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# Public Infrastructure and Regional Economic Development

by Randall W. Eberts

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## Introduction

Recent attention given to the serious deterioration of the nation's public infrastructure raises the question of whether public capital significantly affects economic development. Local policymakers and researchers concerned with regional issues have claimed for years that public infrastructure investment is one of the primary means to implement a strategy of regional growth. In fact, one of the ways local governments compete for new firms is through investing in various types of public facilities.

Yet, very little is known about even the most basic relationships between public and private investment, such as the propensity to substitute between public and private capital, the relative timing of public and private investment, and the effect of public investment on firm and household decisions, to mention a few. Recent research by Aschauer (1989) and Munnell (1990) reports a positive correlation between public infrastructure and productivity aggregated to the national level. However, this research has not identified empirically the linkages by which public infrastructure affects productivity by addressing questions such as the ones posed above. From a research standpoint, one of the benefits of examining the effect of infrastructure at the regional level as opposed to the national level is that the linkages between physical infrastructure and those that use it are more direct when the analysis focuses on smaller geographical areas.

The purpose of this paper is to summarize previous work that has examined the effect of public infrastructure on various types of economic activity at the state and local levels. Section I defines public infrastructure and discusses various ways to measure it that are useful for analytical purposes. Section II examines the effects of public infrastructure on regional growth by first reviewing regional growth theory and then presenting empirical evidence of this relationship. Section III raises the issue of whether the observed effect of public infrastructure on regional growth results from its effect on productivity or from its effect on factors of production. The subsequent discussion focuses on public infrastructure as an input into the firm's production process. Section IV briefly examines the effect of public infrastructure on household location decisions. Finally, the "causation" of public and private investment is discussed in section V. The paper concludes with an overall assessment of the relationship between public infrastructure and regional growth.

## I. Definition and Measurement of Public Infrastructure

### Definition

This paper focuses on the public works component of public infrastructure. This category includes roads, streets, bridges, water treatment and distribution systems, irrigation, waterways, airports, and mass transit—installations and facilities that are basic to the growth and functioning of an economy. The term public infrastructure includes a range of investments broader than public works investment. To distinguish between the various functions of different types of infrastructure, several definitions and classifications are used throughout the literature.

For example, Hansen (1965), in looking at the role of public investment in economic development, divides public infrastructure into two categories: economic overhead capital (EOC) and social overhead capital (SOC). EOC is oriented primarily toward the direct support of productive activities or toward the movement of economic goods and includes most of the public works projects listed above. SOC is designed to enhance human capital and consists of social services such as education, public health facilities, fire and police protection, and homes for the aged.

Other classifications of public infrastructure include investments by the private sector. Mera (1973), examining the economic effects of public infrastructure in Japan, extends Hansen's definition of EOC to include communication systems, railroads, and pollution-abatement equipment. Mera also expands the SOC list of investments to include administrative systems. In some studies, the term infrastructure also includes the spatial concentration of specific sets of economic activities, similar to what urban and regional economists refer to as agglomeration economies.

Common to all of these classifications of public infrastructure are two characteristics that distinguish them from other types of investment. First, public infrastructure provides the basic foundation for economic activity. Second, it generates positive spillovers; that is, its social benefits far exceed what any individual would be willing to pay for its services. These positive spillovers occur for at least three reasons. First, some components of public infrastructure, such as roads and waterways, are nonexcludable services. Users can share these facilities up to a point without decreasing the benefits received by other users. Second, some infrastructure investments, exemplified by water treatment facilities and pollution-abatement equipment, reduce negative externalities (for example, pollution) generated by the private sector. Third, many infrastructure projects, such as power-generating facilities, communication networks, sewer systems, and highways, exhibit economies of scale. Because the large costs of these investments can be spread among many users, the unit cost of production continually falls as more users gain access to the system.

For the purposes of this paper, the scope of public infrastructure is limited to public works investment. Public works projects, in addition to exhibiting many of the public infrastructure characteristics listed above, are also under direct government control and thus can be effective public policy instruments in promoting economic development.

### Measurement

One reason for the lack of empirical work on the effect of public infrastructure on economic development is the paucity of consistent and accurate measures of infrastructure that are suitable for empirical analysis. Unlike measures of private input usage in manufacturing, there are no reliable and consistent government sources of information on public infrastructure, particularly for individual states and metropolitan areas.

Two basic approaches have been suggested for measuring public infrastructure. One method is to measure physical capital in monetary terms by adding up past investment. An alternative approach is to use physical measures by taking inventory of the quantity and quality of all pertinent structures and facilities. Each approach has its advantages and disadvantages.

The standard method of measuring private capital stock is to use the monetary approach, often referred to as the perpetual inventory technique. The measure of capital under this method is the sum of the value of past capital purchases adjusted for depreciation and discard. Two assumptions are essential in using this scheme. First, the purchase price of a unit of capital, which is used to weight each unit of capital, reflects the discounted value of its present and future marginal products. Second, a constant proportion of investment in each period is used to replace old capital (depreciation). The first assumption is met if a perfectly competitive capital market exists. The second assumption is fulfilled if accurate estimates of the asset's average service life, discard rate, and depreciation function are available.

**TABLE 1**

**Levels of Public Capital Stock per Capita and Rankings by Total Public Capital Stock for 40 Selected SMSAs in 1985**

| SMSA | Capital Stock per Capita | Ranking by Total Capital Stock |
|---|---|---|
| New York City | $1,216.0 | 1 |
| Buffalo | 871.7 | 18 |
| San Francisco | 871.5 | 4 |
| Seattle | 858.7 | 12 |
| Memphis | 842.4 | 23 |
| Milwaukee | 823.9 | 15 |
| Cleveland | 762.8 | 13 |
| Los Angeles | 753.0 | 3 |
| Baltimore | 716.6 | 7 |
| Detroit | 714.6 | 5 |
| Pittsburgh | 713.7 | 10 |
| Minneapolis | 687.1 | 11 |
| Rochester | 663.8 | 26 |
| Chicago | 661.7 | 4 |
| Kansas City | 649.6 | 20 |
| Cincinnati | 613.4 | 22 |
| Jersey City | 610.1 | 34 |
| New Orleans | 592.3 | 24 |
| Philadelphia | 584.0 | 6 |
| Portland | 563.1 | 20 |
| Atlanta | 561.9 | 14 |
| Akron | 552.6 | 33 |
| Louisville | 546.4 | 29 |
| Newark | 529.4 | 17 |
| Dayton | 517.2 | 30 |
| Toledo | 500.9 | 31 |
| Grand Rapids | 493.5 | 36 |
| Denver | 492.7 | 19 |
| Indianapolis | 485.1 | 27 |
| Richmond | 484.1 | 35 |
| Columbus | 475.4 | 28 |
| Youngstown | 467.4 | 37 |
| Houston | 467.0 | 9 |
| Dallas | 446.3 | 8 |
| Birmingham | 443.2 | 32 |
| St. Louis | 443.0 | 16 |
| San Diego | 406.4 | 21 |
| Reading | 376.1 | 39 |
| Canton | 330.2 | 38 |
| Erie | 322.7 | 40 |

NOTE: Size and rankings of total public capital stock are measured in 1967 dollars.
SOURCE: Author's calculations.

A frequent criticism of the perpetual inventory approach for public capital stock is that the government is not subject to competitive markets, and public goods are not allocated through a price mechanism. In some cases, user charges such as gasoline taxes finance local public infrastructure investment, but this reflects average costs more than marginal costs.

A considerable portion of the analysis related to economic development is based on a neoclassical production function in which inputs are used up to the point where the value of their marginal product is equal to their cost of use. In such a context, current input capital should be measured as the maximum potential flow of services available from the measured stock. Such a measure of capital can be constructed with the perpetual inventory technique by using a depreciation function that reflects the decline in the asset's ability to produce as much output as when it was originally purchased. This approach is used by the Bureau of Economic Analysis (BEA) for national-level estimates of both private and government assets and in many national and regional studies of total factor productivity.

This approach has been used recently by Eberts, Fogarty, and Garofalo (see Eberts, Dalenberg, and Park [1986] for details) to construct estimates of five functional types of public infrastructure for 40 metropolitan areas from 1958 to 1985. Public outlays for each city since 1904 were obtained from *City Finances* and other U.S. Bureau of the Census publications, and were aggregated using average asset lives, depreciation, and discard functions used by the BEA and other sources to obtain capital stock measures. The size and rankings of total public capital stock for each standard metropolitan statistical area (SMSA) in 1985 (measured in 1967 dollars) are presented in table 1 as an illustration of the estimates such a method would yield. The per capita estimates of public capital stock reveal a wide variation across SMSAs in the amount of capital invested and presumably in the amount of infrastructure services offered within these areas. In addition, the growth rates of public and private capital stock for the 40 SMSAs are shown in table 2. These estimates illustrate the general slowdown in public capital stock accumulation. The notable exceptions to this trend are in the faster-growing regions of the country.

Capital stock estimates have also been constructed for other levels of aggregation. Costa, Ellson, and Martin (1987) use similar techniques to construct public capital stock for states, although with a much shorter time period. Boskin, Robinson, and Huber (1987) estimate capital

**TABLE 2**

**Percentage Change in Public Capital for Selected SMSAs, 1955-1985**

| SMSA | 1955-1965 | 1965-1975 | 1975-1985 |
|---|---|---|---|
| New York City | 22.5 | 13.0 | -4.4 |
| Los Angeles | 31.1 | 15.9 | 1.6 |
| Chicago | 22.3 | 8.5 | 5.1 |
| San Francisco | 34.7 | 29.5 | 8.8 |
| Detroit | 14.8 | 13.6 | 1.0 |
| Philadelphia | 12.9 | 11.4 | 0.5 |
| Baltimore | 19.7 | 25.0 | 17.6 |
| Dallas | 10.2 | 35.9 | 46.7 |
| Houston | 51.4 | 40.6 | 63.9 |
| Pittsburgh | -2.0 | -3.9 | -1.8 |
| Minneapolis | 33.5 | 35.3 | 22.2 |
| Seattle | 10.4 | 22.1 | 8.7 |
| Cleveland | 10.3 | 7.5 | 0.8 |
| Atlanta | 44.7 | 59.3 | 68.0 |
| Milwaukee | 31.8 | 16.9 | 4.9 |
| St. Louis | 9.7 | 5.5 | 1.5 |
| Newark | 11.9 | 2.1 | -3.4 |
| Buffalo | 21.1 | 9.8 | 10.3 |
| Denver | 27.5 | 37.1 | 47.0 |
| Kansas City | 10.3 | 21.9 | 13.1 |
| San Diego | 89.2 | 31.7 | 27.3 |
| Cincinnati | 5.9 | 9.2 | 2.6 |
| Memphis | 54.2 | 35.9 | 9.0 |
| New Orleans | 44.3 | 15.5 | 6.4 |
| Portland | 9.0 | 20.4 | 21.0 |
| Rochester | 10.3 | 18.8 | 2.7 |
| Indianapolis | 26.4 | 24.6 | 14.0 |
| Columbus | 17.9 | 25.2 | 15.2 |
| Louisville | 33.2 | 23.4 | 2.9 |
| Dayton | 27.6 | 20.8 | 10.0 |
| Toledo | 4.8 | 8.8 | 4.9 |
| Birmingham | 11.1 | 25.0 | 10.8 |
| Akron | 15.6 | 15.7 | 8.2 |
| Jersey City | 14.9 | -9.9 | -10.2 |
| Richmond | 9.8 | 24.5 | 15.1 |
| Grand Rapids | 3.0 | 23.5 | 28.9 |
| Youngstown | 28.8 | -2.8 | -7.4 |
| Canton | 2.2 | 7.2 | 8.2 |
| Reading | -5.1 | 7.7 | 6.8 |
| Erie | 0.5 | 1.9 | -8.9 |

NOTE: SMSAs are listed from largest to smallest public capital stock.
SOURCE: Author's calculations.

stock series aggregated across all state and local governments, to critique the BEA's methodology in constructing its state and local public capital stock series aggregated to the national level.

Leven, Legler, and Shapiro (1970) advocate using physical measures of public infrastructure to avoid problems related to the use of prices in the monetary approach. In order to account for differences in capacity and quality, as the price and depreciation measures do to some extent in the first method, they propose to collect information on the physical characteristics of these assets that reflect capacity and quality. In the case of highways, for example, they cite a study that converts physical characteristics of highways to estimates of the traffic flow capacity.

Although their approach avoids the issue of asset prices, there are problems with this approach as well. One issue is the monumental task of collecting adequate measures of the physical size and quality of each type of public infrastructure. For the private sector, it would be virtually impossible because of the diverse types of capital in use. For the public sector, the task is somewhat less formidable because public capital, as Leven, Legler, and Shapiro suggest, can be classified into a few dozen basic types.

Another issue is how to enter these various measures into a regression analysis that relates public infrastructure to economic activity. Entering more than a half dozen public infrastructure measures simultaneously into a regression equation would introduce a number of estimation problems, including multicollinearity. Furthermore, how would one interpret the separate effects of miles of roads versus cargo capacity of ports, for example? In addition, it may prove useful at some point to construct broader classifications of infrastructure, for example combining roads, highways, and bridges into a transportation network, which would be difficult to do under this approach. Also, it would be more convenient in regression analysis to have quality differences incorporated within a single measure. Both requests would require some type of aggregation scheme, perhaps more arbitrary than using prices or user costs.

One alternative is to develop a hybrid approach. The monetary estimates of public capital could be benchmarked by using the physical quantity and quality measures of public infrastructure. This approach would improve the accuracy of comparisons across metropolitan areas and over time by essentially adjusting the price of capital for differences in quality and quantity.

## II. Public Infrastructure and Regional Economic Development

Economic development depends primarily on locational advantage, whether it is between cities, states, or countries. Firms seek areas that offer greater opportunities for economic profit. Public infrastructure can enhance these opportunities either by increasing productivity or by reducing factor costs; that is, by augmenting the efficiency of private inputs employed by firms or by providing an attractive environment within which households are willing to accept lower wages in order to reside.

### Regional Models

Regional and national economic growth depends on processes that are more complex than simply the aggregation of independent decisions of firms and households. The decisions of economic agents are inextricably intertwined, and this interdependency must be taken into account in order to explain the process of development. The traditional, neoclassical view of regional development ignores this interdependence and relies heavily on the notion that capital is perfectly mobile between regions. As described by Romans (1965), capital tends to flow toward those regions offering the highest price and away from regions offering the lowest price, maintaining at all times an equilibrium of price equality after subtracting transport costs. The price of capital is determined by supply and demand. The supply in a region continually adjusts via imports and exports to changes in regional demand so as to maintain interregional price equality.

Richardson (1973) and other regional economists dismiss this framework as too simplistic. Instead, they maintain that regional investment decisions are characterized by the durability of capital, the sequential and interdependent nature of spatial investment decisions, the importance of indivisibilities in the regional economy, spatial frictions on interregional capital flows, and the distinction between private-sector capital and public infrastructure. The interdependence between public-sector investment and private-sector investment is paramount to understanding the regional development process and for prescribing regional economic development policy.

Leven, Legler, and Shapiro (1970) provide a simple picture of the feedback relationships between public and private investment decisions. Their model recognizes that an important share of the regional capital stock consists of social and public capital and that the scale and spatial distribution of public capital may have a significant impact on subsequent private investment decisions and on the location decisions made by firms and households. Since the initial size and distribution of the public capital stock is at least partly predetermined by the prior spatial distribution of households and economic activities in the region, an interdependent system emerges.

Once growth in such a system is under way, the process can easily become self-sustaining and cumulative. However, if the initial population and level of activity are small, and their spatial distribution costly and inefficient, a region may remain in a low-level equilibrium trap (Murphy, Shleifer, and Vishny [1989]). In such a case, attempts to promote regional growth may need the exogenous injection of public and social capital expenditures to generate an expansion rather than merely as a response to changes in the level and spatial distribution of population and economic activity. The difficulty with this approach, as Richardson points out, is that we know very little about the generative impact of various types of public infrastructure on private investment decisions. Furthermore, we know little about the effect of a region's economic conditions on infrastructure's contribution to output.

Hansen (1965) theorizes that the potential effectiveness of economic overhead capital will vary across three broad categories of regions: congested, intermediate, and lagging. Congested regions are characterized by very high concentrations of population, industrial and commercial activities, and public infrastructure. Any marginal social benefits that might accrue from further investment would be outweighed by the marginal social costs of pollution and congestion resulting from increased economic activity. Intermediate regions are characterized by an environment conducive to further activity—an abundance of well-trained labor, cheap power, and raw materials. Here, increased economic activity resulting from infrastructure investment would lead to marginal social benefits exceeding marginal social costs. Lagging regions are characterized by a low standard of living due to small-scale agriculture or stagnant or declining industries. The economic situation offers little attraction to firms, and public infrastructure investment would have little impact.

A number of policy implications emerge from this regional growth theory. The most obvious policy conclusion is that subsidies for infrastructure investment are more likely to pay off in the long run than investment incentives to firms and other subsidies to private capital. Furthermore, following Hansen (1965) and Hirschman (1958), the main task of infrastructure subsidies for underdeveloped areas is to generate the minimum critical size of urbanization that can serve as a core for economic development. For these lagging regions, however, infrastructure may not be enough to attract firms; additional means such as wage subsidies may be necessary. Finally, a major outcome of a spatial approach to regional growth analysis is the need for more coordination between government agencies at all levels and for the integration of all infrastructure decisions in an overall regional development strategy.

Before the wisdom of such policies can be assessed, a number of questions must be answered. For example, how do we identify the mechanisms by which infrastructure investment generates regional growth? What types of infrastructure investment are crucial for promoting regional growth? Partial answers are found in the literature.

## Empirical Findings

A direct test of Hansen's hypotheses about the effects of public infrastructure on regional development is provided by Looney and Frederiksen (1981). Unfortunately from the perspective of U.S. policy, they examine economic development in Mexico. Their findings support Hansen's intuition, however: economic overhead capital has a significant effect on gross domestic product for intermediate regions but not for lagging regions; social overhead capital exhibits the opposite effect, as Hansen predicted.

Costa et al. (1987) support Hansen's hypothesis of differential impacts of infrastructure on regional growth using U.S. data. They find that the larger the stock of public capital relative to private capital within a state, and the larger the stock of public capital per capita, the smaller the impact of public capital stock on manufacturing production. Eberts (1986) also finds regional differentials in the effectiveness of public capital on manufacturing output. He reports that public capital was more effective in SMSAs in the South than in the North and in SMSAs with a lower amount of public capital relative to private capital and labor.

Duffy-Deno and Eberts (1989), examining 28 metropolitan areas from 1980 through 1984, find that public capital stock has positive and statistically significant effects on per capita personal income. The effects come through two channels: first, through the actual construction of the public capital stock; and second, through public capital stock as an unpaid factor in the production process and a consumption good of households. This second effect is twice as large as the first effect using ordinary least squares (OLS) estimation, but the relative magnitudes of the two effects are roughly reversed using two-stage least squares (2SLS).

Other evidence of the differential effects of public infrastructure among regions comes from analysis of the operation of U.S. federal regional development programs on the growth rates of personal income for different categories of distressed areas. Martin (1979) finds that investment in public capital yields few gains for low-income areas, but that business development and planning/technical assistance are more effective in high-unemployment areas.

Mera (1975) provides one of the most comprehensive analyses of the effect of public infrastructure on regional economic growth for the United States. He hypothesizes that the growth of regional economic activity is determined primarily by the growth of public infrastructure and technical progress in the region. The growth of labor and private capital, which are allocated through price differentials, responds to growth differentials in social capital and technical progress. He examines the growth characteristics of the nine U.S. census regions from 1947 to 1963. Mera concludes that more-developed regions are growing because of the growth of public infrastructure, while less-developed regions are growing primarily because of the growth of technology.

Garcia-Mila and McGuire (1987) estimate the contribution of state educational and highway expenditures to gross state product. Using pooled cross-section time-series data from 1970 to 1983, they estimate a Cobb-Douglas production function with these two public inputs along with manufacturing capital stock and production employees as the private inputs. They find that highway capital stock and educational expenditures have a positive and significant effect on gross state product, with educational expenditures having the larger impact.

Other studies support these findings. For example, Helms (1985) shows that government expenditures on highways, local schools, and higher education positively and significantly affect state personal income. A study of the effects of public investment in rural areas by the CONSAD Research Corporation (1969) attempts to assess the effect of public works investment on the growth of real income in 195 small Missouri municipalities. This study finds that public works infrastructure accounted for 30 percent of the gain in real income between 1963 and 1966.

Of the major investment projects considered, federal highways, barge docks, vocational schools, and recreational facilities contributed the most to income growth.

## III. Public Infrastructure and Firms

Is the effect of public infrastructure on regional growth a result of an overall increase in firm-level productivity or an increase in the region's attractiveness to labor and capital? Hulten and Schwab's (1984) research on regional productivity differentials lends some insight into this distinction. They test the hypothesis that the economic decline of the Snowbelt was due to differences in economic efficiency relative to the Sunbelt, by calculating regional differences in total factor productivity (TFP). They find little support for this hypothesis, determining instead that these interregional differences are largely a result of differences in the growth rate of capital and labor. Thus, the implication from these findings is that regional differences in the quality and quantity of public infrastructure may have a greater effect on the migration decisions of factors of production than on productivity differentials.

There is another reason to look at factors of production rather than at Hicks-neutral productivity changes in analyzing the effect of public infrastructure. If public infrastructure is indeed an input (as will be discussed later in this section), then relating public infrastructure to a measure of TFP, which includes only labor and private capital as inputs, may be a misspecification of the relationship. Munnell (1990) raises this issue for explaining TFP at the national level. When public capital is entered into the TFP calculations as a third input, she finds that the variation in TFP over time reflects more a change in public infrastructure than a change in technological innovation.

Very little attention has been given to the technological relationships between public infrastructure and other inputs in a firm's production process. The extant literature addresses this issue primarily from a theoretical standpoint. Three basic questions are considered:

1) How does public infrastructure enter the production process: as a factor-augmenting atmosphere-type input or as an unpaid input?
2) What implications do these two types of public inputs have on the efficient allocation of resources?
3) What effect do public inputs have on a firm's profits, and thus on an area's locational advantage?

### Infrastructure as a Public Input

The basic premise of the theoretical literature is that public infrastructure may increase firm productivity either through increasing the efficiency of private inputs employed by firms or through its own direct contribution to production as an input into the production process. Economists have taken both approaches. Meade's (1952) classification of external economies distinguishes between these two approaches. Meade refers to the first type of public input as the creation of atmosphere. It is analogous to Samuelson's pure public good and is exemplified by free information or technology. In this case, an increase in the level of public inputs results in increased output for all firms through neutral increases in the efficiency with which the private inputs are used. Any firm entering a region immediately benefits from the existing level of public input without affecting the benefits from the public input received by other firms.

In more formal terms, public inputs are considered to enter the production function as factors that augment the productivity of each of the private inputs. If a firm is assumed to operate in a perfectly competitive environment, then each private factor of production receives a payment equal to the value of its contribution to output. Factors, whose productivity has been enhanced by public inputs, receive compensation higher than they would receive in the absence of public inputs. For example, suppose that government-supported research and worker training programs targeted at the electronics industry increase the productivity of labor and capital employed by an electronics firm. Workers and owners of capital receive higher compensation because of increased productivity. However, since the firm's entire revenue has been distributed among the private factors of production, no revenue is left to pay for public inputs. Thus, public inputs will not be supplied without government intervention.

Meade refers to the second type of public input as an unpaid factor. An example is free access roads. This input has private-good characteristics, except that it is not provided through a market process and thus is not paid for on a per-unit basis and does not have a market-determined price. Its private-good characteristics generally result from congestion. In the case of highways, as the number of firms in a region expands, increased use of the highways results in congestion, which effectively reduces the total amount of highway services available to each firm. Thus, from the firm's perspective, the level of public input is fixed, unless the facility is continually underutilized.

Having many characteristics of a private input, the unpaid-factor type of public input is entered into the production process in the same way as private inputs. Unlike the first case, the public input does not augment the productivity of the private inputs. Rather, it contributes independently to the firm's output. Because firms, by definition, do not pay directly for the public input, they initially earn profits or rents according to the value of the marginal product of the public input. It is usually assumed that the rent accrues to some ownership factor such as capital or entrepreneurship. As with a private unpriced input, these profits from the public good will attract other firms into the industry (or area). As additional firms enter the industry, the per-firm usage of the public input declines relative to other inputs. Before and after entry into an industry, capital or the factor collecting the accrued rent is paid the value of its marginal product plus the rent to the unpriced factor. The influx of firms increases the ratio of private inputs to public inputs, causing the marginal product of public inputs to rise relative to private inputs. Local governments, acting as agents for these firms, increase the allocation of public investment relative to the private inputs because of its high marginal productivity. Additional firms move into the region until the rents are dissipated and capital earns a competitive rate of return.

## Optimal Allocation of Public Inputs

The two types of public inputs have different implications concerning the efficient allocation of resources, the level of provision of the public inputs, and the appropriate financing arrangements. For the first case, Samuelson's conditions for the allocation of pure public goods apply. Kaizuka (1965) and Sandmo (1972) show that resources are allocated efficiently when the total savings of all firms brought about by substituting a public input for a single private input are equal to the resource cost of using that private input to produce the public input. However, because of the free-rider problem, government must supply the intermediate input. The revenue necessary for government to provide the service must be raised by some form of taxation or user charges.

Negishi (1973) demonstrates that for a pure public input, an optimal level of public good will be produced if the government supplies a level of public inputs that maximizes the joint net profit of industries. The firm's ability to determine the allocation of public investments is defended by Downs (1957), who argues that a firm's lobbying activities sufficiently influence government decisions. However, when household preferences for public expenditures are represented by majority rule voting, public goods are in general not optimally supplied. Pestieau (1976) shows that only under very restrictive assumptions will majority voting lead to an optimal supply of the public input. In most cases, it will oversupply public inputs.

The same optimality conditions hold for the case of an unpaid factor of production, but the level of provision is different. Negishi shows that for an unpaid factor, the public good most likely will be oversupplied when the government tries to maximize the joint net profit of firms in the long run. He offers the following explanation. Since returns to public goods are imputed to capital in the case of the unpaid factor, capital tends to concentrate excessively in industries that can enjoy more gains from public expenditures than other industries. Unless public goods and capital are perfect substitutes, the capital intensity of the industry raises the productivity of public goods, which implies that more of the public good is required to maximize the industry's profits. Thus, allocation is inefficient even without the additional complication of household preferences and majority rule voting.

## Financing Public Infrastructure

These theoretical results highlight the importance of the total fiscal package, not simply taxes or public investment, in firm location decisions. As previously mentioned, firms with access to public infrastructure earn rents according to the value of the contribution of public infrastructure to production. In the unpaid factor case, a portion of these rents (if not all rents) may be taxed or paid out as user charges in order to finance public infrastructure. The amount of rents remaining with the firm as a result of public unpaid factors depends on the taxing scheme adopted and on properties of the production process or utilization of public inputs.

For any given level of public investment, the amount of rents accruing to firms depends on the sharing arrangements between taxpayers inside and outside a local jurisdiction. For example, if public infrastructure is financed entirely by individuals outside the area (through federal grants, for example), then a firm receives the entire rent, which in turn creates a greater incentive for that firm and others to locate in the area. On the other hand, if the entire burden of financing the public infrastructure investment falls on individuals within the local area, then profits would be much smaller, creating less of an incentive for firms to locate or remain there.

Another arrangement is for households to assume a larger proportion of the financing costs of public investment than warranted by the direct benefits they receive. Some communities pursue this approach through tax moratoriums and lower tax rates for firms, with the idea that the benefits to the community from creating new jobs outweigh the increased burden of financing the investment.

An additional feature of the fiscal package is that taxes need not equal the total rents accruing to firms (and even to households). Benefits from public investment projects characterized by economies of scale and sharing properties will exceed the cost of the project. Since many components of public infrastructure, such as highways and water distribution and treatment facilities, exhibit these properties, it is reasonable to assume that public investment may have a net positive effect on firm productivity and thus on firm location.

## Empirical Findings

A number of basic questions emerge from the theoretical foundations of the relationship between infrastructure and firm-level behavior:

1) How does public capital enter into the production process?
2) What effect does public infrastructure have on a firm's productivity? How does this vary with the type of firm and type of infrastructure?
3) Are private and public capital related as substitutes or complements?
4) What effect does public infrastructure have on firm location decisions?

Only recently have researchers estimated the technical relationships between public infrastructure and other production inputs. Previously, the literature looked primarily at peripheral issues such as the effects of federal programs on economic growth in distressed areas or the effects of various government expenditures on firm location. These are undoubtedly important questions, but their particular focus does not provide much insight into the technical relationships outlined above. Another problem with the earlier studies is that, with the exception of Mera (1973, 1975), they use public expenditures or the number of government employees as proxies for public infrastructure.

More recent studies have tried to address these issues directly by estimating production functions with public capital-stock estimates included as inputs. Eberts (1986) estimates the direct effect of public capital stock on manufacturing output and the technical relationships between public capital and the other production inputs. Public capital stock is estimated using the perpetual inventory technique, described in section I, for each of 38 U.S. metropolitan areas between 1958 and 1978. With this method, capital is measured as the sum of the value of past investments adjusted for depreciation and discard. Public capital stock includes highways, sewage treatment facilities, and water distribution facilities within the SMSA. He estimates a translog production function with value added as output, hours of production and nonproduction workers as the labor input, and a value measure of private manufacturing capital stock as private capital.

Eberts finds that public capital stock makes a positive and statistically significant contribution to manufacturing output, supporting the concept of public capital stock as an unpaid factor of production. Its output elasticity of .03 is small relative to the magnitudes of the other inputs: 0.7 for labor and 0.3 for private capital. It follows that the magnitude of the marginal product of public capital is also relatively small.

The small estimated contribution of public capital may be viewed in two ways. If one considers public capital stock to be a pure public good, then the marginal product of public capital stock reveals the manufacturing sector's valuation of the total stock of public investment in place in the SMSA. If local governments allocate public funds in response to the preferences of the local voters, then the marginal valuation should be equal to their tax share. Thus, it is not unreasonable that a typical firm pays 4 percent of its total value added to local taxes—a value close to the marginal product of public capital.

Another way to interpret the results is to assume that the manufacturing sector uses only a specific portion of the stock. For instance, firms may be spatially concentrated in one area of the metropolitan area and thus intensively use only the roads and sewer systems in that part of the region. If one assumes that the per-unit cost of constructing one unit of private capital is the same as the per-unit cost of constructing one unit of public capital, then the marginal products of the two capital inputs should be equal. Estimates show, however, that the marginal product of private capital is seven times that of the marginal product of public capital. This difference may result from assuming that the manufacturing sector uses the total capital stock instead of some portion of it. If one assumes that the use of the total public capital stock by manufacturing firms is approximately proportional to manufacturing employment's share of the total population, then the use of the public capital stock is overestimated by roughly seven times. Multiplying the marginal product of public capital stock by seven brings it in line with the marginal product of private capital.

With respect to technical relationships, Eberts finds that public capital and private capital are complements, while the private capital/labor pair and the public capital/labor pair are substitutes. Public and private capital are interpreted to be complements when an increase in the level of public capital reduces the price of private capital by increasing its relative abundance. Dalenberg (1987), using the same data as Eberts but estimating a cost function, also finds public capital and private capital to be complements.

Deno (1986) also estimates technical relationships, but uses investment data instead of capital stock data. Using pooled data for U.S. metropolitan areas from 1972 to 1978, he estimates labor and private investment demand equations derived from a Cobb-Douglas production function. He finds that local public investment and private capital are complements. In addition, he finds that a 1 percent increase in public investment is associated with a 0.01 percent increase in net private investment in the short run and a 0.2 percent increase in the long run. Furthermore, he concludes that public investment has a significantly greater positive effect on net private capital formation in distressed cities than in growth cities. In subsequent work, Deno (1988) finds the output elasticities of water, sewer, and highway infrastructure for the full sample of 36 SMSAs are 0.08, 0.30, and 0.31, respectively. These estimates were obtained using a profit function approach for the period 1970 to 1978.

At the state level, Costa et al. (1987) estimate the contribution of public capital stock to manufacturing output by estimating a translog production function. Their analysis differs from that of Eberts in two key ways, in addition to the unit of analysis. First, Costa et al. estimate the production function using cross-sectional data for 1972, while Eberts combines cross-sectional and time series data in his estimation. Second, Costa et al. distribute the BEA estimate of capital among states in proportion to the gross book value of fixed assets at year-end 1971. The private capital stock used by Eberts, on the other hand, is based on the same perpetual inventory technique used to construct the public capital stock.

Costa et al. also find that public capital stock makes a statistically significant contribution to manufacturing output. However, the magnitudes of their public capital elasticities are higher than what Eberts found, which may be partly explained by their inclusion of more categories of public investment. Another difference between the results of these studies is that Costa et al. find private and public capital to be substitutes and public capital and labor to be complements, while Eberts and Deno find the opposite. One explanation for the difference may be in the calculation of these relationships. Costa et al. use the log form of the production function to derive the cross-partial derivative, while Eberts converts back to the original production relationship to compute the technical relationships.

Mera (1973) estimates the technical relationships between various types of infrastructure and other inputs for Japan. Using pooled data of nine regions in 10 years from 1954 to 1963, he estimates a Cobb-Douglas production function for each of three major economic sectors and four types of infrastructure. He reports the following findings: (1) when the infrastructure variable is entered as a separate factor of production, its production elasticity ranges from 0.1 to 0.5, most frequently around 0.2; (2) the transportation and communication infrastructure appears to have a sizable effect on mining, manufacturing, and construction; (3) in most cases, the rates of return from infrastructure are similar to those of private capital; but (4) the elasticity of substitution between private capital and infrastructure is undetermined in this study.

Studies of the determinants of firm location usually concentrate more on the effect of taxes than on the effect of expenditures on location decisions. However, those studies that have included various measures of public infrastructure have found that certain forms of infrastructure are attractive to firms. Some of the strongest results were reported by Fox and Murray (1988), who found that the presence of interstate highway systems had a positive and highly significant effect on the location of individual establishments in the state of Tennessee. Bartik (1985), using a national sample, also found that the number of new branch plants was higher within states with more miles of roads. Eberts (1990) offers evidence that public infrastructure positively affects the number of firm openings in metropolitan areas.

## IV. Public Infrastructure and Households

Public infrastructure may also affect the migration decisions of households by enhancing the area's amenities. However, the existing literature related to household location decisions does not focus much on public infrastructure. Labor migration studies tend to concentrate primarily on demographic characteristics and wage differentials to explain migration flows. Urban quality-of-life comparisons, which deal with the same underlying decision process, come closer to addressing this issue, but their major focus is on attributes such as air quality, climate, and so forth.

One exception is the migration study by Fox, Herzog, and Schlottmann (1989). They estimate the effect of local fiscal expenditures and revenue on household decisions to migrate across metropolitan areas. Using Public Use Microdata Samples, which record a household's place of residence in 1975 and 1980, they determine that fiscal variables are more important factors in pushing people from an area than in attracting them toward one. They explain this result in terms of information. Information on fiscal structure is more readily available in an area where a person has been living than for areas under consideration as migration destinations.

## V. "Causal" Relationships Between Public and Private Investment

Most of the studies that address the stimulative effect of public investment presume that public investment "causes" or precedes private capital. Yet, scant attention has been given to testing this relationship. Eberts and Fogarty (1987) explore the causal relationship between public and private investment. Their premise, following the cumulative model of regional growth, is that the timing of investment indicates the role of public investment in promoting local economic development. If public investment precedes private investment, then it would appear that local areas actively use public outlays as instruments to direct local development. On the other hand, if the sequence of events occurs in the opposite direction, it would appear that local officials merely respond to private investment decisions.

Using data on public capital outlays and manufacturing investment from 1904 to 1978 for 40 U.S. cities, Eberts and Fogarty find a significant causal relationship between public outlays and private investment in 33 of the 40 metropolitan areas examined. The direction of causation goes both ways. Private investment is more likely to influence public outlays in cities located in the South and in cities that have experienced tremendous growth after 1950. Public outlays are more likely to influence private investment in cities that experienced much of their growth before 1950.

Looney and Frederiksen (1981), in their study of Mexico, support the findings of Eberts and Fogarty for older U.S. cities—that public investment appears to be the initiating factor in the development process, rather than a passive or accommodating factor. They do not attempt to determine whether causal directions differ across types of regions, however.

## VI. Overall Assessment

The importance of public infrastructure in promoting economic development has been widely recognized among policymakers. Economists have only recently begun to assess the effects of infrastructure on regional economic development beyond simply a stimulus of construction activity. The consensus among economists is that public infrastructure stimulates economic activity, either by augmenting the productivity of private inputs or through its direct contribution to output. Furthermore, by enhancing a region's amenities, public infrastructure may also attract households and firms, which further contributes to an area's growth.

Results show that public capital stock significantly affects economic activity. The magnitudes of the effects for public capital are much less than for private capital, however. Results also show, with some exception, that public capital and private capital are complements, not substitutes. This relationship may be interpreted to mean that the existence of public infrastructure is a necessary precondition for economic growth.

Evidence suggests that the effect of public infrastructure on regional development depends on the type of investment and on the economic conditions of the region. Studies of Japan and Mexico, in particular, show that investment in communications and transportation appears to have the most significant impact on regional growth. In the United States, public investment appears to have a greater effect on economic activity in distressed cities than in growth cities, in Sunbelt cities than in Northern cities, and in those areas with less public capital stock relative to private capital and population.

The critical question is at what point, if any, does an additional increase in public infrastructure cease to have any effect on economic development? Alder (1965) sums up the effect of transportation on economic development: "It is frequently assumed that all transport improvements stimulate economic growth. The sad truth is that some do, and some do not...." In a broader context, it can be concluded that some types of infrastructure investment will have significant effects, while others will not.

Many local and state governments in the United States are faced with the monumental task of replacing and upgrading their present public capital stock. But the challenge is more than simply maintaining existing structures. The challenge facing these governments is to meet the future infrastructure needs of a U.S. economy that is undergoing dramatic changes with the restructuring of both manufacturing and service industries and the spatial redistribution of these activities. Innovations in areas such as telecommunications and computer automation, to mention only two, are changing the way businesses operate, and infrastructure investment must adapt to this changing technology. Results from studies reported in this paper underline the importance of maintaining, improving, and expanding public capital stock in order to support future economic growth.

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