http://clevelandfed.org/research/workpaper
Best available copy

FEDERAL RESERVE BANK - CLEVELAND
90005610

BOOKCARD
LIBRARY OF THE FEDERAL RESERVE BANK OF CLEVELAND

Working Paper 8610

ESTIMATING THE CONTRIBUTION OF URBAN PUBLIC INFRASTRUCTURE TO REGIONAL GROWTH

By Randall W. Eberts

Randall W. Eberts is an assistant vice president and economist at the Federal Reserve Bank of Cleveland. The author gratefully acknowledges the invaluable assistance of Douglas Dalenberg and Chul Soo Park in constructing the public capital stock series. The National Science Foundation funded the estimation of the public capital stock. Paul Bauer and Joe Stone offered helpful comments and suggestions.

Working papers of the Federal Reserve Bank of Cleveland are preliminary materials circulated to stimulate discussion and critical comment. The views stated herein are the author's and not necessarily those of the Federal Reserve Bank of Cleveland or of the Board of Governors of the Federal Reserve System.

December 1986

http://clevelandfed.org/research/workpaper
Best available copy

BOOKCARD
LIBRARY OF THE FEDERAL
RESERVE BANK OF CLEVELAND

ESTIMATING THE CONTRIBUTION OF URBAN PUBLIC INFRASTRUCTURE TO REGIONAL GROWTH

I. Introduction

The question of whether or not public capital stock significantly affects private sector output and productivity growth remains unanswered and virtually untested. Although this relationship is central to a number of issues of current interest, it has not been possible to estimate directly the effect of public capital stock on economic activity.

The problem lies primarily with the lack of comprehensive estimates of public infrastructure that are appropriate for performing time-series and cross-sectional analysis. To begin to fill this gap, we have estimated components of public capital stock for 38 metropolitan areas from 1958 to 1981 using the perpetual inventory method. This paper reports the first attempt to use these series to estimate the effect of public capital stock on regional manufacturing production. Public capital stock is entered as an input into a translog production function. Estimates of marginal productivities, elasticities, and returns to scale provide information about the effect of public capital stock on output and about the technical relationships between inputs.

II. Background

Current views of regional growth theory stress,the interdependent nature of spatial investment decisions, spatial frictions on inter-

http://clevelandfed.org/research/workpaper
Best available copy

gional capital and labor flows, and the distinction between private ctor capital and public sector capital. Local public capital stock can fect economic activity through various channels. It can indirectly fect economic activity by influencing the location decisions of useholds and firms. The addition of new firms and households into a gion may, in turn, increase the region's agglomeration economies, which ads to even greater growth potential. It can directly influence output d productivity by entering a firm's production process as an unpaid ctor.

Most empirical studies of the effect of public infrastructure on economic development have estimated its indirect effects by relating various asures of public capital to measures of regional economic development. ra (1975) provides the most comprehensive test of the effect of public frastructure on regional economic growth for the U.S. He hypothesizes at the growth of regional economic activity is determined primarily by e growth of public infrastructure and technical progress in the gion. Interregional flows of labor and private capital respond to reonal differences in social capital and technical progress as well as ice differentials. He examines the growth characteristics of the nine S. census regions from 1947 to 1963 and concludes that more-developed gions are growing because of the growth of public infrastructure, while ss-developed regions are growing primarily because of the growth of chnology.

Hansen (1965) focuses on the potential effectiveness of public infraructure across three broad categories of regions: congested, interdiate, and lagging. Congested regions are characterized by a very high ncentration of population, industrial and commercial activities, and

http://clevelandfed.org/research/workpaper
Best available copy

public infrastructure. Any marginal social benefits that might accrue from further investment would be outweighed by the marginal social costs of pollution and congestion due to increased economic activity in the area. Intermediate regions are characterized by an environment conducive to further activity--an abundance of well-trained labor, cheap power, and raw materials. In this area, 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 industry. The economic situation offers little attraction to firms, and public infrastructure investment would have little impact.

A direct test of Hansen's hypotheses is provided by Looney and Frederiksen (1981). Looking at economic development in Mexico, their findings support Hansen's intuition: economic overhead capital has a significant effect on gross domestic product (GDP) for intermediate regions, but not for lagging regions; social overhead capital exhibits the opposite effect, as Hansen predicted.

One way in which local public capital stock affects regional growth is through its effect on agglomeration economies. Public infrastructure affects agglomeration primarily through the influence of the scale and spatial arrangement of public investment on firm and household location decisions. While empirical evidence of the direct link between measures of agglomeration and economic growth is weak, it provides some support for this argument.

Empirical evidence of agglomeration effects takes two approaches. One approach interprets estimates of returns-to-scale as evidence of

http://clevelandfed.org/research/workpaper
Best available copy

gglomeration economies (Shef er [1973] and Carlino [19791). This view is onsistent with the Kaldor hypothesis that economies of scale in the anufacturing sector is the source of cumulative growth of regions Kaldor [1970]). A second approach treats agglomeration economies as perating through the efficiency parameter of the production function Aberg [1973]; Sveikauskas [1975]; Segal [1976]; Moomaw [1982]). These tudies assume that agglomeration economies are independent of returns to cale. Under this approach, Segal indirectly considers the contribution f the public capital stock of Standard Metropolitan Statistical Areas SMSAs) to productivity differentials between SMSAs during the mid-960s. He attributes his estimate of an 8 percent productivity ifferential in favor of the largest metropolitan areas to economies in ransport and communication. Unfortunately, Segal combines private and ublic capital together within a single measure of SMSA capital stock.

One critical step in the argument linking public infrastructure to gglomeration economies is its effect on location decisions. Only a few tudies have explored this relationship. For example, Helms (1985) shows hat government expenditures on highways, local schools, and higher education positively and significantly affect state personal income growth. n the other hand, Herzog, Schlottmann, and Johnson (1986) find that igh-technology workers, presumably a highly mobile labor group, exhibit ittle sensitivity to public infrastructure-type amenities and services.

Eberts (1985) explores the relationship between public infrastructure nd firm location in a somewhat different way by considering the causal elationship between public and private investment. His premise, following the cumulative model of regional growth, is that the timing of nvestment indicates the role of public investment in promoting local

http://clevelandfed.org/research/workpaper
Best available copy

economic development. If public investment precedes private investment, then it would appear that local areas actively use public outlays as an instrument 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 public outlay and manufacturing investment data from 1904 to 1978 for 40 cities, Eberts finds a significant causal relationship between public outlays and private investment in 33 of the 40 cases. The direction of causation goes either way. Private investment is more likely to influence public outlays in cities located in the South and in cities that have experienced above-average 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, in their study of Mexico, support Eberts' findings for older U.S. cities--that public investment appears to be the initiating factor in the development process rather than the passive or accommodating factor.

These results raise an interesting question: Is the growth associated with public infrastructure a result of an overall increase in firm-level productivity or a result of an increase in the region's attractiveness to labor and capital? Hulten and Schwab's (1984) research on regional productivity differentials provides 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. They find little evidence to support this hypothesis. Instead, they find that these interregional differences are largely a result of

http://clevelandfed.org/research/workpaper
Best available copy

fferences in the growth of capital and labor input. Thus, the implica-on from these findings is that regional differences in the quality and antity of public infrastructure may have a greater effect on the gration decisions of factors than on the productivity differentials.

These studies raise a host of issues that can be addressed using the blic capital stock estimates. I propose to explore a simple question at is basic to much of this discussion: what happens when public pital stock is entered as an input into the production function?

III. Public Capital Stock as a Production Input

Following Meade's (1952) classification of public inputs, public pital stock is treated as an unpaid factor of production that contrib-es independently to the firm's output. Since firms, by definition, do t pay directly for the public input, they initially earn profits or nts according to the value of the marginal product of the public put. Thus, firms in metropolitan areas with above-average investments public infrastructure may be more productive than firms in other eas. This advantage explains why firms in high-wage cities may be able compete successfully with firms in low-wage cities. Also, it explains y capital may move from low-wage to high-wage areas.

The use of public capital as an input introduces at least three com-ications related to the efficiency conditions: (1) there are no formal rket prices for public inputs, (2) an individual firm has little con-ol over the quantity of public capital that is in place, since public pital is determined collectively, and (3) public capital stock is used others who are not directly involved in manufacturing.

http://clevelandfed.org/research/workpaper
Best available copy

The consequences of these public capital stock characteristics for estimating a production function are reduced somewhat by aggregating firm-level data to the SMSA-level. At this level, the allocation of public infrastructure becomes more endogenous to the decision-making process. As proposed by Negishi (1973) and Pestieau (1976), local governments may invest in public capital with the goal of maximizing the profits of firms, since individual taxpayers may view the presence of firms as beneficial to the community. In addition, firms may pursue a "Tiebout-like" process of seeking to locate within jurisdictions in which the level of public investment best matches their preferences. Deno and Eberts (1986) construct and estimate a model of the interaction between private and public investment decisions, which takes into account voters' perceptions of the effect of public investment on local economic activity and thus their expected income levels. Although such an interaction of investment decisions underlies the approach taken in this present paper, I emphasize the technical relationships instead of the resource allocation issues.

Another issue is how to apportion the use of public capital stock between manufacturing production activity and other activities. Various sharing measures could be used such as the percentage of the metropolitan population employed in manufacturing or the percentage of local personal income in manufacturing. These measures introduce their own problems, however, so I prefer to enter the entire estimate of the metropolitan public capital stock as an input into the production function.

Another approach is to treat public infrastructure as a quasi-fixed input in a cost function. In the short-run, firms are assumed to respond to input prices of the variable inputs and the existing technology sub-

http://clevelandfed.org/research/workpaper
Best available copy

ect to a given level of output and the existing levels of fixed ictors. This method takes into account the possibility that public ivestment is not allocated at the level preferred by the firm. An iteresting extension of this approach is made by Dalenberg (1986), who icorporates into the cost function an adjustment process for public ivestment based on local public sector resource allocation.

IV. Capital Stock Estimates

Two unique data sets make possible the estimation of the effect of iblic capital stock on SMSA manufacturing: one is a public capital-:ock series for each metropolitan area; the other is a private manufac-iring capital-stock series for each SMSA. The perpetual inventory echnique is used to value both capital stocks. This approach is used by ie Bureau of Economic Analysis for national-level estimates of both :ivate and government assets and in many national and regional produc-.vity studies. The measure of capital under this method is the sum of ie value of past capital purchases adjusted for depreciation and .scard.

Two assumptions are made in using this scheme. First, the purchase :ice of a unit of capital, which is used to weight each unit of capital, eflects the discounted value of its present and future marginal prod-:ts. The first assumption is met if perfectly competitive capital irkets exist. One criticism of the perpetual inventory approach for iblic capital stock is that government is not subject to competitive irket constraints and thus the price does not reflect the marginal :oductivity of public capital. As discussed earlier, this may be less

http://clevelandfed.org/research/workpaper
Best available copy

of a problem for local governments, since they compete for households and firms. Second, a constant proportion of investment in each period is used to replace old capital (depreciation). Fulfillment of the second assumption requires accurate estimates of the asset's average service life, discard rate, and depreciation function.

To derive the stock measures, specific retirement and replacement or depreciation functions are applied to the accumulated gross investment series. The investment series must extend back far enough in time in order to account for all prior investment that has contributed to the current capital stock. Given the average life and retirement and depreciation assumptions used to construct the series, public outlays going back to 1904 were required for each city. The data were obtained from City Finances and from other census publications for the 38 cities. Public outlays for the SMSAs associated with these cities were available from 1964 to present. Per capita estimates of public outlays within a central city and outside the central city within an SMSA are used to construct SMSA-level public outlay estimates for years prior to 1964. SMSA-level estimates are constructed according to the 1977 boundary definitions.

Public capital outlay is defined by the Census Bureau as direct expenditure for either contract or force account construction of buildings, roads, and other improvements, and for purchases of land and existing structures. Included in total outlays are expenditures on: (a) sanitary and storm sewers and sewage disposal facilities, (b) roadways, sidewalks, and all structures and improvements necessary for their use, such as toll highways, bridges, and tunnels, (c) public hospitals, and (d) public service enterprises, which includes airports and ports.

http://clevelandfed.org/research/workpaper
Best available copy

ublic-type services provided privately are not included. Estimates of verage asset lives, depreciation, and discard functions are obtained rom the Bureau of Economic Analysis (BEA) and other sources. The series s converted to constant 1967 dollars by using the Engineering ews-Record indexes for construction. Eberts, Dalenberg, and Park (1986) escribe the construction of the public capital stock estimates in reater detail.

Private manufacturing capital stock estimates are derived for the ame set of SMSAs using investment data from the Census of Manufactures nd the Annual Survey of Manufactures. After adjusting the investment eries by national-level depreciation rates and discard patterns for each wo-digit industry, a capital-stock series is obtained for the period 958 to 1978. Although the depreciation and discard rates do not reflect ocal rates within industries, the rates do vary across SMSAs due to nterregional differences in industrial composition. Capital stock is djusted for capacity utilization using Federal Reserve Board national stimates. SMSA boundary definitions and price indexes are the same as hose used for public capital stock estimates.

Estimates of the total amount of public and private capital stock for ne 38 SMSAs between 1958 and 1978 are shown in figure 1. Total public apital stock grew by 33 percent between 1958 and 1978, while private apital stock increased 55 percent. The ratio of public capital stock to rivate stock averaged 1.52 but declined from 1.60 in the earlier years o 1.36 in the later years. Public capital stock is also broken down nto three major categories (not shown): roads and highways, water upply, and water treatment. Roads and highways comprised 9 percent of otal capital stock on average, water accounted for 14 percent, and water

http://clevelandfed.org/research/workpaper
Best available copy

treatment another 11 percent. These proportions remained relatively constant between 1959 and 1978 with highways increasing slightly, especially in the earlier years, primarily at the expense of water supply. Highways grew the fastest at 50 percent while water treatment grew at 40 percent and water supply at 19 percent.

Public capital stock growth rates have diminished over time. A convenient way to look at the variation in growth rates over time is to divide the annual series into intervals that reflect as closely as possible the trough-to-trough periods of the national business cycle. Four such periods occur between 1958 and 1978: 1958-61, 1961-70, 1970-75, and 1975-78, as shown in table 1. In the first two periods, the average annual growth rate (calculated using arithmetic means) of total public capital stock was around 1.8 percent. In the two more recent periods, the growth rate has steadily fallen to 1.44 percent and 1.03 percent. This recent decline in the growth rate of public capital stock is in sharp contrast to the recent increase in the growth rates of output and private capital stock. During the periods of 1970-75 and 1975-78, when the growth rate of public capital stock fell, manufacturing output rose by a dramatic 6.7 percent and private capital stock increased 7.5 percent. The only major component of public capital stock that exhibited an accelerated growth rate over this period was water treatment facilities.

Another interesting feature of the annual average growth rate series of public capital stock is that, unlike private capital stock, it does not follow the national business cycle. For instance, as one might expect, the annual average growth rate of private capital stock is at the lowest point in its cycle during the year the business cycle trough occurs. Public capital stock, on the other hand, is at or close to its

http://clevelandfed.org/research/workpaper
Best available copy

ighest point during some of these years. A casual look at the growth ate series in figure 2 fails to suggest any obvious lagged relationships hat may bring the private and public capital series in line. The ob- ious explanation is that public investment is determined by factors that re not tied directly to business cycle activities.

Table 2 shows the level of public and private capital stock for each MSA for 1978. The SMSAs are ordered by the size of the public capital tock. Notice the difference in rankings of SMSAs by public capital tock, private capital stock, population, and land area. For example, altimore is ranked eighth according to public capital stock, but is anked thirteenth according to private capital stock and eleventh accord- ng to population. Houston, on the other hand, is ranked third according o private manufacturing capital stock, but thirteenth according to pub- ic capital stock and eighth according to population. Per capita public nd manufacturing capital stock estimates show an even larger disparity n the rankings of SMSAs by these two stocks. New York, for example, anks first in public capital stock per capita, while it ranks thirty- ifth in manufacturing capital stock per capita. Houston's rankings are he exact opposite. Obviously, the public capital stock estimates are ot simply proxies for the area's population size.

Although the age of public capital stock is not considered in the stimation of the production function, it is interesting to examine the ankings of the SMSAs by percentage of public capital stock put in place ithin the last 10 years. The rankings of SMSAs are generally as expect- d: the so-called Sunbelt areas such as Atlanta, Dallas, and Houston ave the largest percentage of recently constructed public capital stock, hile the older Snowbelt areas like Cleveland, Newark, and Jersey City

http://clevelandfed.org/research/workpaper
Best available copy

have the least amount of newly created public capital stock. There are a few surprises, however. Two Sunbelt SMSAs, Los Angeles and San Francisco, are far down the list of metropolitan areas with newly created public capital stock. Two Snowbelt SMSAs, Grand Rapids and Minneapolis, for example, rank near the top of SMSAs with public capital put in place in the last 10 years.

V. Production Function Estimation

To explore the effect of public capital stock on regional manufacturing output and the technical relationships between public capital and the other inputs, a production function is specified and estimated using data from the 38 SMSAs between 1958 and 1978. Consider a production function aggregated to the SMSA-level in which

(1) $$Q = f(K,H,G,T)$$

where Q is the output of the manufacturing sector of each SMSA; K, G and H are private capital stock, labor, and public capital stock in the SMSA; and T is technical change. By employing Hicks' theorem of aggregation, returns to scale for a city as a whole is the weighted average of the returns of individual firms, corrected for the positive and negative externalities they confer on one another (Tolley and Smith, 1979). The weights are the shares of total income generated by each firm, assuming relative prices of goods produced in different SMSAs are constant across SMSAs.

The two variables not yet discussed are price-deflated value added

http://clevelandfed.org/research/workpaper
Best available copy

Q) and worker hours (H) in manufacturing. Value added deflated by the roducer price index is used as a measure of manufacturing output. How-ver, value added reported in Census of Manufactures includes the value f purchased services. Since the capital and labor estimates do not eflect the inputs used to produce these services, including services in he output measure would lead to overestimation of the marginal physical roducts of the three inputs. Value added is thus adjusted to correct or purchased services by using the ratio of GDP from NIPA to census alue added for U.S. manufacturing as described in Beeson (1986).

Hours worked by production and nonproduction workers obtained from he Census of Manufactures are used as a measure of labor.

A variant of the translog specification of a VES production function s chosen to estimate the production relationships. Thus, equation (1) s respecified as:

$$\begin{aligned}(2)\quad \ln Q = {} & b_o + b_T \ln T + b_K \ln K + b_H \ln H + b_G \ln G + \\ & b_{KH}(\ln K)(\ln H) + b_{KG}(\ln K)(\ln G) + b_{HG}(\ln H)(\ln G) + \\ & b_{K2} \ln K^2 + b_{H2} \ln H^2 + b_{G2} \ln G^2 + e\end{aligned}$$

n adopting equation (2), it is assumed that technical change is Hicks eutral and that the production technologies are similar across cities. ne production function in equation (2) is estimated with and without ıblic capital stock as an input using the Park's method of correcting or disturbances that are both serially and contemporaneously correlated Kmenta [1971]).

Three separate models were estimated. The first model is a translog ınction without public capital stock as an input. The second model

http://clevelandfed.org/research/workpaper
Best available copy

includes capital stock estimates for roads and highways and water treatment and supply as a way to control for differences in composition of public capital stock across metropolitan areas. The third model includes a measure of the total public capital stock in the SMSA, as defined earlier. Estimates of the coefficients are displayed in table 3, and estimates of marginal elasticities, marginal physical products, and economies of scale are reported in table 4.

Each input has a positive and statistically significant direct effect on manufacturing output. The estimates of the marginal elasticities of labor and private capital are very similar across the three models. When public capital stock is entered as either measure, the marginal elasticity of labor falls slightly, while the marginal elasticity of private capital remains the same. The fall in the marginal elasticity of labor is offset by an increase in the magnitude of the marginal elasticity of public capital so that both models exhibit constant returns to scale. Since each measure of public capital stock yields virtually identical results, the remaining discussion makes no distinction between the two models.

The magnitude of the marginal elasticity of public capital is quite small compared with estimates of the marginal elasticities of the other two inputs. This low estimate may be related to the fact that public capital stock is shared not only by manufacturing firms within an SMSA, but also by firms in other sectors and by households. One can see the potential effect of this public good aspect on the marginal physical product of public capital by conducting the following conceptual experiment. Suppose that the per unit prices of public and private capital stock are equal, presumably due to perfect capital markets. In this

http://clevelandfed.org/research/workpaper
Best available copy

ase, one would expect the marginal physical product of the two capital tocks to be equal. Yet, the estimate of the marginal physical product f private capital is 5 to 10 times greater than that of public capital, epending upon the measure of public capital stock. If one were to ttribute this difference to the fact that we are observing the use of ublic capital by manufacturers much further down the marginal product chedule than is the actual case, then we would conclude that only one-eventh or 14 percent (taking the midpoint of the two estimates) of the otal public capital stock is used on average by the manufacturing sec-or. In fact, a crude sharing measure, the ratio of manufacturing mployment to metropolitan population, comes very close to this percent-ge at 11 percent. Using the size of the labor force instead of popu-ation would increase this percentage to something closer to 14 percent.

Another way to interpret these results is to consider public capital tock to be a pure public good. Assuming that local governments compete or households and firms and thus allocate resources efficiently, the alue of the marginal product of public capital stock reveals the manu-acturing sector's valuation of the total stock of public investment in lace in the SMSA. Since the production function exhibits constant eturns to scale, the output elasticity of public capital equals the hare of total revenue paid to the public sector for the use of public apital. It is not unreasonable for a typical firm to pay around four ercent of its total income to state and local taxes, which is the esti-ate of the output elasticity of public capital.

Estimates of the marginal productivities of each of the three inputs epend upon the coefficients of the interaction terms in the production unction and the input and output levels. Consequently, as these levels

http://clevelandfed.org/research/workpaper
Best available copy

change over time, marginal products also change. For example, the marginal product of labor continually increases over time as labor declines relative to private and public output. The marginal product of capital increases throughout the 1960s and then remains relatively constant. The marginal product of public capital continually falls throughout the 20-year period as public and private capital increase. This decline results partly from the negative second partial derivative of public and private capital. Thus, allowing output to vary but fixing labor, an increase in public capital is associated with a decrease in private capital productivity. In this respect, the levels of public and private capital could be considered to move in the same direction.

Technological relationships between inputs can also be described as substitutes or complements. The definition of complements and substitutes is based upon the input demand relationship, which assumes that costs vary but that output is held constant. A pair of inputs are complements if the cross-price effect is negative and substitutes if the cross-price effect is positive. It can be shown that

$$\partial x_i/\partial p_j = -C_{ji}/D,$$

where Cj_i is the co-factor of the element in row j and column i of the bordered Hessian, which is derived from the cost minimization problem. D is the determinant. Therefore, the relationship between inputs can be derived from technical relationships without estimating input prices. Since the determinant is negative, inputs are complements if the co-factor is negative and substitutes if the co-factor is positive.

http://clevelandfed.org/research/workpaper
Best available copy

Calculation of the co-factors based on estimated coefficients indi-tes that public and private capital are substitutes, labor and private pital are substitutes, while public capital and labor are complements. e finding that public capital and labor are complements is consistent th Deno and Eberts' (1986) study, which estimated input demand uations for labor and private investment. One interpretation of this lationship is that public capital stock provides a base for the future pansion of manufacturing employment.

VI. Conclusion

The production function estimates yield three basic results. First, blic capital stock makes a positive and significant contribution to nufacturing output in the sample of 38 SMSAs. Second, its contribu-on, unadjusted for the public good characteristics of public capital, much less than that of private capital and labor. Third, public pital and labor are complementary inputs, whereas private capital and olic capital, and private capital and labor, are substitutes.

As mentioned at the beginning of the paper, public capital stock is portant to issues related to regional economic growth. Public infra-ructure is considered to be an important element of agglomeration onomies. Following previous work using population as a proxy for glomeration, one would expect public capital stock to yield increasing turns to scale, which is not the case here. However, the results here e not directly comparable to the results of other studies on agglomera-on. In this paper, public capital is entered as an input; in the other pers, Hicks-neutral technical change is regressed against population.

http://clevelandfed.org/research/workpaper
Best available copy

Therefore, the results are merely suggestive of future research.

Previous work suggests that, in many respects, public capital stock may be considered the foundation of regional economic development. The finding that public capital and manufacturing employment are complementary inputs into the regional production function indicates that public capital stock is necessary for future expansion in the manufacturing sector. However, the overall effect of public capital investment on manufacturing output is relatively small. Previous research suggests that specific types of public infrastructure may have more noticeable effects on the output of specific sectors in regions with differing characteristics. Future work should look at more disaggregated numbers for manufacturing and for public capital stock and take into account regional differences.

Finally, Hulten and Schwab suggest that regional growth differences are due not to productivity growth differentials, but to input growth differentials. Although we do not address this question directly, our results, by showing a positive and significant relationship between public capital stock and manufacturing output, indicate that regional growth differences are influenced by the growth rate of a third input, public capital stock.

http://clevelandfed.org/research/workpaper
Best available copy

References

ɔerg, Y. "Regional Productivity Differences in Swedish Manufacturing," Regional and Urban Economics, vol. 3, no. 2 (1973), pp. 131-56.

ɘeson, Patricia E. "Productivity Growth and the Decline of Manufacturing in Large Metropolitan Areas: 1959-1978," Working Paper 8607, Federal Reserve Bank of Cleveland, July 1986.

ırlino, Gerald A. "Increasing Returns to Scale in Metropolitan Manufacturing," Journal of Regional Science vol. 19, no. 3 (August 1979), pp. 363-74.

ılenberg, Douglas. "A Dynamic Factor Demand Model for Public Infrastructure," Dissertation Proposal, University of Oregon, Department of Economics, 1986.

:no, Kevin, and Randall W. Eberts. "The Impact of Public Investment on Net Private Investment and Labor Demand: A Dynamic Analysis," Mimeo, 1986.

ɔerts, Randall W. "The Role of Public Investment in Regional Economic Development," Presented at the Association for Public Policy Analysis and Management, Washington, D.C., October 15, 1985.

ɔerts, Randall W., Douglas Dalenberg, and Chul Soo Park. "Public Infrastructure Data Development for NSF," Mimeo, University of Oregon, 1986.

ınsen, Niles M. "Unbalanced Growth and Regional Development," Western Economic Journal, vol. 4 (Fall 1965), pp. 3-14.

ɘlms, L. Jay. "The Effect of State and Local Taxes on Economic Growth: A Time Series-Cross Section Approach," Review of Economics and Statistics, vol. 67, no. 4 (November 1985), pp. 574-582.

ɘrzog, Henry W., Alan M. Schlottmann, and Donald L. Johnson. "High-Technology Jobs and Worker Mobility," Journal of Regional Science, vol. 26, no. 3 (August 1986), pp. 445-60.

ılten, Charles R., and Robert M. Schwab. "Regional Productivity Growth in U.S. Manufacturing: 1951-78," American Economic Review, vol. 74, no. 1 (March 1984), pp. 152-62.

ıldor, Nicholas. "The Case for Regional Policies," Scottish Journal of Political Economy, vol. 17, no. 3 (November 1970), pp. 337-48.

ıenta, Jan. Elements of Econometrics. New York: Macmillan, 1971.

ɘven, Charles, John Legler, and Perry Shapiro. An Analytical Framework for Regional Development Policy. Cambridge, MA: The MIT Press, 1970.

http://clevelandfed.org/research/workpaper
Best available copy

Looney, Robert, and Peter Frederiksen. "The Regional Impact of Infrastructure Investment in Mexico," Regional Studies , vol. 15, no. 4 (1981), pp. 285-96.

Meade, J. E. "External Economies and Diseconomies in a Competitive Situation," Economic Journal, vol. 62 (March 19521, pp. 54-67.

Mera, Keoichi. Income Distribution and Regional Development. Tokyo, Japan: University of Tokyo Press, 1975.

Moomaw, Ronald. "Productive Efficiency and Region," Southern Economic Journal, vol. 48, no. 2 (October 1981), pp. 344-57.

Negishi, Takashi. "The Excess of Public Expenditures on Industries," Journal of Public Economics, vol. 2, no. 3 (July 1973), pp. 231-40.

Pestieau, Pierre. "Public Intermediate Goods and Majority Voting," Public Finance, vol. 31, no. 2 (1976), pp. 209-17.

Segal, David. "Are There Returns to Scale in City Size?" The Review of Economics and Statistics, vol. 58, no. 3 (August 1976), pp. 339-50.

Shefer, Daniel. "Localization Economies in SMSA's: A Production Function Analysis," Journal of Regional Science, vol. 13, no. 1 (April 19731, pp. 55-64.

Sveikauskas, Leo A. "The Productivity of Cities," Quarterly Journal of Economics, vol. 89, no. 3 (August 1975), pp. 393-413.

Tolley, George S., and B. Smith. "Scale Economies, Externalities, and City Size," in Tolley, Graves, and Gardner, eds., Urban Growth Policy in a Market Economy. New York: Academic Press, 1979, pp. 37-49.

http://clevelandfed.org/research/workpaper
Best available copy

Table 1: Average Annual Growth Rates of Manufacturing Output Labor, Private Capital, and Public Capital for the 39 SMSAs

sriable	1958-61	1961-70	1970-75	1975-78
utput	2.62	4.32	1.08	6.70
sbor	.64	1.62	-1.88	3.06
rivate Capital Stock	1.34	3.01	.77	7.35
otal Public Capital Stock	1.80	1.81	1.44	1.04
oad and Highways	4.57	2.85	.99	.77
aste Treatment	3.04	1.91	1.36	1.92
ater System	3.72	1.89	- .20	.07

ote: Time periods correspond to the trough-to-trough intervals of the national business cycle.

http://clevelandfed.org/research/workpaper
Best available copy

Table 2: Rankings of SMSA's by Size of Public Capital Stock, Private Capital Stock, Population, Area, and Age of Public Capital Stock

Ranking of SMSA by:

SMSA	Public Capital	Private Capital	Population	Area	Per Capita Public	Per Capita Private	Age
New York	1	5	1	32	1	35	32
Los Angeles	2	4	2	9	7	24	31
Chicago	3	1	3	11	13	13	18
Detroit	4	2	5	10	9	4	23
San Francisco	5	11	6	19	2	29	27
Philadelphia	6	6	4	13	18	21	28
Pittsburgh	7	7	10	17	11	7	26
Baltimore	8	13	11	22	10	22	9
Minneapolis	9	13	11	22	10	22	7
Cleveland	10	8	16	28	8	6	29
Seattle	11	22	17	7	5	26	21
Dallas	12	14	7	1	33	32	2
Houston	13	3	8	2	35	1	4
Milwaukee	14	15	20	29	6	14	30
Atlanta	15	21	13	65	24	33	1
St. Louis	16	9	9	3	32	20	25
Newark	17	10	14	34	22	9	34
Buffalo	18	12	23	27	3	3	15
Cincinnati	19	18	19	23	17	19	22
Kansas City	20	20	21	15	15	23	10
San Diego	21	36	15	8	36	36	12
Memphis	22	33	28	21	4	25	19
Denver	23	23	18	4	26	30	3
New Orleans	24	35	24	25	19	34	33
Portland	25	29	22	12	23	31	8
Rochester	26	17	27	18	14	5	24
Indianapolis	27	19	25	16	29	15	14
Columbus	28	30	26	20	30	28	13
Louisville	29	27	29	31	20	17	20
Dayton	30	26	31	26	25	16	17
Birmingham	31	24	30	14	34	12	6
Akron	32	28	32	35	21	8	16
Jersey City	33	32	35	36	16	10	36
Richmond	34	34	33	24	27	18	11
Grand Rapids	35	31	34	30	31	11	5
Youngstown	36	25	36	33	28	2	35

Note: Erie, Canton, and Reading were not included in these rankings, although they were included in the rest of the analysis. Age of the public capital stock is measured as the percentage of public capital put in place during the last 10 years. Definitions of the other variables are described in the text.

http://clevelandfed.org/research/workpaper
Best available copy

Table 3: Production Function Estimates with and without Public Capital Stock

Variable	Model A	Model B	Model C
tercept	.142	-.754	-1.23
	(1.19)	(7.37)	(10.29)
(time)	.136	.127	.130
	(135.60)	(202.56)	(117.56)
(hours)	1.24	.956	.650
	(33.69)	(39.59)	(13.59)
(prvcap)	.130	.429	.555
	(2.62)	(12.86)	(13.93)
(pubcap)		.155	.354
		(7.20)	(9.13)
(hours)* Ln(prvcap)	-.077	-.020	-.051
	(5.31)	(2.82)	(3.01)
(prvcap)* Ln(pubcap)		-.046	-.142
		(11.58)	(14.89)
(hours)* Ln(pubcap)		.031	.109
		(3.98)	(6.46)
$(hours)^2$	.010	-.064	-.215
	(.64)	(6.76)	(8.22)
$(prvcap)^2$	.078	.042	.075
	(4.92)	(4.49)	(5.20)
$(pubcap)^2$		.007	.017
		(.77)	(1.15)

te: Model A does not contain public capital stock; Model B contains public capital stock measured as water treatment, water supply, and highways and roads; Model C contains public capital stock measured as total public capital stock defined in the text. Park's method of correcting for auto-correlation and heteroskedasticity is used. T-statistics are in parentheses. The Park's procedure in SAS does not report an R-square.

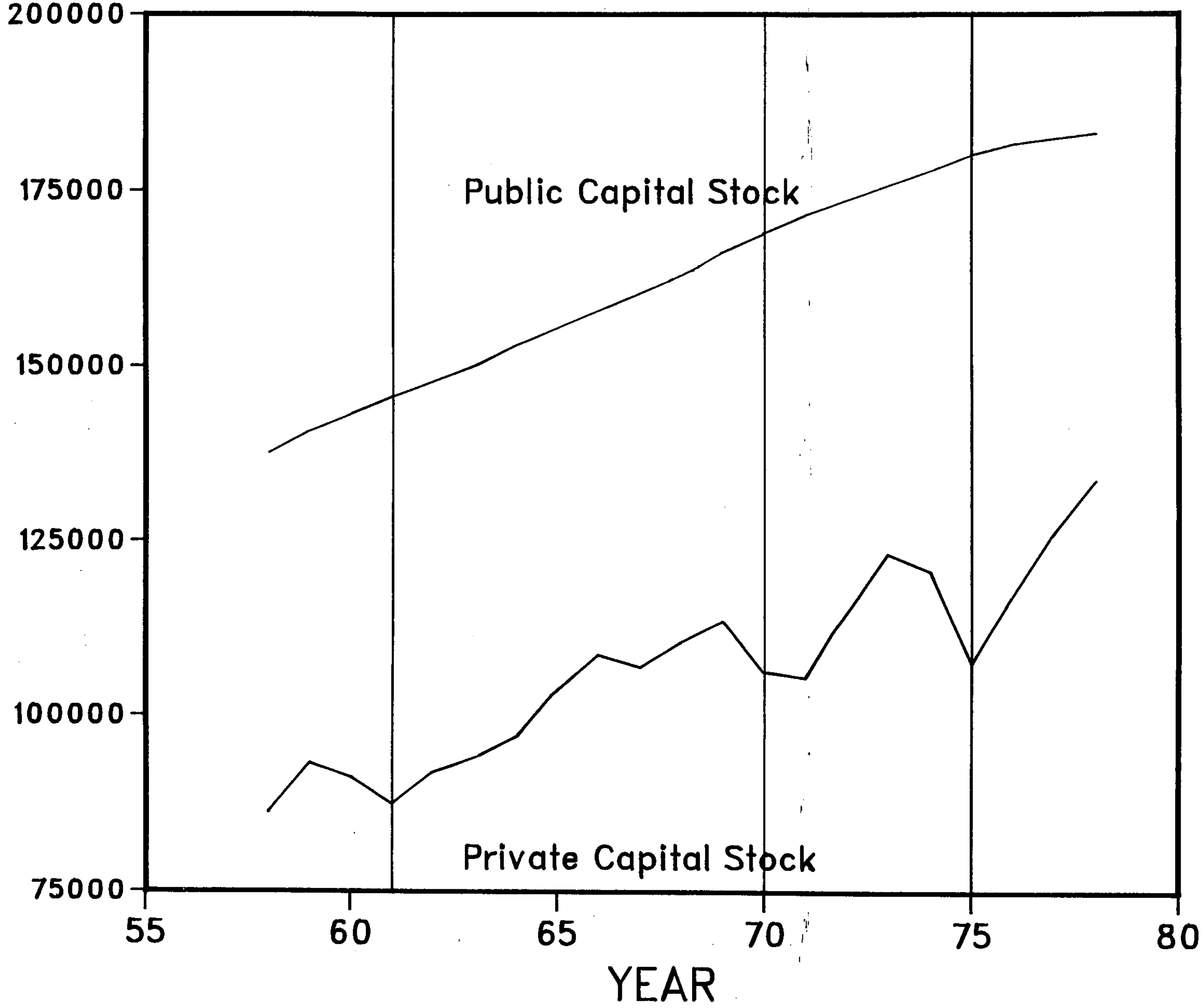
http://clevelandfed.org/research/workpaper
Best available copy

Table 4: Estimates of Marginal Elasticities, Marginal Physical Products, and Returns to Scale

Characteristic	Model A	Model B	Model C
Values of:			
Marginal Elasticity of:			
Labor	.79	.66	.66
Private Capital	.22	.32	.31
Public Capital		.03	.04
Returns to Scale	1.01	1.01	1.00
Marginal Physical Product of:			
Labor	5.08	4.21	4.27
Private Capital	.23	.32	.30
Public Capital		.07	.03
Signs of:			
Second Partial Derivative between:			
Private and public capital		-	-
Private capital and labor	+	+	+
Private capital and private capital			
Public capital and labor		+	+
Public capital and public capital		-	-
Labor and labor		-	-
Co-factor between:			
Private and public capital		+	+
Private capital and labor	+	+	+
Public capital and labor		-	-

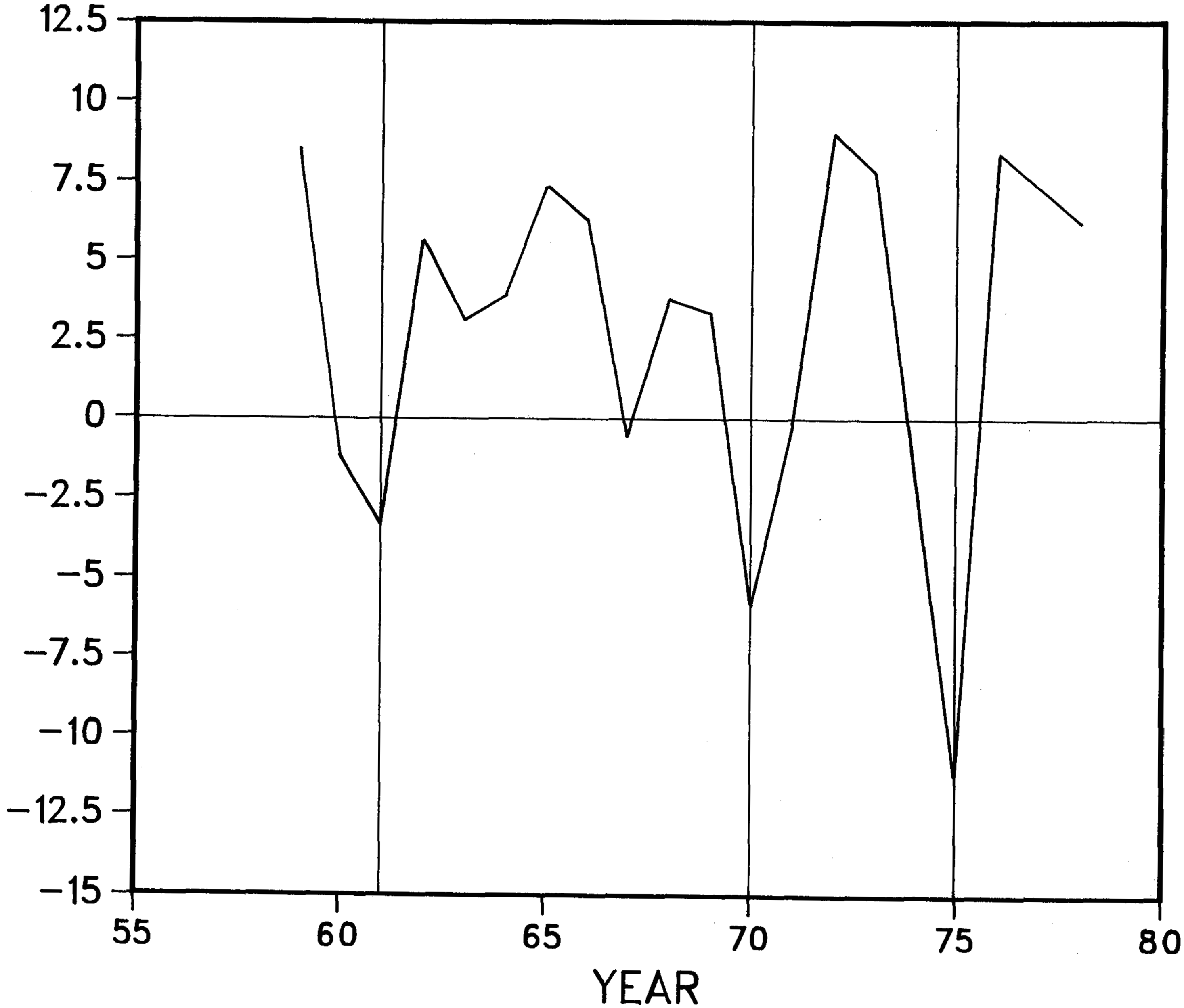
Note: Elasticities and marginal products are calculated from estimates displayed in table 3.

http://clevelandfed.org/research/workpaper
Best available copy



http://clevelandfed.org/research/workpaper
Best available copy

Figure 2: Growth Rate of Private Capital Stock



http://clevelandfed.org/research/workpaper
Best available copy