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CROSS-SECTIONAL ANALYSIS OF PUBLIC INFRASTRUCTURE AND REGIONAL PRODUCTIVITY GROWTH

by Randall W. Eberts

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I. Introduction

The apparent simultaneous occurrence of a serious deterioration of the nation's public infrastructure and the dramatic slowdown in national productivity during the 1970s raises the question of whether public capital significantly affects private sector productivity. Hulten and Schwab (1984) examine differences in manufacturing productivity growth between the Sun Belt and Snow Belt and conclude that there is "...no evidence to support the hypothesis that an aging public infrastructure, obsolete capital stock, or higher rate of unionization have slowed total factor productivity growth in the snow belt" (p. 152). Their dismissal of the role public infrastructure plays in explaining regional differences in total factor productivity (TFP) is based on their observation that TFP does not differ significantly between the Sun and Snow Belts. Consequently, little regional difference in TFP can be attributed to a decline in public infrastructure. However, they do not estimate directly the effect of public infrastructure on regional productivity.

The purpose of this paper is to test Hulten and Schwab's assertion directly by estimating the effect of the growth of public infrastructure on the growth of manufacturing TFP across Standard Metropolitan Statistical Areas (SMSAs).[1] Concentrating on SMSAs as the unit of analysis rather than on Hulten and Schwab's use of census regions has two advantages. First, it provides more degrees of freedom to estimate the relationship between infrastructure and TFP than that afforded by census regions. Second, because public capital stock is typically located in a specific area, it is more appropriate to focus the analysis on economic activity from a particular geographic area within the immediate vicinity of the infrastructure. An SMSA provides a convenient unit of analysis for establishing this linkage.

In this study, annual growth rates of TFP in manufacturing are estimated for 36 metropolitan areas between 1965 and 1977. Public capital stock for each area is estimated using the perpetual inventory technique. Average annual growth rates of both TFP and local public capital are calculated and averaged for two periods, 1965 to 1973 and 1973 to 1977, which correspond as closely as our data permit to the time periods used by Hulten and Schwab. Growth rates in public capital stock are then used to explain growth rates of TFP and other components of the growth rate of manufacturing value added, including share-weighted growth of labor and private capital.

Results generally support Hulten and Schwab's assertions, with one notable exception. Contrary to their conclusion that there is no basis for public infrastructure affecting TFP, we have found that variation across SMSAs in public capital stock growth has a positive and statistically significant effect on TFP across regions. More consistent with their position is our finding that variation across SMSAs in growth rates of public capital stock is highly correlated with the variation in growth of the two private inputs. In addition, variation across SMSAs of the slowdown in output growth is not significantly correlated with the change in growth rate of public capital stock.

Results related to the composition of output growth are also consistent with Hulten and Schwab's position. TFP growth accounts for at least half of the growth in output for both periods. The change in TFP growth between 1965 and 1973 and 1973 and 1977 accounts for most of the slowdown in output growth during the two periods.

II. Methodology

We have followed a two-step process to estimate the effect of public infrastructure on TFP. The first involves estimating TFP without public infrastructure in the production function. The second attempts to explain variations in TFP across SMSAs by regressing the growth rate of TFP for each SMSA on the growth rate of public infrastructure and other determinants. A representative sample of 36 SMSAs is used in the analysis. Although these areas do not cover the entire manufacturing activity considered by Hulten and Schwab, they are representative of their results, as will be shown.

Estimation of TFP in manufacturing within SMSAs follows the same method adopted by Hulten and Schwab, using the accounting framework developed by Denison (1979), Jorgenson and Griliches (1967), and Kendrick (1980). Consider a neoclassical production function aggregated to the SMSA level in which output (Q_t) is a function of technical change (A_t), private capital (K_t), labor (L_t), and other factors (Z_t), which could include energy and materials:

$$(1) \qquad Q_t = f(A_t, V(K_t, L_t), Z_t).$$

Technology is assumed to be weakly separable between value added and Z_t, and technical change (A_t) is assumed to be Hicks neutral. Therefore, for the purpose of estimating TFP, private capital and labor are the only necessary inputs. Employing Hicks' theorem of aggregation, returns to scale for a metropolitan area as a whole are the weighted average of returns of individual firms, corrected for the positive and negative externalities they confer on one another (Tolley and Smith [1979]). 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 growth rate of output in the manufacturing sector of SMSAs can be decomposed into its source components by differentiating the generalized production function (equation [1]) with respect to time and by assuming profit maximization, so that the value of marginal product of each input equals its price:

$$(2) \qquad d\ln Q/dt = S^t{}_K \, d\ln K/dt + S^t{}_L \, d\ln L/dt + d\ln A/dt.$$

Under constant returns to scale in private inputs, the shares of private capital and labor (S_K and S_L, respectively) sum to one.

In equation (2), the SMSA growth rate of output equals the output-elasticity-weighted sum of rates of growth of private inputs and a residual (A_t). The residual, generally thought of as technological progress, accounts for the change in output not attributable to the change in the two private inputs. It includes public infrastructure, along with other SMSA-specific characteristics. Local public infrastructure is typically financed through taxes and intergovernmental grants. Because firms, by definition, do not pay directly for public infrastructure, and assuming that the tax is not a pure benefit tax, firms initially earn profits or rents according to the value of the increase in productivity attributed to the infrastructure. Consequently, firms in metropolitan areas with an above-average stock of public infrastructure may be more productive than firms in other areas, ceteris paribus.[2]

The Tornqvist approximation of the Divisia index, shown in equation (2), can be transformed into a discrete time analog by using logarithmic differentials. Equation (2) then becomes

$$(3) \qquad \ln Q(t)-\ln Q(t-1) = [(S_K(t)+S_K(t-1))/2]\ (\ln K(t)-\ln K(t-1) + [(S_L(t)+S_L(t-1))/2]\ (\ln L(t)-\ln L(t-1) + \ln A(t)-\ln A(t-1),$$

where S_L equals payroll per value added (wL/Q) and S_K equals $1-S_L$.

III. Data

A. Capital Stock

Data were obtained from standard sources, with the exception of public and private capital stocks. Public capital stock series for each SMSA were constructed for this project from government finance data; the private manufacturing capital stock series for each SMSA were estimated by Fogarty and Garofalo (1982). The perpetual inventory technique, employed by the Bureau of Economic Analysis (BEA) for national-level estimates of both private and government assets and in many national and regional productivity studies, was used to value both private and public capital stocks. 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 made in using this method. 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 is used to replace old capital (depreciation) during each period. The first assumption is met if perfectly competitive capital markets exist. One criticism of using the perpetual inventory approach for public capital stock is that government is not subject to competitive market constraints and thus prices do not reflect the marginal productivity of public capital. This problem is less critical for local governments, however, because they compete for households and firms. Fulfillment of the second assumption requires accurate estimates of an asset's average service life, discard rate, and depreciation function. Sources of this information will be discussed later.

Public capital outlay is defined by the Bureau of the Census as direct expenditure for 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 for (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) water supply and distribution systems, (d) public hospitals, and (e) public-service enterprises, which include airports and ports. Public-type services provided privately are not included.

To derive the stock measures, specific retirement and depreciation functions are applied to the accumulated gross investment series, which must extend back far enough in time to encompass all prior investment that has contributed to the current capital stock. Given the average life, retirement, and depreciation assumptions used to construct the series, public outlays since 1904 were required for each of the 36 metropolitan areas studied.

Public outlay data were obtained from City Finances and other Bureau of the Census publications for the 36 cities from 1904 to the present. Public outlays for the SMSAs associated with these cities were not available until 1964. Per capita estimates of public outlays within and outside of the central city within an SMSA are used to construct SMSA-level public outlay estimates for those years prior to 1964. SMSA-level estimates are constructed according to the 1977 boundary definitions.

Estimates of average asset lives, depreciation, and discard functions were obtained from the BEA and other sources. We assumed that public capital depreciated according to the "efficiency" function. Under this formulation, stock holds a high percentage of its original value for much of its life, but then its value declines at an increasing rate. A beta value of 0.9 was used. The series were converted to constant 1967 dollars by using the Engineering News-Record indexes for construction. Eberts, Dalenberg, and Park (1986) describe the construction of the public capital stock estimates in greater detail.

Fogarty and Garofalo (1982) constructed private capital stock estimates for manufacturing for the same set of SMSAs using investment data from the Census of Manufacturers and the Annual Survey of Manufacturers. They obtained capital stock series for the period 1958 to 1978 by adjusting the investment series by national-level depreciation rates and discard patterns for each two-digit industry. Although the depreciation and discard rates do not reflect local rates within industries, they do vary across SMSAs, because of interregional differences in industrial composition. SMSA boundary definitions and price indexes are the same as those used for public capital stock estimates. Private capital stock is adjusted for capacity utilization using Federal Reserve Board national estimates.

B. Output and Labor

Manufacturing value added, deflated by the Producer Price Index, is used as a measure of manufacturing output. However, value added reported by the Bureau of the Census includes the value of purchased services. Because private capital and labor estimates do not reflect the inputs used to produce these services, the inclusion of services in the output measure would lead to overestimation of the marginal physical products of the inputs. Value added is adjusted to correct for purchased services by using the ratio of gross domestic product from the National Income and Product Accounts to Census value added for U.S. manufacturing, as described in Beeson (1987).

Hours worked by production and nonproduction workers (H) are used as a measure of labor. The former are obtained directly from the Census of Manufacturers and Surveys of Manufacturers; hours of nonproduction workers are not directly available. A standard approximation, adopted here, is to multiply the number of nonproduction workers by 2,080--the number of hours typically worked during one year.

C. Estimates of the Components of Output Growth

The sample of SMSAs considered in this study, although not encompassing the entire manufacturing output contained in Hulten and Schwab's study, is representative of their findings. As shown in table 1, estimates of output growth and its components (for example, TFP growth and private capital and labor growth weighted by their shares of output) are consistent with those of Hulten and Schwab for similar periods. Output grew at an annual average rate of 2.82 percent for the full sample of SMSAs between 1965 and 1977, as compared with 3.31 percent reported by Hulten and Schwab for the nation between 1951 and 1978. TFP accounted for the largest share of output growth, equaling 50 percent and matching the proportion reported by Hulten and Schwab.

Several other similarities exist between our estimates and those of Hulten and Schwab. Output in the Sun Belt SMSAs grew significantly faster than output in the Snow Belt SMSAs; however, TFP growth was lower in the Sun Belt than in the Snow Belt. Consequently, TFP accounted for 66.5 percent of Snow Belt output growth but only 33.3 percent of Sun Belt output growth. Growth in hours worked contributed most to the growth of output in the Sun Belt. The difference in growth rates between the two regions resulted primarily from differences in the growth rate of private capital.

Also, as noted by Hulten and Schwab, the growth rate of output slowed dramatically for both the Snow Belt and the Sun Belt after 1973. Table 2 shows that the average growth rate for all SMSAs declined from a 3.51 percent average annual growth rate between 1965 and 1973 to a 0.30 percent growth rate between 1973 and 1977. During the latter period, TFP and labor actually declined, while public and private capital stock increased, but at a slower pace than during the earlier period.

Each of the two periods chosen by Hulten and Schwab straddle a recession. A short recession occurred between December 1969 and November 1970, and a longer and deeper recession took place between November 1973 and March 1975. The relative magnitudes of these economic contractions and the proportion of the time periods that they occupied most likely affect the growth rates of the variables that we and Hulten and Schwab examined. Because the purpose of this paper is to follow Hulten and Schwab's approach, which did not adjust for these factors, neither do we. Furthermore, because the sample statistics for SMSAs closely match Hulten and Schwab's estimates, it is reasonable to assume that results obtained in this study are relevant for interpreting their assertions about public infrastructure.

D. Public Capital Stock

Estimates of public capital reveal two characteristics that suggest infrastructure may be associated with regional differences in growth rates of output and the slowdown of output and TFP that occurred during the latter half of the 1970s. As shown in table 1, public capital stock in Sun Belt SMSAs grew at nearly twice the rate of public capital stock in Snow Belt SMSAs during the 1965 to 1977 period. This difference in growth rates of public capital stock closely follows the general pattern of output growth of SMSAs between these two regions.

Similar to TFP and output growth, public capital stock formation slowed between 1965 to 1973 and 1973 to 1977, but not as rapidly as did either TFP or output, as shown in table 2. During both periods, Snow Belt SMSAs invested in public infrastructure at a significantly lower rate than did Sun Belt SMSAs. However, when measured relative to labor input, the growth rate of public capital stock per hours worked actually increased from the first to the second period, because hours worked declined. However, public capital formation per hours worked still grew at a slower pace than did private capital formation per hours worked, which is evidence of the increasing scarcity of public capital stock relative to other inputs.

IV. Results

A. Productivity Regressions

Following Hulten and Schwab, two measures of productivity are considered: TFP and labor productivity. These two productivity measures should yield similar results since they are highly correlated (correlation coefficient of 0.72 for each period). To explore the relationship between productivity growth and public capital growth, variation across SMSAs of each measure is explained by variation in growth rate of public capital stock and several control variables. The various specifications of this relationship are contained in table 3 for the 1965 to 1973 period and in table 4 for the 1973 to 1977 period.

For the first period, the simple correlation between the growth rate of public capital stock and the growth rate of TFP yields a negative but statistically insignificant relationship. However, controlling for age of the SMSA, as proxied by the percentage of 1970 housing stock built prior to 1950, public capital stock has a positive and statistically significant effect on TFP; a 1 percent increase in public capital is associated with a 0.49 percent increase in TFP. Estimates based on labor productivity are of similar magnitude.

Magnitude of the coefficient on public capital in the TFP and labor productivity equations does not change significantly when other variables are added, such as unionization, population, educational attainment of workers, percentage of manufacturing in durable goods, the Snow Belt/Sun Belt dummy variable, or the growth rate of the two private inputs. Of these, only the age variable is statistically significant across all specifications of the TFP equation. The capital/labor ratio is statistically significant in the labor productivity equation. In both equations, the positive coefficient suggests that during the first period, cities with older housing stock have higher TFP growth. However, by the second period, this relationship turns negative, although it is not statistically significant. Thus, the older, more traditional manufacturing cities that had a comparative advantage during the first period appear to lose it by the second period.[3]

As an aside, Hulten and Schwab, following Olson's (1982) work, also list unionization as a likely factor behind the decline in productivity. However, our estimates show no statistically significant relationship between union representation and the TFP growth rate for either period.

The statistically significant relationship between public infrastructure and TFP found during the first period disappears during the second period. As shown in table 4, the coefficient on public capital stock is not statistically significant at any reasonable confidence level under any of the specifications. In fact, the variables explain little of the variation in TFP or labor productivity that occurs during the second period, as evidenced by the adjusted R-squareds.[4]

Therefore, although public capital stock is shown to affect TFP growth, the effect is limited to the earlier period of analysis.

B. Estimates of Output and Input Regressions

The major thrust of Hulten and Schwab's analysis is that interregional differences in manufacturing output are largely the result of differences in the growth of capital and labor. Public capital is expected to have a positive effect on the flows of these factors across regions. For instance, several studies of the determinants of firm location have found that public capital stock has a positive and significant effect on firm openings (for example, Bartik [1985], Eberts [1990], and Fox and Murray [forthcoming]). Fox, Herzog, and Schlottmann (1989) also have shown that local fiscal expenditures (which include public outlays) and revenue affect the migration decisions of households across metropolitan areas.

The growth rate of public capital stock is strongly related to growth of the combined measure of share-weighted private inputs. Tables 5 and 6 show that a 1 percent increase in public capital stock is associated with a 0.76 percent increase in growth of combined inputs for the first period, and a 0.70 percent increase during the second period. SMSAs with higher-than-average union representation have lower-than-average input growth.

Public capital stock affects the share-weighted growth of each input about equally. For both periods, the coefficients are positive and statistically significant.[5] However, increased union representation appears to depress capital formation more than it reduces labor growth.

Public capital is positively related to output, but this takes place primarily through its effect on private capital and labor. For the first period, when public capital is entered in the output regression without private capital and labor inputs, its coefficient is positive and statistically significant. When the two private inputs are also included, however, the coefficient on public capital falls from 0.78 to 0.14. Although the standard error of the estimate is lower for the second specification, the smaller magnitude of the coefficient renders it statistically insignificant. The same phenomenon occurs during the second period.[6]

Therefore, results suggest that most of the effect of public capital stock on TFP results from its effect on private inputs.

C. Productivity Slowdown Between 1965 to 1973 and 1973 to 1977

Hulten and Schwab also consider the regional contribution to the productivity slowdown that occurred during the early 1970s by looking at the aggregate change in TFP. They subtract the average annual growth rate in TFP (and labor productivity) that occurs during the second period from the same measures in the first period. They then apportion the change in the growth rate of output to changes in the three components: TFP, share-weighted private capital, and share-weighted labor. Based on this accounting framework, they conclude that more than half of the slowdown in output between the two periods results from a slowdown in productivity.

We find the three components of output growth contributing in the same order of importance in our sample of SMSAs: 80 percent of the 3.17-percentage-point decline in growth rate of output between the two periods results from a change in the growth rate of TFP, while labor and private capital contribute 14 percent and 6 percent, respectively.

Variation in the change of output growth across SMSAs is explained primarily by the change in the growth rate of labor. Regressing the difference in the growth rate of output between the two periods on the change in the growth rate of share-weighted private capital, share-weighted labor, and public capital stock reveals that labor has the largest effect, followed by private capital, and then public capital (table 7). However, while the first two coefficients are statistically significant, the public capital stock coefficient is not.

Regressing the difference in the growth rate of TFP between the two periods on the difference in the growth rate of public capital stock and the other two inputs, shown in table 7, yields a statistically insignificant coefficient for public capital stock. Only the coefficient on labor is statistically significant.

V. Conclusion

This paper offers direct tests of Hulten and Schwab's assertions about the relationships between local public capital stock and regional manufacturing output, inputs, and productivity.[7] Results show that public capital stock does affect productivity, measured either as TFP or labor productivity. However, the effect is statistically significant only for the pre-1973 period. Results also show that public capital stock affects output, but only when private inputs are not included in the regression equation. When they are included, the size of the coefficient on public capital stock falls and becomes statistically insignificant. Nonetheless, both private capital and labor are highly correlated with public capital stock. Therefore, it appears that within this framework, the primary channel through which public capital stock influences output is via private inputs.

This paper lends insight into two conjectures offered by Hulten and Schwab. First, the effect of public capital stock on regional productivity cannot be dismissed, although it appears to play only a limited role. Second, public infrastructure appears to be a major factor in explaining growth rates of inputs, which Hulten and Schwab show to be significant determinants of differences in regional growth rates. Therefore, this study identifies the broad role of public infrastructure in explaining regional growth differentials, primarily through its effect on factor flows.

Footnotes

1. Beeson (1987) found various determinants of TFP at the state level. Aschauer (1989) and Munnell (1990) have examined the effect of public capital stock on TFP growth using national-level time-series data.

2. This advantage explains why firms in high-wage cities may be able to compete successfully with firms in low-wage cities. Also, it explains why capital may move from low-wage to high-wage areas. Eventually, however, the advantage may dissipate as additional firms move into an area.

As Beeson (1987) points out, a region's rate of productivity growth depends on its rate of technical change and degree of scale economies, both of which may be affected by public infrastructure. For instance, public school systems and colleges may increase a region's rate of technical change by training a skilled labor force and linking a metropolitan area to the national and international network of ideas and innovations, thereby affecting the rate at which firms develop and incorporate technical advances into their production processes. Public transportation networks may increase a region's scale economies through encouraging specialization by firms in the manufacturing sector. Beeson separates TFP into components related to scale economies and technical change, in order to test the individual effects of regional characteristics on these components.

3. Another interpretation of age of housing is that it provides a proxy for public infrastructure. Entering age of housing along with public capital stock measures may reduce the errors-in-variable bias of the public capital stock measure by adding another dimension to the measure of infrastructure.

4. An alternative explanation would be that the offsetting effects of recessions and expansions on economic performance during the second period may leave little variation to explain. However, the relatively good fit of the output equation for the second period, shown in table 6, runs counter to that explanation.

5. The same positive and statistically significant relationships were found between inputs and public capital stock when inputs were not weighted by their share of value added. It should be noted that these equations are not factor-demand equations, because factor prices have not been included. Rather, they are best interpreted as correlations between private input growth and public capital growth.

6. Because each of the private inputs is weighted by its share of total output, we would expect the coefficient of each input to be one, which is the case for labor but not for private capital. When unweighted input growth is used, estimates for the first period are 0.65 for labor and 0.23 for private capital, which are much closer to the input elasticities typically estimated for these factors. Using unweighted input growth does

not change the statistically insignificant relationship between public capital stock and output.

Another issue is the appropriate specification of the production function. Using the simple log-linear production described above, constant returns to scale cannot be rejected. Thus, the labor productivity estimates, in tables 3 and 4, can be viewed as an output equation with constant returns to scale imposed on the private inputs. In this case, public capital stock remains positive and statistically significant even when private capital per labor growth is entered into the equation. However, when SMSA-characteristic variables such as age of housing are omitted from the equation, public capital stock is statistically insignificant. Other specifications, such as a translog production function, were not estimated, because this paper focuses primarily on the components of output growth. See Eberts (1986) for an investigation of public capital stock as an input into the production function.

7. Considerably more information could be gained by examining annual growth rates instead of aggregating these rates across broader periods. This line of inquiry has been pursued in other papers, for example, Eberts (1986). Rather, the purpose of this paper was to extend Hulten and Schwab's approach to estimate the effect of infrastructure on TFP.

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Table 1: Means for Snow Belt and Sun Belt SMSAs, 1965-77

Variables	All	Average Annual Growth Snow Belt	Sun Belt
Output	2.82	2.36	3.54
TFP	1.41	1.57	1.18
	(50.0)	(66.5)	(33.3)
Private Capital	1.24	.80	1.93
	(44.0)	(33.9)	(54.5)
Labor (hours)	.17	-.005	.44
	(6.0)	(.4)	(12.4)
Public Capital	1.70	1.17	2.53
Labor Productivity	2.42	2.35	2.54
Private Capital/Labor	2.02	1.59	2.69
Public Capital/Labor	1.30	1.16	1.52

Note: Growth rates are computed by averaging the annual growth rates within each time period. Labor is computed as the number of hours worked during the year, as described in the text. Labor and private capital are weighted by their share of total output, assuming constant returns to scale for the private inputs. Numbers in parentheses are the share of the growth rate of output for each component: TFP, private capital, and labor.

Source: Author's calculations.

Table 2: Means for Snow Belt and Sun Belt SMSAs, 1965-73 and 1973-77

	1965-73		1973-77	
Variables	Average Annual Growth	Snow Belt/ Sun Belt	Average Annual Growth	Snow Belt/ Sun Belt
Output	3.51	-.62	.33	-2.5
		(-1.03)		(-2.91)
TFP	1.48	.88	-1.08	-.32
		(2.35)		(-.61)
Private Capital	1.65	-.98	1.46	-1.38
		(-2.58)		(-3.22)
Labor	.38	-.39	-0.05	-.81
		(1.55)		(2.40)
Public Capital	1.76	-1.31	1.41	-1.23
		(-3.83)		(-2.86)
Labor Productivity	2.69	.21	.40	-.91
		(.64)		(-2.01)
Private Capital/Labor	2.49	-1.00	2.77	-.64
		(-2.16)		(-.99)
Public Capital/Labor	.95	-.48	1.48	.38
		(-1.03)		(.57)

Note: Growth rates are computed by averaging the annual growth rates within each time period. Labor is computed as the number of hours worked during the year, as described in the text. Labor and private capital are weighted by their share of total output, assuming constant returns to scale for the private inputs. Numbers in Snow Belt/Sun Belt column are the estimated coefficients of the dummy variable indicating SMSAs in the Snow Belt. The numbers in parentheses are the t-statistics of these coefficients.

Source: Author's calculations.

Table 3: Relationship Between Average Annual Growth in Public Capital Stock and Average Annual Growth in TFP, 1965-73

Variables	Total Factor Productivity A	Total Factor Productivity B	Total Factor Productivity C	Total Factor Productivity D	Labor Productivity A	Labor Productivity B
Public Capital Stock	-.217 (1.55)	.488 (1.90)	.497 (1.91)	.542 (1.79)	.613 (2.25)	.544 (1.89)
Age of Housing		.0008 (3.14)	.0007 (2.71)	.0008 (1.92)	.0006 (2.29)	.0008 (2.21)
Unionization			.0001 (.56)	-.00006 (-.17)		-.0002 (-.55)
Population				-.76E-06 (-.24)		-.58E-06 (-.20)
Population squared				.91E-10 (.27)		.40E-10 (.12)
Education				.003 (.42)		.003 (.56)
Durable Manufacturing				.00001 (.11)		-.69E-05 (-.07)
Private Capital				-.319 (-1.08)		.308 (2.31)
Labor				.370 (.91)		
Snow Belt				.002 (.23)		.001 (.25)
Adjusted R-squared	.04	.24	.22	.10	.09	.10

Note: Variables are described as follows: (1) public capital stock is measured as the average annual growth rate, (2) the age of housing is the percentage of 1970 housing stock in place in 1950, (3) unionization is the percentage of workers covered by collective bargaining contracts, (4) population is the size of the SMSA, averaged over the relevant time period, (5) education is the median education level of workers in the SMSA in 1970, (6) durable manufacturing is the percentage of manufacturing workers in durable-goods industries, (7) labor and private capital are defined in table 1, and (8) Snow Belt is a dummy variable indicating those SMSAs in the Snow Belt (which include SMSAs in the South Atlantic, East South Central, West South Central, Mountain and Pacific census divisions).
Source: Author's calculations.

Table 4: Relationship Between Growth in Public Capital Stock and Growth in TFP, 1973-77

	Total Factor Productivity				Labor Productivity	
Variables	A	B	C	D	A	B
Public Capital Stock	-.060 (-.31)	-.307 (-1.11)	-.257 (-.90)	-.113 (-.38)	-.428 (-.17)	-.104 (-.37)
Age of Housing		-.0004 (-1.16)	-.0006 (-1.57)	.0004 (.72)	-.0003 (-1.06)	.0004 (.72)
Unionization			.0005 (1.24)	-.0003 (-.50)		-.0005 (-1.05)
Population				.34E-05 (.67)		.30E-05 (.57)
Population Squared				-.34E-09 (-.59)		-.36E-09 (-.66)
Education				.009 (.98)		.008 (.90)
Durable Manufacturing				.0002 (1.36)		.0002 (1.46)
Private Capital				-.351 (-1.22)		.158 (.97)
Labor				.559 (1.39)		
Snow Belt				-.010 (-1.27)		-.012 (-1.62)
Adjusted R-squared	-.03	.00	.00	.10	.00	-.02

Note: See table 3 for variable definitions.

Source: Author's calculations.

Table 5: Growth of Public Capital Stock and Growth of Output and Inputs, 1965-73

Variables	Output A	Output B	Combined Inputs	Capital	Labor
Public Capital	.78 (2.75)	.14 (.70)	.76 (2.90)	.46 (2.80)	.30 (2.48)
Snow Belt	.0086 (1.35)	.006 (1.40)	.003 (.54)	.002 (.40)	.002 (.62)
Unionization	-.0005 (-1.27)	.0001 (.27)	-.0008 (-2.08)	-.0006 (-2.56)	-.0002 (-1.03)
Private Capital		.65 (2.46)			
Labor		1.13 (3.19)			
Constant	.030 (2.12)	.012 (1.14)	.026 (1.98)	.023 (2.89)	.002 (.37)
Adjusted R-squared	.28	.71	.44	.49	.25

Note: See table 3 for variable definitions.

Source: Author's calculations.

Table 6: Growth of Public Capital Stock and Growth of Output and Inputs, 1973-77

Variables	Output A	Output B	Combined Inputs	Capital	Labor
Public Capital	.66	-.13	.69	.38	.32
	(1.80)	(-.53)	(2.77)	(2.47)	(2.24)
Snow Belt	-.017	-.005	-.009	-.004	-.005
	(-1.67)	(-.81)	(-1.28)	(-.99)	(1.37)
Unionization	-.00002	.00006	-.0005	-.0006	.0001
	(-.03)	(.14)	(-1.16)	(-2.06)	(.50)
Private Capital		.53			
		(1.99)			
Labor		1.86			
		(6.21)			
Constant	.005	-.0003	.024	.027	-.005
	(.24)	(-.02)	(1.77)	(3.23)	(-.67)
Adjusted R-squared	.22	.74	.42	.46	.20

Note: See table 3 for variable definitions.

Source: Author's calculations.

Table 7: Sources of the Slowdown of Growth in Output and Total Factor Productivity (TFP), 1965-73 and 1973-77

	Change in Growth Rate of:	
	Output	TFP
Change in Growth Rate of:		
Share-Weighted Labor	2.29 (5.58)	1.29 (3.14)
Share-Weighted Private Capital	.71 (1.82)	-.29 (-.74)
Public Capital	.09 (.26)	.09 (.26)
Constant	.02 (5.33)	.02 (5.33)
Adjusted R-squared	.48	.18

Note: Variables are constructed by subtracting the growth rate in the second period from the growth rate in the first period.

Source: Author's calculations.