents the largest single component

of public capital, consists of streets, highways, bridges, airports, transit systems, public utilities, and the like. State and local governments own about two-thirds of public capital, while the federal government owns the stock of military capital, which represents about one-fifth of the total. The collective governments maintain and expand the stock of public capital with expenditures financed by taxes and borrowing.

There are straightforward reasons for believing that public capital is important to private production. Our interstate freeway system, for instance, has dramatically reduced travel time for cars and trucks, speeding the delivery of raw materials and finished goods and allowing workers to pursue employment opportunities farther from home. While in this example public capital acts as a complement to private resources, it can also act as a substitute. For example, public investment might "crowd out" private investment if firms rely on public capital for productive purposes rather than expanding their own capacity. Empirical research can help us determine which effect dominates and whether the effect is large enough to justify an expansion of public infrastructure investment.

■ Long-run Trends in Public Investment and Public Capital

During the 23-year period from 1947 to 1969, nonmilitary public investment in the United States averaged 3.5 percent of GNP. From 1970 to 1992, however, the corresponding figure was only 2.5 percent, a decline of nearly one-third. In contrast, private investment as a share of GNP rose from an average of 19.9 percent to 23.0 percent over the same intervals. These trends are further highlighted in figures 1 and 2, which plot the ratios of public to private investment and public to private capital. Both series have tended to decrease over time, leading some to conclude that the United States is currently underinvesting in public capital.[3]

■ Public Capital and the U.S. Productivity Slowdown

Between 1947 and 1969, U.S. labor productivity (defined as real GNP divided by total labor hours) grew at an average rate of about 2.7 percent per year. From 1970 to 1992, that rate dropped to less than 1 percent per year. A substantial body of economic research has been directed at identifying the cause of this so-called productivity slowdown. The primary evidence for what we will call the public capital hypothesis can be seen in figure 3, which plots U.S. labor productivity versus the stock of public capital per labor hour. The downturn in the growth rate of U.S. productivity that began in the early 1970s coincides with a similar decrease in the growth rate of public capital. Further evidence for this theory can be found in cross-country data, which show that differences in the rate of productivity growth across the G-7 countries can be partly explained by differences in infrastructure spending (see Aschauer [1989b]).[4] It is important to note, however, that this evidence does not prove the existence of a causal link running from public capital to productivity. Indeed, some researchers argue precisely the reverse—that the U.S. productivity slowdown is responsible for the decline in public capital growth. Such reverse causation might occur, for example, because a slower-growing economy

FIGURE 1 RATIO OF PUBLIC TO PRIVATE INVESTMENT

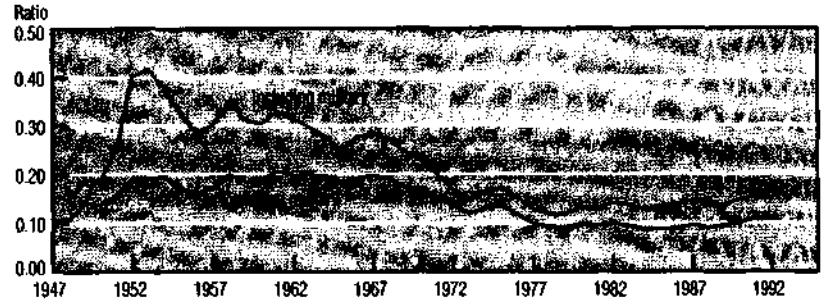


FIGURE 2 RATIO OF PUBLIC TO PRIVATE CAPITAL

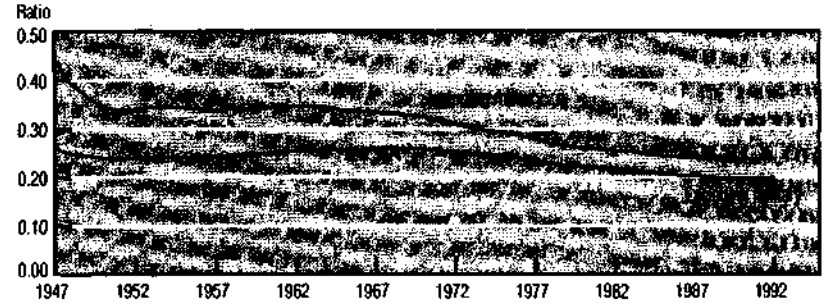
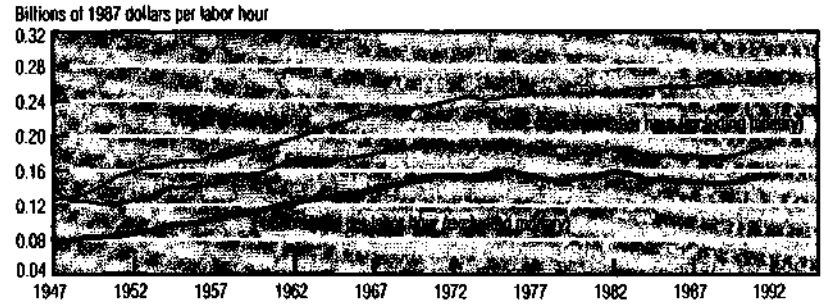


FIGURE 3 LABOR PRODUCTIVITY VS. PUBLIC CAPITAL



NOTE: The public capital and public investment series include government-owned equipment, structures, and residential components. The private capital and private investment series include privately owned fixed components (equipment and structures), consumer durables, and residential components.

SOURCES: The capital and investment series are in 1987 dollars and are from *Fixed Reproducible Tangible Wealth in the United States,* U.S. Department of Commerce, 1993. Output is real GNP in 1987 dollars from Citibase. Labor hours are from the LHOURS series in Citibase, which is based on household survey data.

does not generate enough per capita income and tax revenue to fund public investment projects adequately.

The decline in public capital growth is just one of the many explanations for the U.S. productivity slowdown. Alternative theories include 1) a return to "normal" productivity growth from the unsustainably high growth rates experienced after the Great Depression and World War II, 2) changes in demographic factors that have tended to reduce the quality of the labor force, 3) a falloff in the rate of R&D spending, 4) an increase in the cost of complying with government regulations (such as mandated pollution controls), and 5) higher energy costs due to oil price shocks. While many of the alternative explanations are intuitively appealing and can be supported by certain aspects of the data, proponents of the public capital hypothesis tend to view them as piecemeal in nature or theoretically or statistically flawed.[5]

■ The Rate of Return on Public versus Private Investment

One way of gauging the productive effects of public capital is to estimate its rate of return in terms of increasing the level of private output in the U.S. economy. This rate measures the "bang for the buck" of funds invested in public investment projects, and can be compared to the corresponding figure for private investment projects. After all, an increase in public investment usually means higher taxes or additional government borrowing that may absorb funds which would otherwise be available to the private sector. A government policy of expanding infrastructure investment would be justified if the rate of return on public investment were determined to be substantially higher than that for private investment.

The principle of diminishing marginal returns tells us that as the stock of a particular type of capital increases, the rate of return for investing in that capital declines. For example, construction of a second Golden Gate Bridge would yield far fewer benefits to the San Francisco economy than did the original. Hence, the total size of the public capital stock plays a role in determining the rate of return on any additional investments. The return rate also depends on what is known as the "output elasticity" of public capital. Output elasticity measures the impact that a given resource input (such as public capital, private capital, or labor) has on final output (real GNP). For example, an output elasticity of 0.10 for public capital implies that a 1 percent increase in the stock of public capital would boost real GNP by 0.10 percent. The actual output elasticity must be estimated using data on output and resource inputs. For a given resource, a larger elasticity or a smaller input size will result in a higher rate of return.[6]

■ The Empirical Evidence

In recent years, numerous empirical studies have attempted to estimate the output elasticity of public capital. The results, which vary widely, are sensitive to the statistical techniques employed, the sample period, and whether the data are at national, state, regional, or industry level. Table 1 summarizes the results of some empirical studies which conclude that public capital has a statistically significant effect on private output in the U.S. economy. Finer breakdowns of the data tend to imply smaller estimates for public capital's output elasticity. This might be expected from a theoretical standpoint, because the benefits derived from many infrastructure projects, such as highways, are not confined to a narrowly defined geographic area. With finer breakdowns, this "spillover effect" may not be fully captured in the data.

The output elasticities estimated by Aschauer (1989a) and Munnell (1990a) at the national level (0.39 and 0.34, respectively) are the highest reported in the literature. In both cases, the estimated output elasticity of private capital is about 0.3. These estimates imply that the rate of return on public investment is about three times higher than the corresponding private return.[7] Taken seriously, these numbers suggest that tremendous gains can be had by expanding public investment. However, there are good reasons for viewing the results with skepticism.

First, the elasticity estimates in table 1 are based on aggregate data. Thus, they do not contain much information about the output effects of specific public investment projects. For example, the construction of a concrete sound barrier along a stretch of highway would be classified as an expansion of public infrastructure. Once completed, however, we would not expect the barrier to contribute much to private-sector production, as does a road or bridge. Decisions regarding actual investment spending should be guided by an examination of the costs and benefits of individual projects. Barro (1992) points out that cost-benefit analyses applied to individual public investment projects do not support the claims of extraordinary rates of return.

Second, elasticity estimates are sensitive to the use of alternative statistical techniques for dealing with issues like trends in the data or omitted explanatory variables. For example, Aschauer and Munnell employ aggregate time series data in which the behavior of variables is dominated by trends. The productivity and public capital series both experienced a sharp change in trend in the early 1970s (see figure 3). This coincident shift is responsible for the large elasticities estimated by these researchers. Thus, we should be cautious about drawing policy conclusions from their results because the numbers are largely driven by what amounts to a single observation. Ideally, we need to observe multiple trend shifts to determine whether the perceived relationship between productivity and public capital holds up.

Aaron (1990) and Tatom (1991) show that removing the effects of the trends and taking account of possible missing explanatory variables (such as oil price shocks) can lead one to conclude that the best estimate for the output elasticity of public capital is zero. Holtz-Eakin (1993) and Hulten and Schwab (1993) reach a similar conclusion by factoring in the possibility of missing variables that help explain output differences among states or regions.

Flores de Frutos and Pereira (1993) further add to the controversy by claiming that public capital can have a substantial effect on private output even though the empirically measured value of public

TABLE 1 SOME EMPIRICAL ESTIMATES OF PUBLIC CAPITAL'S OUTPUT ELASTICITY

Author(s)	Type of Public Capital	Data Sample	Output Elasticity
National-Level Studies			
Aschauer (1989a)	Nonmilitary, nonresidential	1949–85	0.39
Munnell (1990a)	Nonmilitary, nonresidential	1949–87	0.34
Finn (1993)	Highways and streets	1950–89	0.16
State-Level Studies			
Munnell (1990b)	Nonmilitary, nonresidential	48 states, 1970–86	0.15
Costa, Ellson, and Martin (1987)	Nonmilitary, nonresidential	48 states, 1972 only	0.20
Garcia-Milà and McGuire (1992)	Highways and streets	48 states, 1970–83	0.045
Regional Studies			
Eberts (1986)	Core infrastructure	38 MSAs,[a] 1958–78	0.04

a. Metropolitan statistical areas.

capital's output elasticity is zero. The intuition for this seemingly contradictory statement is that public capital can be viewed as impacting the economy's production process in two different ways. First, public capital may enter the production process as a direct input, analogous to labor and private capital. This so-called direct effect is what is being measured by the empirical studies cited above. Second, public capital may indirectly affect output by increasing the productivity of private-sector capital and labor. Thus, the output effects of public capital may be subsumed into the measured output elasticities of the private inputs.[8]

To summarize, while the majority of empirical studies conclude that public capital has at least some productive effect, the results seem to vary widely depending on the choice of research method. Thus, we should be wary of using these results to justify policies favoring the expansion of infrastructure investment.

The Optimal Level of Public Investment

What can economic theory tell us about the "optimal" level of public investment? One way of assessing optimality is to construct an economic model in which the government makes spending and financing decisions to maximize the welfare of the average citizen. Using such a model in a previous study (Lansing [1994]), I find that if public capital's output elasticity (at the national level) is 0.08, then the optimal level of public investment is approximately 4 percent of GNP. If the output elasticity is 0.34 (as estimated by Munnell [1990a]), then the optimal level of public investment is nearly *20 percent* of GNP.

From these calculations, we can see that any conclusions regarding the need to expand public investment are highly sensitive to estimates of the critical output elasticity. Given the imprecise nature of the estimates, it is entirely possible that a policy of expanding public investment is not called for, and could even reduce economic welfare (since the extra spending must be financed by higher current or future taxes).

Conclusion

The controversy surrounding the productive effects of public capital is far from settled. Economic intuition and certain aspects of the data suggest that expanding infrastructure investment would have a positive impact on private output. However, it is not clear from the empirical studies just how large the effect would be or whether the economic benefits of additional government spending would justify the economic costs of higher taxes or the increased borrowing necessary to finance the projects. In any case, it is not likely that a policy of expanding infrastructure investment will produce a miraculous acceleration in productivity growth.

Footnotes

1. See *Economic Report of the President 1994*, U.S. Government Printing Office, p. 30.

2. For an analysis of the economic effects of human capital and R&D investment, see "How Federal Spending for Infrastructure and Other Public Investments Affects the Economy," Congressional Budget Office Study, July 1991. For an examination of the productive effects of public R&D investment at the industry level, see Nadiri and Mamuneas (1994).

3. See *Economic Report of the President 1994*, U.S. Government Printing Office, p. 43.

4. The G-7 countries are Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.

5. For a more detailed discussion of the alternative hypotheses, see Munnell (1990a), Tatom (1991), Aschauer (1993), and the references cited therein.

6. The rate of return on a resource input can be computed using the following formula: Rate of return = (output elasticity of the input) × (real GNP) ÷ (size of the input). The rate of return is also referred to as the "marginal product" of the input.

7. Using the formula in footnote 6, this return ratio can be computed very simply by combining the two measures of output elasticity with our knowledge that the public capital stock is about one-third the size of the private capital stock.

8. For additional discussion and critiques of the empirical evidence, see Munnell (1992) and Aschauer (1993).

The Federal Reserve Bank of Cleveland and the *Journal of Money, Credit and Banking* announce:

Derivatives and Intermediation

November 2–3, 1995
Cleveland, Ohio

The Federal Reserve Bank of Cleveland and the *Journal of Money, Credit and Banking* are jointly sponsoring a conference on Derivatives and Intermediation: Theory and Evidence.

The growing derivatives market poses several challenges for policymakers. The first is to understand the sources of financial innovation resulting in the proliferation of these products. What economic forces make derivatives viable instruments? What gains do rational participants obtain from these contracts, and why do they dominate transactions in the cash securities markets? To what extent does regulatory policy—bankruptcy rules, capital requirements, accounting rules, and deposit insurance—affect the market? In other words, does derivative-related financial innovation stem from changes in the marketplace or from changes in the regulatory environment? The answer is crucial to understanding both derivatives and intermediation. The second challenge for policymakers is to understand how derivatives impact regulatory concerns in the areas of bank risk, payments system reform, and intermediary powers.

Call for Papers

The conference proceedings will be published in the *Journal of Money, Credit and Banking*, and authors will receive an honorarium. Prospective contributors are invited to send a completed paper or detailed abstract by May 30, 1995 to:

Joseph G. Haubrich
Research Department
Federal Reserve Bank of Cleveland
P.O. Box 6387
Cleveland, OH 44101–1387

Federal Reserve Bank of Cleveland
Research Department
P.O. Box 6387
Cleveland, OH 44101

Address Correction Requested:
Please send corrected mailing label to the above address.

BULK RATE
U.S. Postage Paid
Cleveland, OH
Permit No. 385

March 1, 1995

ECONOMIC COMMENTARY
Federal Reserve Bank of Cleveland

Is Public Capital Productive? A Review of the Evidence

by Kevin J. Lansing

In recent years, analysts and policymakers have voiced concern that public investment in the United States may be too low. In response, the Clinton administration's original economic strategy emphasized a plan to expand investment in public infrastructure.[1] Now, however, the Republican-controlled Congress is looking for ways to achieve a balanced budget by the year 2002. When the budget ax falls, will infrastructure programs be among those targeted for cuts? In making such decisions, policymakers need to consider the evidence regarding the productive effects of public capital on the U.S. economy.

What Is Public Investment?

Before examining the relationship between public capital and private-sector production, it is necessary to define what is meant by public investment. Investment can be defined as the expenditure of current resources to produce some future benefit. In contrast, consumption expenditures yield immediate benefits. By these definitions, we would classify public investment as any type of government outlay that provides economic benefits beyond the current budget cycle.

Although it is often difficult to quantify the benefits of government programs, there are basically three types of public outlays that can clearly be labeled as investment: physical infrastructure programs, human capital programs, and government-funded research and development (R&D). Infrastructure programs support the stock of physical public capital, such as transportation and environmental facilities. Human capital programs are aimed at increasing the skills and productive knowledge that people bring to their jobs. And government-funded R&D helps to expand the body of basic knowledge that drives technological progress. This wealth of knowledge can be viewed as the nation's stock of intangible capital.

The Rationale for Public Investment

There are various ways of rationalizing public investment programs. The standard "public good" argument states that the government should provide goods and services that would otherwise be underproduced by the private sector. For example, a private road-building firm may undertake too little highway construction because it fails to consider the economic benefits that accrue to communities outside the immediate vicinity of the road. Such logic has also been used to argue that highway construction should be funded at the federal government level, as opposed to leaving these decisions to state or local governments.

Another rationale is that the government has an advantage over individual firms in its ability to manage the risk associated with certain types of investment. The high-risk nature of R&D projects, for example, may cause private firms to

Many analysts and policymakers are calling for increased infrastructure spending to help spur output and productivity in the U.S. economy. However, economic research provides conflicting evidence on the magnitude of public capital's productive effect. While certain aspects of the data suggest that expanding infrastructure investment would boost private output, it is unclear just how large the effect would be or whether the economic benefits would outweigh the attendant costs.

divert fewer resources to this activity than is socially desirable. Finally, public investment programs may be rationalized as a means of achieving various social goals. Job training, for instance, can be viewed as a way to help reduce income inequality, since it improves the prospect of higher-paying jobs for the poor.

The Role of Public Capital in Production

While all three categories of public investment are quantitatively significant in the U.S. economy, this article will focus on the productive effects of physical public capital.[2] In the United States, the stock of physical public capital is about one-third the size of the private capital stock. The "core" infrastructure, which represents the largest single component