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Is Public Expenditure Productive?

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I. Introduction

This paper considers the recent behavior of productivity in the private United States economy and the extent to which its movements can be explained by public sector capital accumulation as well as by the flow of government expenditures on goods and services. Much of the traditional discussion of fiscal policy centers on the public sector deficit and the importance of the decision of the fiscal authorities to issue debt rather than utilize contemporaneous taxes to cover a particular spending level. Government deficits are thought to have a variety of effects on the private economy, ranging from forcing up real interest rates and "crowding out" private investment in additional plant and equipment to raising wealth and stimulating household consumption demand.[1]

The equilibrium or newclassical approach to fiscal policy presents a different analysis of the impact of fiscal decisions on the private sector. At the core of this perspective on fiscal policy lies the proposition that, to a first approximation, the (lump-sum) financial policies of the government are irrelevant to private sector outcomes. This hypothesis of an equivalence between tax and debt finance of a particular time sequence of government spending has been subjected to empirical testing along a number of routes. Boskin (1987), Eisner (1986), Feldstein (1982), Modigliani and Sterling (1986), and Poterba and Summers (1987) recently have presented evidence that private consumption expenditure is stimulated by bond-financed tax cuts. However, Aschauer (1985), Barro (1978), Kochin (1974), Kormendi (1983), Leiderman and Razin (1988), Seater (1982), Seater and Mariano (1985), and Tanner (1978, 1979) balance the scale with contrasting findings. While Hoelscher (1986) finds a positive influence of government deficits on long-term interest rates, Evans (1985, 1986, 1987) and Plosser (1982, 1987) either have been unable to uncover any statistical association between public sector bond issuance and interest rates or have obtained evidence of a negative relationship.

While opinion, along with the evidence, may differ on the appropriateness of the fiscal equivalence proposition, the equilibrium approach allows an important shift of emphasis to the public sector decisions which are made regarding real variables such as changes in tax rates, and consequent alterations in private incentives to consume, invest, and produce as well as shifts in spending patterns across time and across categories of goods and services.[2] For instance, Ahmed (1986) and Barro (1981, 1987) have emphasized the distinction between transitory and permanent changes in the level of government purchases of goods and services for explaining movements in interest rates, output, and the trade balance. A temporary surge in government expenditure is theorized to induce excess demand pressures which raise real interest rates, generate an increase in domestic production along intertemporal substitution lines, and result in a trade deficit. Permanent expansions of government spending, by reducing private sector wealth and by ultimately inducing increases in tax rates, have much smaller effects on excess demand, after-tax real interest rates, production, and the current account. These papers contain empirical results which permit, if not compel, one to assert the appropriateness of this approach to the analysis of government spending shocks on the economy.

Similarly, Aschauer (1988b) advances the idea that on neoclassical grounds expansions of public investment spending should have a larger stimulative impact on private output than equal-sized increases in public consumption expenditure. Specifically, public investment is argued to induce an increase in the rate of return to private capital and, thereby, to stimulate private investment expenditure. The empirical analysis indicates that movements in public investment bring forth movements in private sector output which are as much as four to seven times as large as the public sector outlays, while changes in government consumption have, at best, a small positive influence on production, somewhat smaller than unity.[3]

The results of this paper allow tentative answers to at least two questions of importance in the macroeconomic literature. First, by indicating the degree to which public expenditures are productive, we are in a better position to judge the extent to which public expenditure policies induce excess aggregate demand pressures, raise interest rates, and stimulate production. For instance, given a sufficiently high marginal productivity of government spending, a temporary surge in public expenditure may well bring about a multiple expansion of output, even in an economy with fully utilized resources. Second, we may consider the role of government expenditures in longer term movements in productivity. Indeed, as is argued in Section IV, the decrease in productive government services may be crucial in explaining the general decline in the rate of growth of productivity which apparently arose in the early 1970's.[4]

Section II contains a discussion of the theoretical framework of this paper. Section III presents the results of estimating the theoretical relationship between productivity and government expenditure variables. Section IV relates the results of the empirical section to the productivity slowdown in the private business economy. Section V concludes with a consideration of directions for future research.

II. Conceptual Framework

The analysis is centered on the aggregate production technology

$$Y_t = A_t{*}f(N_t, K_t, G_t) \tag{1}$$

where Y_t = a measure of real aggregate output of goods and services of the private sector, N_t = aggregate employment of labor services, K_t = aggregate private nonresidential capital input, and A_t = a measure of productivity or Hicks neutral technical change. The variable G_t represents a flow of services from the government sector; for instance, assuming that the services of public capital are proportional to public capital, G_t may be taken as the public capital stock. The productivity measure implicitly is a function of aggregate shocks and perhaps of time independently of the aforementioned variables.

Assuming a generalized Cobb-Douglas form for the production technology yields the logarithmic version

$$y_t = a_t + e_N{*}n_t + e_K{*}k_t + e_G{*}g_t \tag{2}$$

where lower case variables denote logarithms of upper case variables and e_i = elasticity of output with respect to the variable $i = N, K, G$. We assume that the government provides services directly to private producers without employing user fees and subsequently finances expenditures through taxes.

Public finance theory stresses that a basic rationale for government provision of goods and services is that for one reason or another economic agents in the private market economy are unable or unwilling to accomplish the task. The benefits from certain activities may not be "appropriable" in that there is no practical manner in which producers may exclude particular agents from consuming the goods or services. The inability to exclude brings with it the inability to charge and receive a price such as to yield a competitive return to the producer. Consequently, the private market would fail to properly allocate resources to their most efficient uses. Another reason for public intervention, and perhaps provision, arises from economies of scale in production. The acquisition and distribution of water, for example, may allow for substantial decreases in cost along with increases in the scale of production; and while pricing mechanisms can be developed so as to insure an efficient allocation of resources, it is also necessary in such cases to allow a monopolist to engage in the entirety of production. Perhaps the most efficient, or at least the most easily monitored producing entity would then be the government itself.

The argument for possible economies of scale resting behind the public provision of a significant share of the inputs to private production suggests that a reasonable specification of the private technology would involve assuming that f( ) exhibits constant returns to scale over the private inputs N_t and K_t but increasing returns over all inputs, inclusive of government services G_t. In this case, private factors may be paid according to their marginal productivity and private output will be exhaustively distributed. Assuming competitive product and factor markets we may obtain the productivity measures

$$y_t - k_t = a_t + e_N{}^*(n_t - k_t) + e_G{}^* g_t \tag{3}$$

and

$$p_t = y_t - s_N{}^* n_t - s_K{}^* k_t$$
$$= a_t + e_G{}^* g_t. \tag{4}$$

Here, equation (3) expresses output per unit of capital as it relates to the private labor-capital ratio and to the flow of government services. Alternatively, equation (4) shows that total factor productivity, p_t, is positively related to government services, where s_i = gross of tax share of factor i in total product, $i = N, K$. Thus, in the case of increasing returns across all factors appropriate productivity specifications involve the absolute level of the government service flow as the use of the factor is available to all producers.

On the other hand, it may be argued that congestion effects are severe enough so as to render the assumption of increasing returns inappropriate, at least in the relevant range. Accordingly, consider next the case of constant returns to scale across all factors, private and public. In this case, if private factors are paid according to their marginal products, private output will not be fully distributed. Nevertheless, we may still obtain an expression for the productivity of private capital as

$$y_t - k_t = a_t + e_N{}^*(n_t - k_t) + e_G{}^*(g_t - k_t). \tag{5}$$

To obtain an expression for total factor productivity, it is necessary to make some assumption about the manner in which the rents from public services are appropriated by the private factors of production. We will simply assert that private factor shares are proportionally related to their respective true marginal productivities, or

$$s_i = \theta^* e_i$$
$$i = N, K.$$

This allows us to obtain the expression for total factor productivity

$$p_t = a_t + e_G{}^*(g_t - i_t) \tag{6}$$

where $i_t = s_K{}^* k_t + s_N{}^* n_t$ is a combination unit of labor and private capital inputs.[5] Note that equations (3) and (4) are special cases of equations (5) and (6) respectively, so we may conveniently test for the appropriateness of the two specifications of returns to scale.

III. Empirical Analysis

The empirical analysis focuses on the period 1949 to 1985 and utilizes annual data.[6] The data on output, hours, private capital, and productivity are for the total private business economy and are obtained from the Monthly Labor Review, published by the Department of Labor. Data on the public capital stock are from a publication of the Department of Commerce, Fixed Reproducible Tangible Wealth 1925-85. The public capital stock data are net of depreciation and measured in constant 1982 dollars. The depreciation methodology is straight-line over useful service lives, the latter determined by comparisons with similar private capital assets, information obtained from various governmental agencies on actual service lives, as well as on assumptions made by Goldsmith in an earlier background study. This public capital stock variable is inclusive of federal, state and local capital stocks of equipment and structures.[7] The flow government spending variables are from the National Income and Product Accounts. The capacity utilization rate is from the Federal Reserve Bulletin and is restricted to the manufacturing sector of the economy.

The general equations to be estimated are given as

$$y_t - k_t = a_0 + a_1{*}t + a_2{*}(n_t - k_t) + a_3{*}(g_t - k_t) + a_4{*}cu_t + u_t$$

and

$$p_t = b_0 + b_1{*}t + b_2{*}(g_t - i_t) + b_3{*}cu_t + e_t.$$

The logarithm of the capacity utilization rate, cu_t, is employed to control for the influence of the business cycle as well as to allow comparison with previous productivity studies which ascribed importance to declining capacity use in explaining the productivity slowdown of the 1970's and 1980's.[8]

Table 1 contains estimates of the above equations where the government variable is the net stock of nonmilitary public structures and equipment. Equation (1.1) shows a strong positive relationship between output per unit of capital input, the private labor-capital ratio, and the ratio of the public capital stock to the private capital input. A one percent increase in the labor-capital ratio brings forth an increase in the productivity of capital equal to .35 of one percent, while a one percent increase in the ratio of public to private capital stocks raises productivity by .39 of one percent. After accounting for the average growth rates of the private labor-capital ratio and the public capital-private capital ratio, output per unit of capital grew by .8 percent per year over the sample period. Finally, as was to be expected, the productivity of capital is highly procyclical, as evidenced by the significantly positive coefficient on the capacity utilization rate.

Equation (1.2) allows for separate coefficient estimates of the private and public capital stocks and thereby allows for a test of the constant returns to scale restriction implicit in equation (1.1). At a heuristic level, we see that the coefficient on the private capital input is opposite in sign and of roughly the same magnitude as the coefficient on the public capital stock. We might expect, therefore, not to be able to reject the constant returns to scale restriction at typical significance levels. Indeed, the value of the relevant F-statistic is 1.27, substantially below the five percent critical point of the F distribution with (1, 31) degrees of freedom, 4.16.

It is interesting to compare the results of equations (1.1) and (1.2) to the results which are obtained upon omitting the public capital stock variable. Equation (1.3) shows how this omission affects the previous results. The most significant change is that the coefficient on the labor-capital ratio changes from significantly positive to significantly negative, indicating a negative marginal productivity of labor. Furthermore, the coefficient on the private capital stock is significantly negative, thereby indicating a rejection of the assumption of constant returns to scale over private labor and capital. Note, however, that the low value of the Durbin-Watson statistic points out the presence of significant positive serial correlation in the residuals of the estimated equation. Equation (1.4) reestimates the relation employing a correction for first-order autocorrelation. The coefficient of the labor-capital ratio is now slightly positive and insignificantly different from zero, while the coefficient on private capital remains significantly negative. The reason for the serial correlation now seems clear; an important factor of production—which is itself autocorrelated—has been omitted from the usual specification of the private production technology. Including the public capital stock variable eliminates the serial correlation and allows positive and significant elasticities to be attributed to the private factors as well.

Equations (1.5) through (1.8) relate total factor productivity to public capital and private inputs. Equation (1.5) exhibits the strength of the relationship between the public capital stock and productivity apart from any other factors of production. Equation (1.6) allows for the influence of the private capital stock and labor inputs; under the assumption of constant returns to scale, these coefficients are expected to be equal, in absolute value, to the shares of the respective factors multiplied by the scaling parameter, θ. Equation (1.7) indicates that the combined private labor-capital input is statistically significant and carries a sign appropriate to the assumption of constant returns to scale. Equation (1.8) imposes constant returns to scale across all inputs with only a minor alteration in the responsiveness of productivity to the public capital stock. The F-statistic for the purpose of testing the constant returns to scale constraint equals 1.32, substantially below $F_{5\%}(1, 33) = 4.13$.

It is also of interest to directly estimate the value of the scaling parameter θ. Under the identifying restriction that the ratio of labor's share to capital's share equals the ratio of their respective elasticities, we may obtain the following equation:

$$y_t - k_t = c_0 + c_1{}^*t + (c_2/c_3)^*(n_t - k_t) + (1 - (1/c_3))^*(kgxm_t - k_t)$$
$$+ c_4{}^*cu_t + v_t$$

where $c_2 = s_N$ and $c_3 = \theta$. Estimation by nonlinear least squares yields the following parameter estimates:

c_0	=	-2.42	(-21.58)
c_1	=	.01	(4.62)
c_2	=	.58	(4.26)
c_3	=	1.62	(25.81)
c_4	=	.43	(12.28)

R^2 = .977 SER = .0078 DW = 1.79 SSE = .001960

Importantly, the estimated value of labor's share, .58, lies within one standard error of the actual average value of labor's share during the sample period, .65. The scaling parameter indicates that the shares of both labor and capital are sixty-two percent higher than their respective elasticities, a result in agreement with the previous estimates in Table 1.

The strong, positive relationship between public capital and productivity is also robust to choice of the sample period. The results of Table 2 indicate that reestimating the productivity equations for the periods 1949-67/1968-85, 1953-1985 and 1949-1981 yields a response of productivity to movements in public capital in the range .38 to .56. On the other hand, there exists less stability in the association of output per unit of capital to the private labor-capital ratio, with a low and insignificant coefficient value in the period 1949-1967. Still, explicit F tests cannot reject the hypothesis of overall coefficient stability for any of the chosen subsamples.

The equations in Tables 1 and 2 which involve the public capital stock contain no indication of serial correlation in the estimated error terms. Despite this fact, Table 3 contains regressions involving the lagged values of the regressand and regressors of each equation so as to consider the appropriateness of estimating in level form. Neither in the case of output per unit of capital nor total factor productivity are the lagged values of the regressand or regressors significantly different from zero. Furthermore, the coefficients on the contemporaneous variables retain nearly the same signs as well as their statistical significance as compared to the original specification.

Of course, it is conceivable that the relationship between public capital and productivity is merely evidence of a reverse causation from productivity, proxying for per capita income, to the demand for public capital.[9] We offer a number of checks against the appropriateness of this latter interpretation. First, the fact that public capital aids in fitting a production function leads to a presumption against this latter interpretation of the data. Second, two stage least squares estimates were obtained, using the lagged value of the public capital ratio as an instrument. The results were robust to this alternative method of estimation; for example, for the productivity of capital we generate the following production relation:

$$y_t - k_k = \underset{(-18.05)}{-2.33} + \underset{(4.68)}{.01^{*}t} + \underset{(4.85)}{.41^{*}(n_t - k_t)} + \underset{(15.44)}{.40^{*}(kgxm_t - k_t)} + \underset{(9.06)}{.39^{*}cu_t}$$

$R^2 = .977$ SER $= .0077$ DW $= 1.74$ SSE $= .001843$

As another check on the direction of causation, we can isolate a particular sector of the economy and certain type of public capital in which a strong a priori case for a productivity effect can be made. The following regression relates the level of output per employee in the trucking industry to the net stock of public highways during the period 1949 to 1985:

$$y_t - n_t = \underset{(-10.73)}{7.74} \underset{(-2.25)}{-.76^{*}n_t} + \underset{(2.39)}{.33^{*}k_t} + \underset{(5.70)}{.80^{*}kgh_t} + \underset{(3.56)}{.61^{*}cu_t}$$

$R^2 = .987$ SER $= .030$ SSE $= .026057$ rho $= .68$ (5.96)

where $y =$ logarithm of gross national product in the trucking industry, $n =$ logarithm of employees in trucking, $k =$ logarithm of net stock of structures and equipment in trucking (all from the National Income and Product Accounts) and $kgh =$ logarithm of net stock of highways. The stock of highways takes on a coefficient value of .80 which is at a high degree of statistical significance. In this case, the implied sum of the elasticities of private capital and labor as well as the public stock of highways equals 1.37, suggesting the presence of increasing returns to scale across all variables. Still, the restriction of constant returns to scale cannot be rejected at the 5% level.

Government Spending and Productivity

Table 4 contains regressions relating the flow expenditures of the total government sector to output per unit of private capital, given the nonmilitary public capital stock and the capacity utilization rate, over the period 1949 to 1985. Regressions involving total factor productivity sketched essentially the same picture and are therefore not reported here. The government spending variables are expressed relative to the private capital input. As the regressions include the capacity utilization rate, which presumably would capture the demand-side influence of government expenditure on the economy, it seems proper to interpret the estimated coefficients on the flow spending variables as a measure of their contribution to productivity in the private business economy.[10] Still, for a variety of reasons the level of expenditures may be a poor proxy for the flow of productive inputs from the public sector. Perhaps most importantly from the perspective of the current study, it would overstate their contribution to the amount of publicly provided inputs to the degree that current public investment were included, similar to the way total consumer spending would overstate the level of consumption due to the inclusion of consumer expenditures on durable goods. Accordingly, unless stated otherwise, the government flow variables are defined net of public investment in nonmilitary equipment and structures.

Equation (4.1) indicates that the total level of government spending, relative to the private capital input, contains no additional explanatory power for productivity in the private business economy. The estimated elasticity is small, .01, and statistically insignificant. Equation (4.2) allows for a separate influence of non-military and military spending, respectively, on productivity. Both variables carry insignificant coefficient values. Note, however, that the standard error of the coefficient estimate on the public capital stock variable has increased, owing to the collinearity between this variable and a weighted geometric average of the nonmilitary and military flow spending variables. Equations (4.3) and (4.4) contain specifications with nonmilitary and military spending entered separately; again, neither flow variable attains either quantitative or statistical importance in explaining movements in total factor productivity.

Equations (4.5) through (4.8) take account of the potential endogeneity of the government variables by employing two stage least squares estimation procedures, using lagged values of the government variables as instruments. As in the ordinary least squares regressions, the flow expenditure variables are insignificant independent of the manner in which they are entered into the specification. However, in equation (4.6) the public capital stock is significant only at the ten percent level, again owing to the high degree of collinearity between the public capital stock and a geometric weighted sum of nonmilitary and military expenditure.

Equations (4.9) and (4.10) distinguish between expenditures on labor input and other goods and services.[11] In equation (4.9) it is seen that government employee compensation has little additional explanatory power for productivity. In equation (4.10) neither the compensation variable nor spending on other goods and services enters significantly in the productivity expression. From the perspective of the present paper, these results are consistent with—though by no means conclusive evidence in favor of—the idea that there are offsetting effects of government spending, net of public investment, on productivity in the private sector. While police services may enhance productivity, government resources devoted to the regulatory process may detract from measured output per unit of input thereby leaving, on net, no discernable impact.[12]

Military versus Nonmilitary Capital

During the sample period 1949-1985, the military capital stock accounted for as much as thirty-three percent of the total government stock of structures and equipment. Despite the magnitude of the military capital stock, one would expect on a priori grounds that military structures and equipment would be of less importance in understanding trends in productivity than nonmilitary government capital. The addition of the logarithm of military capital, *kgm*, to the basic specification allows the regression results

$$y_t - k_t = \underset{(-10.51)}{-2.29} + \underset{(4.64)}{.008^*t} + \underset{(4.67)}{.38^*(n_t - k_t)} + \underset{(15.33)}{.39^*(kgxm_t - k_t)}$$

$$- \underset{(-.72)}{.01^*(kgm_t - k_t)} + \underset{(11.41)}{.42^*cu_t}$$

$$R^2 = .976 \quad \text{SER} = .0079 \quad \text{DW} = 1.83 \quad \text{SSE} = .001928$$

Although the coefficient value on the military capital ratio is negative, its insignificance indicates that it aids little in understanding productivity movements during the sample period.

Structures versus Equipment

We next consider the importance of discriminating between public sector nonmilitary structures and equipment, the former accounting for 93% of total nonmilitary public capital. In interpreting these and subsequent results, note that from the perspective of the production technology, in decomposing the public capital stock in this manner we would expect that the sum of the estimated coefficients on the separate capital variables should not significantly depart from the estimated coefficient for the aggregate stock.[13] Table 5 contains regressions in which structures and equipment are allowed to have separate effects on productivity. Equation (5.1) indicates that structures are of primary importance to productivity. Equipment carries the proper sign but is of little statistical importance. However, taking the two coefficient estimates at their face value, their sum indeed equals the coefficient carried by the total nonmilitary capital stock in Table 1, equation (1). Equation (5.2) suggests that structures acts as a good proxy for the total nonmilitary public capital stock, with the coefficient estimate equalling that obtained previously for the total stock. Equations (5.3) and (5.4), on the other hand, indicate that the stock of equipment fares worse as a proxy variable for the total stock, although when entered alone its coefficient is positive and significant.

"Core" Infrastructure and Productivity

It may be argued that a "core" infrastructure consisting of streets and highways, airports, electrical and gas facilities, mass transit, water systems, and sewers should possess greatest explanatory power for productivity. These public structures might be modelled most appropriately in a fixed coefficients manner, thereby reflecting their joint necessity in fostering economic growth and productivity improvement. Table 6 contains estimated elasticities for such an infrastructure as well as for other categories of public nonmilitary capital. The table also presents the share of each category in the total nonmilitary stock of public capital and F statistics relevant for testing the constraint that the sum of the coefficients on each of the various categories and their respective complements equals .39, the coefficient value taken by the aggregate nonmilitary public capital stock. The estimated elasticity for the core infrastructure, which accounted for 55% of the total nonmilitary stock, equals .24 and is highly significant. The value of the F statistic for testing the sum of coefficients constraint is .16, compared to the 5% critical point of the F distribution with (1, 31) degrees of freedom, 4.16. Public sector hospitals, 6% of the total stock, carries an elasticity of .06 but is insiginificantly different from zero at the 10% level. The category "other buildings," consisting of general office buildings, police and fire stations, courthouses, auditoriums, garages, and passenger terminals, and representing 7% of the total stock has an estimated elasticity of .04, also insignificant at the 10% level. The elasticity of output with respect to conservation and development structures—park facilities, hatcheries, etc.—is estimated as .02. Finally, the stock of educational buildings—16% of the total stock—has an estimated elasticity which is negative and insignificant. At first blush, this might appear to offer evidence against the interpretation of a production relationship between the aggregate public capital stock and the productivity measures. However, one would expect there to be significant temporal lags between the construction of educational facilities and any consequent impact which they might have on productivity. In fact, the result that the estimated coefficient on educational buildings is minor in conjunction with the fact that the share of educational structures in total structures is large offers some additional evidence against the argument of a reverse causation from per capita income to the demand for public capital.

V. Public Capital and the Productivity Slowdown

After averaging 2.2 percent during the two decades from 1950 to 1970, the annual growth rate of total factor productivity in the private business economy slumped to .6 percent per year during the period 1971 to 1985. The period from 1980 to 1985 exhibited the worst average yearly productivity growth, a mere .2 percent. Many explanations of the causes of the productivity decline have been offered. One potential reason is a fall-off in expenditures on research and development and consequent decline in technological growth. The growth rate of domestic R&D expenditures was 6.5 percent from 1960 to 1969 but fell to 2.6 percent from 1969 to 1979 at the same time that productivity growth in the private economy declined from 2 percent to .9 percent. However, Scherer (1982) and Griliches (1980, 1983) have concluded that "it is unlikely that the recent productivity slowdown can be blamed on the R&D slowdown. If anything, the causality may run in the other direction."[14] Denison (1985) mentions the possibility of increases in energy prices during the 1970's playing a role in the decline in productivity but performs some preliminary calculations and comes to the conclusion that the oil price shocks "made a contribution but that it was not major until after 1979, and that even then it was not the dominant cause of the productivity slowdown."[15] Others have noted the halt in the migration of workers from farm to nonfarm occupations which occurred about 1965. As it may be argued that before that point in time these workers were moving from less to more productive occupations, total factor productivity grew at a high rate, but then slowed as labor ceased to shift across sectors. While the timing is right, the Bureau of Labor Statistics estimates that this source cannot go far enough in explaining the general fall-off in productivity.

The results of this paper suggest the importance of considering public capital expenditures in attempting to explain the productivity decline. Table 7 presents average annual growth rates of total factor productivity and the nonmilitary public capital stock. The growth rate of the net stock of government capital fell from 4.1% during the period 1950-70 to 1.6% during the later period 1971-85. Figure 1 is instructive, picturing the normalized relationship between total factor productivity (after accounting for the effects of time, the private factors of production and the capacity utilization rate) and the public capital stock (detrended). Dramatically, the fall-off in productivity growth is matched, or slightly preceded, by a precipitous decline in additions to the net stock of public nonmilitary structures and equipment.

Surprisingly, the potential importance of public capital in explaining the productivity slowdown does not appear to have been discussed widely in the professional literature. In a study of regional productivity growth in manufacturing, Hulten and Schwab (1984) discover that output growth in the Sun Belt was twice that in the Snow Belt but that it was due to variations in the rates of growth of private capital and labor. Thus, they "find no evidence to support the hypothesis that an aging public infrastructure...(has) slowed total factor productivity growth in the Snow Belt."[16 17] However, the authors make no attempt to directly measure the importance of public capital to productivity. Further, Garcia-Mila and McGuire (1987) have found strong contributory power for highways in state-wide production functions.

V. Conclusion

The newclassical approach to fiscal policy, by de-emphasizing the importance of public financial decisions, has opened up new avenues along which to tread in the search of important effects of public policy on the economy. This study may be placed in this category as it finds significant weight should be attributed to public investment decisions--specifically, additions to the stock of nonmilitary structures such as highways, streets, water systems, and sewers--when assessing the role the government plays in the course of economic growth and productivity improvement.

In future research, it would be useful to extend the analysis to permit a cross-country comparison of public investment and productivity trends. For example, during the period 1973 to 1985, public net investment in the United States and Japan averaged .3 and 5.1 percent of gross domestic product, while their respective growth rates of real gross domestic output per employed person were .6 and 3.1 percent per annum.[18] As illustrated by Figure 2, a simple regression of average annual growth rates of labor productivity in the "G-7" countries against ratios of public investment to gross domestic output for the period 1973-85 yields a slope coefficient of .47 with an associated T-statistic of 3.98. On the other hand, the growth of output per hour in these countries during the same period was negatively related to the ratio of government consumption to output.

Public sector deficits truly may be important for determining the level of real interest rates, private investment decisions, and the economy's dynamic performance. Still, it must be admitted that the real intertemporal allocation of public sector resources is likely to be of comparable or even dominating importance. Indeed, while on a National Income and Product Accounts basis the public sector budget deficit has averaged 1 percent of Gross National Product from 1949 to 1985, the level of net public investment has averaged 1.4 percent. The presumption would be that fluctuations in the latter variable could have marked effects on the private sector; indeed, that is the basic conclusion to be drawn from this paper.

Footnotes

[1] See, for instance, Eisner (1986).

[2] For a complete analysis of the equilibrium or newclassical approach to fiscal policy, see Aschauer (1988a), Barro (1988), and Bernheim (1987).

[3] Darby (1984) makes a quality adjustment for hours worked and disputes the existence of any productivity decline. Even so, he states that "the fact that factors such as regulation, governmental size, oil prices, management practicies, educational quality, moral fiber, and the like have not been required to fully explain twentieth-century variations in labor productivity does not imply that they have been unimportant. Any or all of them may have been quite important in determining the trend rate of total factor productivity growth" p. 317.

[4] In the empirical analysis, the combination labor and capital input is given as the antilogarithm of $S_K{*}(k_t - k_{t-1}) + S_N{*}(n_t - n_{t-1})$, where the S_i are simple averages of the current and lagged factor shares.

[5] Only yearly observations are available for the public capital stock and total factor productivity variables.

[6] The net public capital stock variables as published are end-of-year values. Consequently, the raw data have been converted to mid-year values by simple arithmetic averaging so as to conform to the private capital input utilized in calculating total factor productivity.

[7] Tatom (1980) also employs the capacity utilization rate to improve an aggregate productivity relation, but with the restricition that the utilization rate be entered multiplicatively to the private capital stock.

[8] Wagner's Law—that government expenditure is a superior good—suggests this possibility. It should be noted, however, that there is little support for this "law" in this particular sample. A regression of the ratio of public nonmilitary spending on per capita gross national product yields

$$(gxm_t - y_t) = \underset{(-4.44)}{-2.78} + \underset{(2.08)}{.014}{*}\text{time} - \underset{(-.75)}{.25}{*}\,(y_t - pop_t)$$

$$R^2 = .618 \quad \text{SER} = .0761 \quad \text{DW} = .38 \quad \text{SSE} = .197$$

and in first differenced form

$$D(gxm_t - y_t) = \underset{(2.66)}{.021} - \underset{(-4.88)}{.99}{*}D(y_t - pop_t)$$

$$R^2 = .395 \quad \text{SER} = .039 \quad \text{DW} = 1.34 \quad \text{SSE} = .052$$

[9] It is also important to take account of the possible impact on productivity of the changes in distortional taxes which would be associated with permanent movements in the flow of government expenditure. However, when an average marginal income tax rate (Barro and Sahasukul (1986)) is included in the regressions

of Table 4, the estimated coefficient is insignificantly different from zero at usual levels and only minor alterations in the other coefficients arise.

[10] Note that the present paper is concerned with the impact of government spending—on a flow and stock basis—on productivity rather than with governmental inputs per se.

[11] It would be of interest to investigate further a more refined decomposition of government spending into various functional categories to assess their relative contributions to productivity.

[12] Let $KG^{eG} = \Pi KG^{ei}$. Then if e_N and e_K are to remain unchanged and constant returns to scale over all inputs is to be maintained, $\sum e_i = e_G$.

[13] Griliches (1980), p. 347.

[14] Denison (1985), p. 52.

[15] Hulten and Schwab (1984), p. 152.

[16] More recently, however, Hulten and Schwab (1987) point out the "slower growth of real input used in [the state and local] sector, which in turn is linked to the slowdown in the growth of government in the 1970's (and possibly to the slowdown in growth throughout the economy during this period)" p. 26.

[17] The data are from the OECD *National Accounts and Historical Statistics.*

References

Ahmed, Shagil. 1986. "Temporary and Permanent Government Spending in an Open Economy." *Journal of Monetary Economics* 17: 197-224.

Arrow, Kenneth J. and Mordecai Kurz. 1970. *Public Investment, the Rate of Return, and Optimal Fiscal Policy*. Baltimore: The Johns Hopkins Press.

Aschauer, David A. 1985. "Fiscal Policy and Aggregate Demand." *American Economic Review* 75: 117-127.

_______________. 1988a. "The Equilibrium Approach to Fiscal Policy." *Journal of Money, Credit, and Banking* 20: 41-62.

_______________. 1988b. "Public Consumption, Public Investment, and Output in the United States 1949-85." Federal Reserve Bank of Chicago *Staff Memoranda*.

Barro, Robert J. 1978. *The Impact of Social Security on Private Saving*. Washington D.C.: American Enterprise Institute.

_______________. 1981. "Output Effects of Government Purchases." *Journal of Political Economy* 89: 1086-1121.

_______________. 1987. "Government Spending, Interest Rates, Prices, and Budget Deficits in the United Kingdom 1701-1918." *Journal of Monetary Economics* 20: 221-247.

_______________. 1988. "The Neoclassical Approach to Fiscal Policy." University of Rochester working paper.

_______________. and Chaipat Sahasukul. 1986. "Average Marginal Tax Rates from Social Security and the Individual Income Tax." *Journal of Business* 59: 555-566.

Bernheim, B. Douglas. 1987. "Ricardian Equivalence: An Evaluation of Theory and Evidence." *NBER Macroeconomics Annual*: 263-304.

Boskin, Michael J. 1987. "Concepts and Measures of Federal Deficits and Debt and Their Impact on Economic Activity." NBER Working Paper #2332.

Darby, Michael R. 1984. "The U.S. Productivity Slowdown: A Case of Statistical Myopia." *American Economic Review* 74: 301-322.

Denison, Edward F. 1985. *Trends in American Economic Growth 1929-82*. Washington D.C.: The Brookings Institution.

Economic Report of the President. 1987. Washington D.C.: U.S. Government Printing Office.

Eisner, Robert. 1986. *How Real Is the Federal Deficit?* New York: The Free Press.

Evans, Paul. 1985. "Do Large Deficits Produce High Interst Rates?" *American Economic Review* 75: 68-87.

_______________. 1986. "Do Deficits Raise Nominal Interest Rates? Evidence from Six Industrial Countries." University of Houston. Mimeo.

_______________. 1987. "Interest Rates and Expected Future Budget Deficits in the United States." *Journal of Political Economy* 95: 34-58.

Feldstein, Martin S. 1982. "Government Deficits and Aggregate Demand." *Journal of Monetary Economics* 9: 1-20.

Federal Reserve Bulletin. Washington D.C.: Board of Governors of the Federal Reserve System. Various Issues.

Fixed Reproducible Tangible Wealth in the United States 1928-85. 1987. Washington D.C.: Department of Commerce.

Garcia-Mila, Teresa and Therese J. McGuire. 1987. "The Contribution of Publicly Provided Inputs to States' Economies." Unpublished.

Granger, C.W.J. and P. Newbold. 1974. "Spurious Regressions in Econometrics." *Journal of Econometrics*. 2: 111-120.

Griliches, Zvi. 1979. "Issues in Assessing the Contribution of Research and Development to Economic Growth." *Bell Journal of Economics* Spring, 92-116.

______________. 1980. "R&D and the Productivity Slowdown." *American Economic Review Papers and Proceedings* 70: 343-347.

______________. 1983. "Productivity and Technical Change." *NBER Reporter* Spring, 2-5.

Historical Statistics 1960-1985. 1987. Paris: Organization for Economic Cooperation and Development.

Hoelscher, Gregory. 1986. "New Evidence on Deficits and Interest Rates." *Journal of Money, Credit, and Banking* 18: 1-17.

Hulten, Charles R. and Robert M. Schwab. 1984. "Regional Productivity Growth in U.S. Manufacturing 1951-78." *American Economic Review* 74: 152-162.

______________. (1987) "Income Originating in the State and Local Sector." NBER Working Paper #2314.

Kochin, Levis A. 1974. "Are Future Taxes Anticipated by Consumers?" *Journal of Money, Credit, and Banking* 6: 385-394.

Kormendi, Roger C. 1983. "Government Debt, Government Spending, and Private Sector Behavior." *American Economic Review* 73: 994-1010.

Leiderman, Leonardo and Assaf Razin. 1988. "Testing Ricardian Neutrality with an Intertemporal Stochastic Model." *Journal of Money, Credit, and Banking* 20: 1-21.

Modigliani. Franco and Arlie Sterling. 1986. "Government Debt, Government Spending, and Private Sector Behavior: A Comment." *American Economic Review* 76: 1168-79.

Monthly Labor Review. Washington D.C.: Department of Labor. Various Issues.

National Accounts 1973-1985. 1987. Paris: Organization for Economic Cooperation and Development.

Nelson, Charles R. and Heejohn Kang. 1984. "Pitfalls in the Use of Time as an Explanatory Variable in Regression." *Journal of Business and Economic Studies* 2: 73-82.

_______________. and Charles I. Plosser. 1982. "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications." *Journal of Monetary Economics* 10: 139-172.

Plosser, Charles I. 1982. "Government Financing Decisions and Asset Returns." *Journal of Monetary Economics* 9: 325-352.

_______________. 1987. "Fiscal Policy and the Term Structure." *Journal of Monetary Economics* 20: 343-368.

Poterba, James M. and Lawrence H. Summers. 1987. "Finite Lifetimes, and the Effects of Budget Deficits on National Savings." *Journal of Monetary Economics* 20: 369-392.

Scherer, F.M. 1982. "Inter-Industry Technology Flows and Productivity Growth." *Review of Economics and Statistics* 64: 618-630.

Seater, John J. 1982. "Are Future Taxes Discounted?" *Journal of Money, Credit, and Banking* 14: 376-389.

_______________. and Roberto S. Mariano. 1985. "New Tests of the Life Cycle and Tax Discounting Hypotheses." *Journal of Monetary Economics* 15: 196-215.

Tanner, John E. 1978. "Fiscal Policy and Consumer Behavior." *Review of Economics and Statistics* 61: 317-321.

_______________. 1979. "An Empirical Study of Tax Discounting." *Journal of Money, Credit, and Banking* 11: 214-218.

Tatom, John A. 1980. "The 'Problem' of Procyclical Real Wages and Productivity." *Journal of Political Economy* 88: 385-394.

Table 1

Net Nonmilitary Public Capital and Productivity 1949-85

A. Output Per Unit of Capital (y-k)

Equation	Estimation Method	constant	time	n-k	kgxm-k	kgxm	k	cu	rho	$\bar{R}^2$	SER	DW	SSE
1	OLS	−2.42	.008	.35	.39	-	-	.43	-	.976	.0078	1.79	.001960
		(−21.58)	(4.62)	(4.85)	(16.23)	-	-	(12.28)	-				
2	OLS	−5.60	.010	.29	-	.36	−.44	.45	-	.977	.0078	1.74	.001883
		(−10.90)	(4.46)	(3.04)	-	(9.79)	(−7.95)	(11.31)	-				
3	OLS	−.94	.011	−.48	-	-	−.66	.74	-	.910	.0015	.63	.00770
		(−2.44)	(2.48)	(−4.73)	-	-	(−6.57)	(14.24)	-				
4	FOAC	.19	.020	.08	-	-	−.72	.47	.96	.963	.0099	2.05	.002959
		(.13)	(1.42)	(.46)	-	- -	(−3.24)	(6.47)	(10.80)				

B. Total Factor Productivity (p)

Equation	Estimation Method	constant	time	kgxm	k	n	i	kgxm-i	cu	$\bar{R}^2$	SER	DW	SSE
5	OLS	−3.87	−.002	.49	-	-	-	-	.35	.993	.0136	.99	.006080
		(−9.56)	(−1.45)	(14.54)	-	-	-	-	(8.7)				
6	OLS	−.72	.010	.34	−.09	−.36	-	-	.45	.998	.0079	1.73	.001931
		(−1.39)	(4.75)	(9.20)	(−.98)	(−3.82)	-	-	(11.15)				
7	OLS	−1.08	.001	.37	-	-	−.45	-	.42	.998	.0078	1.75	.001962
		(−2.61)	(6.52)	(15.02)			(−8.19)	-	(17.10)				
8	OLS	−1.53	.009	-			-	.39	.41	.998	.0078	1.79	.002046
		(−10.01)	(5.39)					(26.33)	(18.19)				

T statistics in parentheses.

y = logarithm of private business economy output
n = logarithm of private labor input
k = logarithm of private capital input
kgxm = logarithm of nonmilitary public capital
p = logarithm of private business economy total factor productivity
i = logarithm of combined private labor and capital input
cu = logarithm of capacity utilization rate in manufacturing

Table 2

Net Nonmilitary Public Capital and Productivity: Subsample Stability

A. Output Per Unit of Capital

Equation	Sample	constant	time	n-k	kgxm-k	cu	$\bar{R}^2$	SER	DW	SSE
1	1949-67	−2.34 (−21.44)	−.002 (−.37)	.02 (.09)	.56 (3.63)	.52 (7.76)	.981	.0054	1.74	.000406
2	1968-85	−2.48 (−8.06)	.013 (2.97)	.45 (2.49)	.53 (4.90)	.39 (4.00)	.969	.0099	1.84	.001271
3	1953-85	−2.32 (−17.62)	.010 (4.73)	.42 (4.83)	.41 (15.40)	.39 (8.78)	.979	.0078	1.77	.001694
4	1949-81	−2.39 (−18.69)	.008 (4.28)	.35 (4.52)	.39 (13.00)	.42 (11.12)	.959	.0083	1.77	.001919

B. Total Factor Productivity

Equation	Sample	constant	time	kgxm-i	cu	$\bar{R}^2$	SER	DW	SSE
5	1949-67	−1.25 (−.94)	.010 (2.52)	.36 (2.59)	.41 (8.83)	.997	.0061	1.99	.00549
6	1968-85	−2.65 (−2.59)	.010 (13.58)	.49 (5.53)	.45 (8.61)	.928	.0099	1.83	.001369
7	1953-85	−1.53 (−8.79)	.009 (34.85)	.40 (24.36)	.40 (16.36)	.997	.0078	1.74	.001761
8	1949-81	−1.54 (−7.07)	.009 (21.43)	.39 (18.33)	.41 (15.46)	.997	.0083	1.76	.002008

Table 3

$y-k$		p	
c	−2.39 (−2.91)	c	−1.25 (−2.66)
time	.009 (2.75)	*time*	.008 (3.58)
$(y-k)_{-1}$	−.08 (−.26)	p_{-1}	.08 (.33)
$(n-k)$	.56 (2.91)	$kgxm-i$	.33 (2.22)
$(n-k)_{-1}$	−.14 (−.97)	$(kgxm-i)_{-1}$	.04 (.18)
$(kgxm-k)$	.33 (2.14)		
$(kgxm-k)_{-1}$	.11 (.51)		
cu	.36 (4.84)	cu	.39 (7.28)
cu_{-1}	.05 (.30)	cu_{-1}	−.06 (−.56)
$\bar{R}^2$	.977	$\bar{R}^2$	.997
SER	.0078	*SER*	.0076
DW	1.96	*DW*	2.03
SSE	.001624	*SSE*	.001690
F	1.45	*F*	2.11

Table 4

Government Spending and Productivity 1949-85
Dependent Variable: Output per Unit of Capital in Private Business Economy

Equation	1	2	3	4	5	6	7	8	9	10
Estimation Method	OLS	OLS	OLS	OLS	TSLS	TSLS	TSLS	TSLS	OLS	OLS
constant	−2.41	−2.45	−2.44	−2.41	−2.33	−2.43	−2.42	−2.38	−2.40	−2.42
	(−20.82)	(−17.82)	(−18.04)	(−19.84)	(−17.57)	(−16.34)	(−17.59)	(−17.03)	(−20.91)	(−19.77)
time	.009	.008	.008	.008	.009	.008	.008	.008	.009	.009
	(4.40)	(3.76)	(3.78)	(4.25)	(4.18)	(3.76)	(3.95)	(3.53)	(4.32)	(4.22)
n-k	.37	.35	.34	.36	.40	.39	.39	.37	.38	38
	(4.69)	(4.24)	(4.26)	(4.59)	(4.54)	(4.66)	(4.77)	(3.90)	(4.73)	(4.70)
kgxm-k	.39	.36	.37	.39	.40	.25	.29	.38	.38	.37
	(16.00)	(5.66)	(7.03)	(15.63)	(14.97)	(1.99)	(3.73)	(12.61)	(14.82)	(11.36)
g-k	.01	-	-	-	-.01	-	-	-	-	-
	(.58)	-	-	-	(-.55)	-	-	-	-	-
gxm-k	-	.03	.01	-	-	.12	.09	-	-	-
	-	(.55)	(.31)	-	-	(1.11)	(1.39)	-	-	-
gm-k		.004	-	.001	-	.01	-	-.01	-	-
		(.49)	-	(.18)	-	(.37)	-	(-1.00)	-	-
gcomp-k		-	-	-	-	-	-	-	.02	.05
		-	-	-	-	-	-	-	(.78)	(.81)
gxcomp-k		-	-	-	-	-	-	-	-	-.01
	-	-	-	-	-	-	-	-	-	(-.49)
cu	.42	.43	.43	.42	.40	.39	.40	.42	.41	.40
	(10.15)	(10.44)	(11.03)	(10.62)	(8.37)	(8.71)	(9.44)	(8.40)	(9.48)	(9.11)
$\overline{R}^2$	.976	.976	.976	.976	.976	.978	.978	.976	.977	.976
SER	.0079	.0080	.0079	.0079	.0079	.0077	.0075	.0079	.0079	.0080
DW	1.80	1.82	1.81	1.79	1.75	1.95	1.93	1.80	1.80	1.79
SSE	.001938	.001938	.001954	.001958	.001895	.00172	.001704	.001884	.001922	001907

g = logarithm of total government spending on goods and services net of public investment
gxm = logarithm of nonmilitary spending on goods and services net of public investment
gm = logarithm of military spending on goods and services
gcomp = logarithm of government employee compensation
gxcomp = logarithm of total government spending on goods and services net of public investment and employee compensation

Table 5

Nonmilitary Equipment and Structures and Productivity 1949-85
Dependent Variable: Output per Unit of Capital in Private Business

Equation	1	2	3	4
Estimation Method	OLS	OLS	OLS	FOAC
constant	−6.07 (−27.18)	−6.15 (−28.29)	−3.57 (−12.31)	−3.57 (−6.31)
time	.008 (3.86)	.006 (3.70)	.002 (.33)	.004 (.84)
n-k	.33 (4.17)	.28 (4.02)	.06 (.31)	.15 (.71)
kgst-k	.37 (13.10)	.39 (16.06)	- -	- -
kge-k	.02 (1.25)	- -	.13 (3.84)	.19 (2.83)
cu	.44 (11.67)	.46 (13.60)	.56 (6.11)	.43 (4.43)
$\bar{R}^2$	.977	.976	.853	.940
SER	.0078	.0079	.0197	.0126
DW	1.83	1.73	.46	1.37
SSE	.001901	.001997	.012386	.004749
rho	- -	- -		.78 (6.54)

kgst = logarithm of nonmilitary structures
kge = logarithm of nonmilitary equipment

Table 6

Public Capital by Type and Productivity 1949-85

Type	Coefficient Estimate	T-statistic	Percent of Total	F
Core Infrastructure (highways, mass transit, airports, electrical and gas facilities, water, sewers)	.24	(5.07)	55	.16
Other Buildings (office buildings, police and fire stations, courthouses, garages, passenger terminals)	.04	(1.57)	7	.01
Hospitals	.06	(1.62)	3	.33
Conservation and Development	.02	(.92)	4	.01
Educational Buildings	−.01	(−.18)	16	.99

Table 7

Average Annual Growth of Productivity and Public Capital

	p	kgxm
1950-85	1.5	3.0
1950-70	2.0	4.1
1971-85	.8	1.6
1981-85	.7	.7

Figure 1

Trends in total factor productivity and public capital

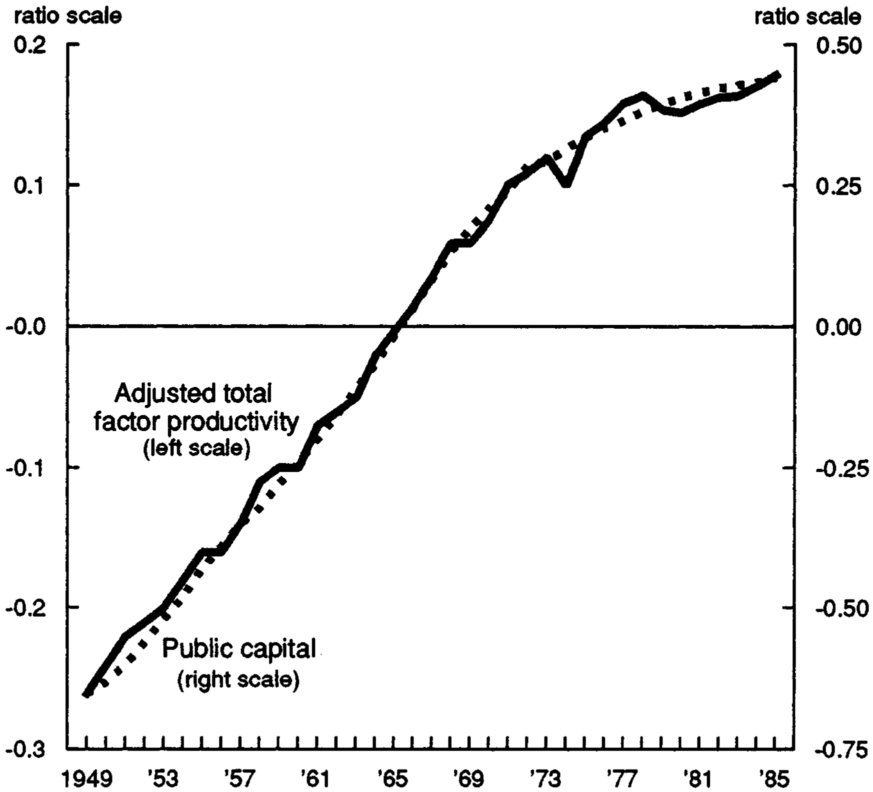

Figure 2

Public investment and productivity