BACK OF THE G-7 PACK: PUBLIC INVESTMENT AND PRODUCTIVITY GROWTH IN THE GROUP OF SEVEN

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Public policies to promote economic growth and international competitiveness have traditionally been focused on savings and private investment in plant and equipment. And with good reason: In the words of Martin Feldstein, "an increase in the saving rate is the key to a higher rate of economic growth and a faster rise in the nation's standard of living.... [T]he evidence is overwhelming that countries with high rates of saving and investment are the ones in which productivity, income and the standard of living rise most rapidly."[1]

Such a focus leads to specific policy initiatives to boost the national savings rate as well as to stimulate private capital accumulation. Among these initiatives are consumption-based tax systems, individual retirement accounts, preferential tax treatment of long-term capital gains, accelerated depreciation of physical capital assets, and investment tax credits. While economists quibble about the quantitative importance of these savings and investment incentives, they are in near unanimous agreement on their qualitative significance for economic growth.

However, there is another potential "supply-side" avenue by which public policy may be able to exert significant influence on the process of sustained economic expansion. What the above policies have in common is that they work through the tax system to affect either the supply of loan funds--savings--or the demand for those funds--private investment in capital goods. Instead, we might look to the opposite side of the government's budget, at the composition of public expenditure and the possible effects various budget policies may have on private sector productivity and economic growth.

In this paper, I distinguish between public *consumption* and public *investment* and argue that this distinction is as important for economic growth calculations as the analogous calculation on the private side of the economy. Public nonmilitary investment--which I take as a proxy for a public infrastructure of roads, highways, mass transit, airports, port facilities, and the like--is argued to have positive direct and indirect effects on private sector output and productivity growth.

The direct effect on private sector output growth arises from the availability of public capital to support private sector production; roads, highways, and airports allow the distribution of goods and services throughout national and international markets. The indirect effect evolves from the complementarity between private and public capital in private-sector productive activity; an increase in the stock of public capital raises the return to private capital which, in turn, serves to spur the rate of expansion of the private-sector capital stock.[2] Supporting these arguments, I offer empirical evidence of a positive effect of public investment on private investment and private output growth.

Trends in public expenditure

In all the Group of Seven (G-7) industrialized countries, the growth in gross domestic product per employed person--labor productivity growth--has fallen over the last twenty years. Productivity growth for these countries taken together averaged 4.0 percent per year during 1960-68, 3.2 percent during 1968-73, 1.4 percent during 1973-79, and 1.5 percent during 1979-86. In each of the G-7 countries, productivity growth during the 1970s and 1980s was some 50 percent less than that attained during the 1960s. At the same time, there was wide dispersion in average productivity growth across these countries. For instance, between 1960 and 1986, Japan achieved a productivity growth rate of 5.5 percent per year, West Germany one of 3.2 percent per year, and the United States one of only 1.2 percent per year.

Figure 1 depicts trends in public net (of depreciation) investment during the years 1967 to 1985 for the major industrialized economies.[3] Three broad features stand out. First, in five of the seven countries, the ratio of public investment spending to gross domestic product trended downward; in the United States (from 1.7 percent of GDP in 1967 to 0.3 percent by 1985), in West Germany (from 3.1 percent to 1.5 percent), in France (from 3.5 percent to 1.6 percent), in the United Kingdom (from 3.9 percent to 0.7 percent), and in Canada (from 3.1 percent to 1.0 percent). In Japan, public investment as a share of gross domestic output rose from 3.8 percent in 1967 to 4.1 percent in 1985, peaking at 5.8 percent in 1979. In Italy, public investment climbed from 2.8 percent in 1971 to 3.3 percent in 1983 and then declined slightly to 3.1 percent in 1985.

Second, there exist fairly wide differences in some of the public investment ratios across countries. While public investment absorbed some 5.1 percent of gross output in Japan over this time period, the United States devoted a much

smaller output share to upgrading its capital stock, less than 1.0 percent. In between are to be found the European countries of France, Italy, the United Kingdom, and West Germany along with Canada. Finally, there seems to be no pursuit of countercyclical public works policies; for example, in the United States the public investment ratio was 0.7 percent in 1973 and 1974, 0.6 percent in 1975 and 0.4 percent in 1976 while it was 0.3 percent in 1980, falling to 0.1 percent in 1981 and 1982.

On the other hand, no downward shift in government consumption spending--inclusive of military spending--is apparent in the data for these countries. As can be seen in Figure 2, the ratios of public consumption to gross domestic product rose in all countries, with the exception of the United States, and in most cases by 2 or 3 percentage points. In the United States, no clear trend is readily discernible, although public consumption was close to one percentage point lower in 1985 than in 1967.

These statistics paint an interesting picture of government spending priorities over the roughly twenty-year period from 1967 to 1985. Generally speaking, while public investment slid downward, public consumption climbed. What, if any, effect might this alteration in government budget shares have had on output and productivity growth across these countries? I argue that public capital--particularly infrastructure capital such as roads, highways, dams, water and sewer systems, mass transit, airport facilities and the like--is a vital input to the private production process. If this is the case, then the general shift in budget priorities away from capital accumulation toward consumption may offer a partial explanation for the productivity decline experienced by the industrial economies.

Methodology

I assume a neoclassical production technology whereby private sector output is obtained by application of labor services to private and public capital stocks. As shown in the appendix, this framework leads to the following regression equation

$$Dp_t = b_0 + b_1 * Dn_t + b_2 * ir_{t-1} + b_3 * gir_{t-1} + b_4 * Dcu_t$$

where Dp_t = labor productivity growth, Dn_t = employment growth, ir_{t-1} = ratio of private net investment to gross domestic product (lagged one year), gir_{t-1} = ratio of public nonmilitary net investment (also lagged), and Dcu_t =

rate of change in capacity utilization. According to standard restrictions on the production function, we expect to estimate b_1 negatively. Simply stated, the application of more laborers to given quantities of private and public capital stocks lowers the productivity of labor. On the other hand, given the number of workers, raising the amounts of private or public capital should, on average, make each worker more productive, so we also expect b_2 and b_3 to be estimated positively. As labor productivity growth is highly procyclical--rising in booms and falling in recessions--it is likely we will find b_4 is positive. We now confront the data with the above equation to see if they perform according to our theoretical expectations.

Empirical results

I estimated the equation on data gathered for the Group of Seven countries over the period 1966 to 1985. Detail on these data is given in the Appendix. In general, the data provide strong support for the idea that public investment is a critical determinant of labor productivity growth. An increase in the level of public nonmilitary investment by one percent of gross output yields a gain in productivity growth of about 0.4 percent per year. The strong positive relationship between public investment and productivity growth is robust to changes in the set of countries included in the data sample and after consideration of the effects of oil shocks in the 1970s. Table 1 contains the basic set of estimated relationships between the level of public investment and productivity growth. The public investment variable is exclusive of military capital expenditures; is expressed relative to the level of gross domestic product; and is lagged one period. I believe this variable to be a good proxy for the percentage growth in the nonmilitary public capital stock during the previous period. The productivity growth variable measures labor productivity growth as the percentage growth rate of gross domestic output per employed person in each of the Group of Seven industrialized economies.

Column 1 of Table 1 illustrates the strength of the independent effect of public investment on the growth rate of labor productivity. A one-percentage-point increase in the share of gross domestic output devoted to public capital accumulation is associated with a 0.73 percentage point rise in the labor productivity growth rate. The standard error of 0.14 yields a ninety-five percent confidence interval which lies well above zero, namely (.45, 1.01). The public investment variable alone is capable of explaining 17 percent of the variation in productivity growth across time and countries.

Column 2 expands the list of variables allowed to influence productivity growth to include private investment, growth in total employment, and capacity utilization. As with the public investment variable, private investment is expressed relative to gross domestic product and is lagged one year to proxy for previous growth in the private capital stock. The capacity utilization variable is entered in the attempt to convert growth in the stocks of public and private capital (captured by gir and ir, respectively) into service flows from these stocks. While the estimated coefficient on public investment is markedly reduced--from 0.73 to 0.44--it still is statistically significant at better than a ninety-nine percent level. The private investment variable enters positively, suggesting that a one-percentage-point increase in the ratio of private capital accumulation to gross domestic product will raise productivity growth by an amount equal to nearly one-quarter of a percentage point. Consistent with the expectation of a diminishing marginal productivity of labor, a one-percentage-point increase in the rate of growth of total employment lowers the rate of growth of labor productivity by somewhat more than one-third of a percentage point. Within the organizing context of a Cobb-Douglas production technology, the coefficient on total employment should equal unity minus labor's share in gross domestic product; the estimated coefficient therefore suggests that labor's output share was some 65 percent--a reasonable estimate.[4] Finally, as expected, the capacity utilization variable bears a positive relationship with productivity growth.

Columns 3 and 4 of Table 1 exhibit the robustness of the estimated relationship by limiting the samples to exclude the United States and Japan (Column 3) and to include only the four major European economies (Column 4). Excluding the United States and Japan--the countries with the lowest and highest public investment ratios during this period--does not erode the relationship between public investment and productivity; indeed, the estimated coefficient on public investment is increased from 0.44 in the full sample to 0.59 in the limited sample. There is a sizable reduction in the coefficient associated with private investment, however, and the adjusted coefficient of determination is reduced from 58 percent to 46 percent. Focusing on the European countries of France, Italy, the United Kingdom, and West Germany, the relationship between public investment and productivity growth remains significantly positive, although the estimated standard error of the coefficient rises by a non-trivial amount.

The period of analysis, 1966 to 1985, includes years in which there were significant "supply-side" disruptions to production in the highly industrialized economies. Most obvious are the oil price shocks of late 1973 and 1979.

Column 5 allows for the separate effects of these oil price shocks by including dummy variables for 1974 (the first year in which the effect of the first major oil price shock would be apparent) and 1979. As expected, the dummy variables are significantly negative, indicating that productivity growth fell by more in those years than can be explained by the private capital and public investment variables and employment growth. The estimated coefficients on these latter variables, however, are not altered in an important way from those in Column 2 and the adjusted coefficient of determination rises only a small amount, from 58 to 61 percent.

Column 6 illustrates that the ratio of government consumption--measured residually by subtracting public investment from total government spending on goods and services--to GDP bears a marginally significant *negative* relationship with productivity growth. A one-percentage-point increase in the share of gross domestic product devoted to government consumption is estimated to reduce labor productivity growth by somewhat more than one-tenth of a percentage point. Note that this result, in conjunction with the positive association between productivity growth and public investment, indicates that countries can achieve substantial productivity gains by holding fixed tax revenues and altering the composition of government spending away from public consumption and toward public nonmilitary capital accumulation.

Thus, the results of Table 1 are fully compatible with the idea that public capital is a necessary input to the private production process. Without sufficient investment in a public infrastructure of roads, local transportation, airports, and port facilities, the task of private-sector production becomes much more exacting in terms of sacrifice of either current consumption or leisure activities.

Of course, this is not the only possible explanation for the positive association of public investment and labor productivity. One could argue, for example, that the statistical correlation is the reverse--that public investment slumps in periods of low productivity and (presumed) reductions in tax revenues and is stepped up in times or prosperity and more generous growth in revenues. In economists' language, public investment would be considered a "normal" good. This argument, however, has its own hurdles to clear.

First, the public (and private) investment variable is lagged one year. Statistically, it is therefore a predetermined variable; this reduces the force of the reverse causation argument to some degree. Second, as Column 6 indicates, while there is a positive association between public investment and

productivity, there is a negative association between public consumption and productivity. The counterargument thus must explain why public consumption, unlike public investment, appears to be an inferior good. Third, the estimated coefficients in Column 2 are all of the right sign and of a reasonable economic magnitude from a technological standpoint; it seems unlikely that this is a mere happenstance.

Finally, the results in Table 2 provide more concrete evidence against the reverse causation hypothesis. In these equations, the public investment variable has been purged of its direct relationship with the level of economic activity by prior regression on the rate of growth of gross domestic product. The residuals from this estimated equation are then used in place of the "raw" public investment variable in the regressions reported in Table 2. Column 1 shows the simple relationship between productivity growth and public investment, purged of its income growth component, to be statistically strong and positive. Column 2 allows for the additional effects of private investment, employment, and capacity utilization. As in Table 1, the relationship between public investment and labor productivity growth is attenuated but still of quantitative and statistical importance. Column 3 allows for dummy variables for 1974 and 1979 with only a minor change from the results of Column 2. In Column 4, private investment is also purged of its direct association with output growth, with the result of a significantly lower estimated relationship between private investment and growth in output per employed person. Finally, Column 5 adds in the ratio of public consumption to gross domestic product. As with the results in Table 1, the estimated relationship between productivity growth and the share of government consumption in gross output is negative, but now at a diminished level of statistical significance.

Table 3 contains reduced form estimates of the relationship between private investment, public investment, and public consumption over the same sample. Column 1 shows a rise in public investment of 1 percent of gross domestic product is associated with an increase in total investment (public plus private) of 2.5 percentage points, or an increase in private investment of 1.5 percent of output. Column 2 calculates that a rise in government consumption of one percent of gross output depresses national investment by 0.59 of a percentage point. The effect of public investment on national investment is reduced substantially, from 2.5 to 1.4 percentage points. This last result is due, no doubt, to the strong negative relationship between public investment and consumption and associated omitted variable bias in Column 1. Columns 3 and 4 repeat the previous regressions but with public and total investment

ratios which are purged of their correlation with the growth rate of gross domestic product. As can be seen, the positive association of national investment with public investment and the negative relationship with public consumption is maintained.

Conclusion

There exists a strong, positive correlation between various productivity measures and public nonmilitary capital expenditure. Aschauer (1988) has established this correlation for annual United States data over the period 1949-1985 and Barro (1989) has attained similar cross sectional results for a sample of 72 countries.[5] Further, Garcia-Mila and McGuire (1987) have found a statistically significant positive association between gross state product and public capital--highways and educational structures--for the 48 contiguous states.

The contribution of this paper is to expand this list of results and to offer evidence against the "reverse causation" hypothesis that low productivity growth tows in its wake low public capital expenditures. Table 2 contains results which establish a positive correlation between labor productivity growth and public investment even after the latter variable has been purged of its economic growth component by previous regression on the growth rate of gross domestic product. On this basis, I submit that public capital is a vital ingredient in the recipe for economic growth and rising standards of living.

Footnotes

[1]See Martin Feldstein, "A National Savings President," *Wall Street Journal*, November 21, 1988, p. A14.

[2]See David A. Aschauer, "Government Spending and the 'Falling Rate of Profit'," Federal Reserve Bank of Chicago, *Economic Perspectives*, May/June 1988 for elaboration and supporting evidence for the United States.

[3]For Italy, data on public consumption and public investment is available only after 1970.

[4]In the United States, the ratio of employee compensation to gross domestic output equalled 58 percent in 1966 and 60 percent in 1985.

[5]However, Barro suggested that this relationship is due to the reverse causation discussed above. He also estimates a public capital stock to output ratio and, upon regressing the growth in output (per person) on this estimated variable, finds that while the relationship is still positive, it is not statistically significant at conventional levels. By his own admission, however, his public capital

stock measures are subject to large errors in measurement. Indeed, for the United States (for which we have direct estimates of public capital) his measure deviates by 50 percent from its actual value.

References

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Appendix

In algebraic form, we have the production technology

$$y_t = f(n_t, k_{t-1}, kg_{t-1}; cu_t)$$

where y_t = private sector output during year t, n_t = employment during the same year, k_{t-1} = the private capital stock at the beginning of year t, kg_{t-1} = the public nonmilitary capital stock also as of the start of year t, and cu_t = the rate of utilization of capacity in production. This last variable is entered to capture shocks to the production technology as well as to convert capital *stocks* into *flows* of capital services.

Unfortunately separate estimates of private and public capital stocks are currently unavailable for the Group of Seven industrial nations; however, we can finesse this data deficiency by shifting the emphasis from the level of production to the growth in production. First, by assuming a logarithmic form for the production technology we may derive the expression

$$Dy_t = a_0 + a_1*Dn_t + a_2*Dk_{t-1} + a_3*Dkg_{t-1} + a_4*Dcu_t$$

where Dx_t denotes the percentage growth rate of variable x during period t. In this form, we can employ a proxy for growth in capital stocks, i.e. the ratio of investment, private and public, to gross output. The relationship between the two variables is given by

$$ir = (k/y)*Dk$$

where ir = ratio of (private) investment to gross output. As long as the capital to output ratio, k/y, is fairly stable the ratio of investment spending to output, ir, will be a good proxy for growth in the capital stock the obvious extension of the public side.

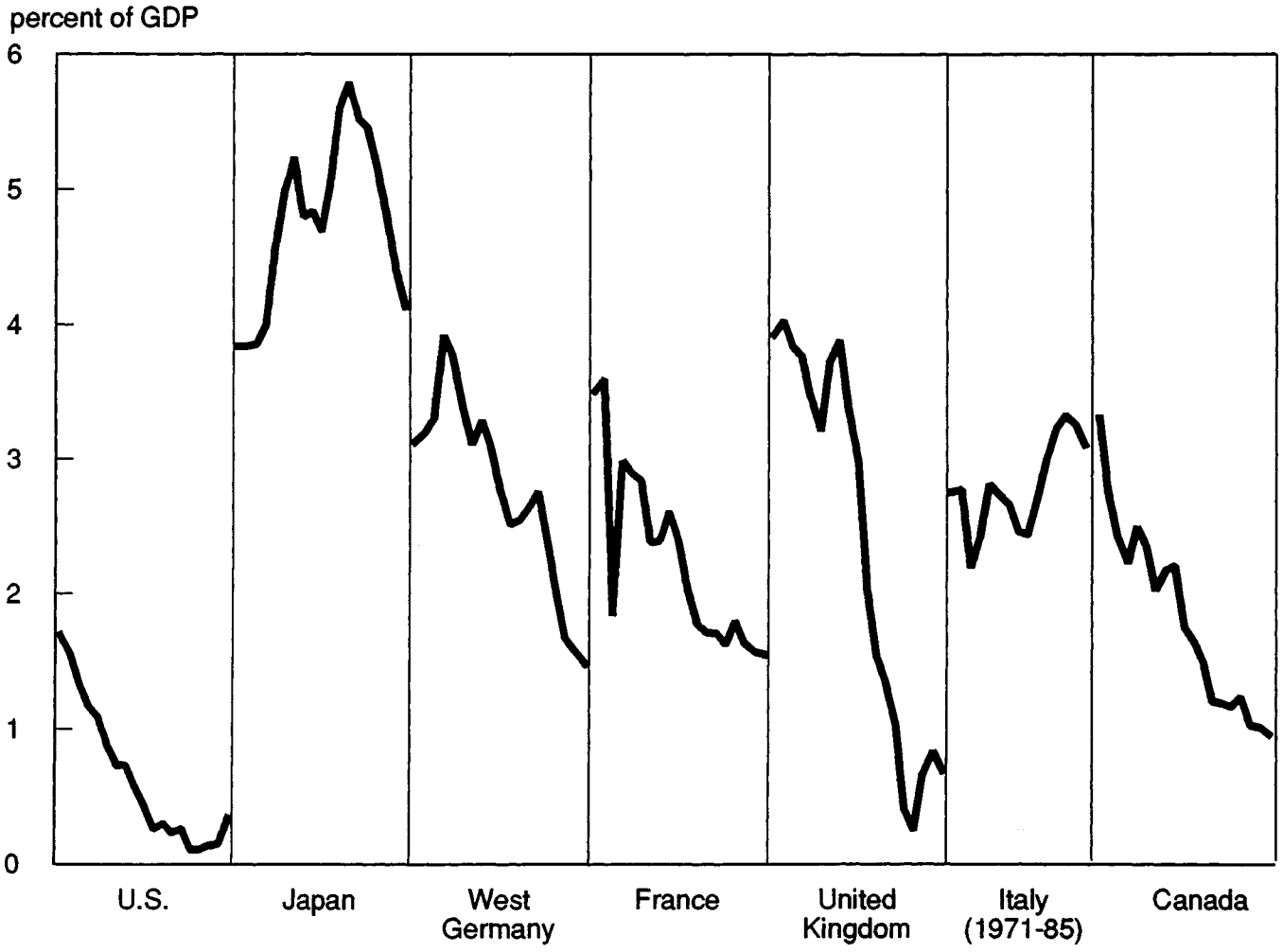
We finally write the equation to be estimated empirically as

$$Dp_t = b_0 + b_1*Dn_t + b_2*ir_{t-1} + b_3*gir_{t-1} + b_4*Dcu_t$$

where $Dp_t = Dy_t - Dn_t$ = labor productivity growth and so $b_1 = (a_1 - 1)$. Under the standard assumptions of a positive but diminishing marginal product of labor, we expect to find b_1 to be negative. We also assume a complementarity between labor and the services of private and public capital stocks. Thus, by raising the stocks of either private or public capital--given labor input--the

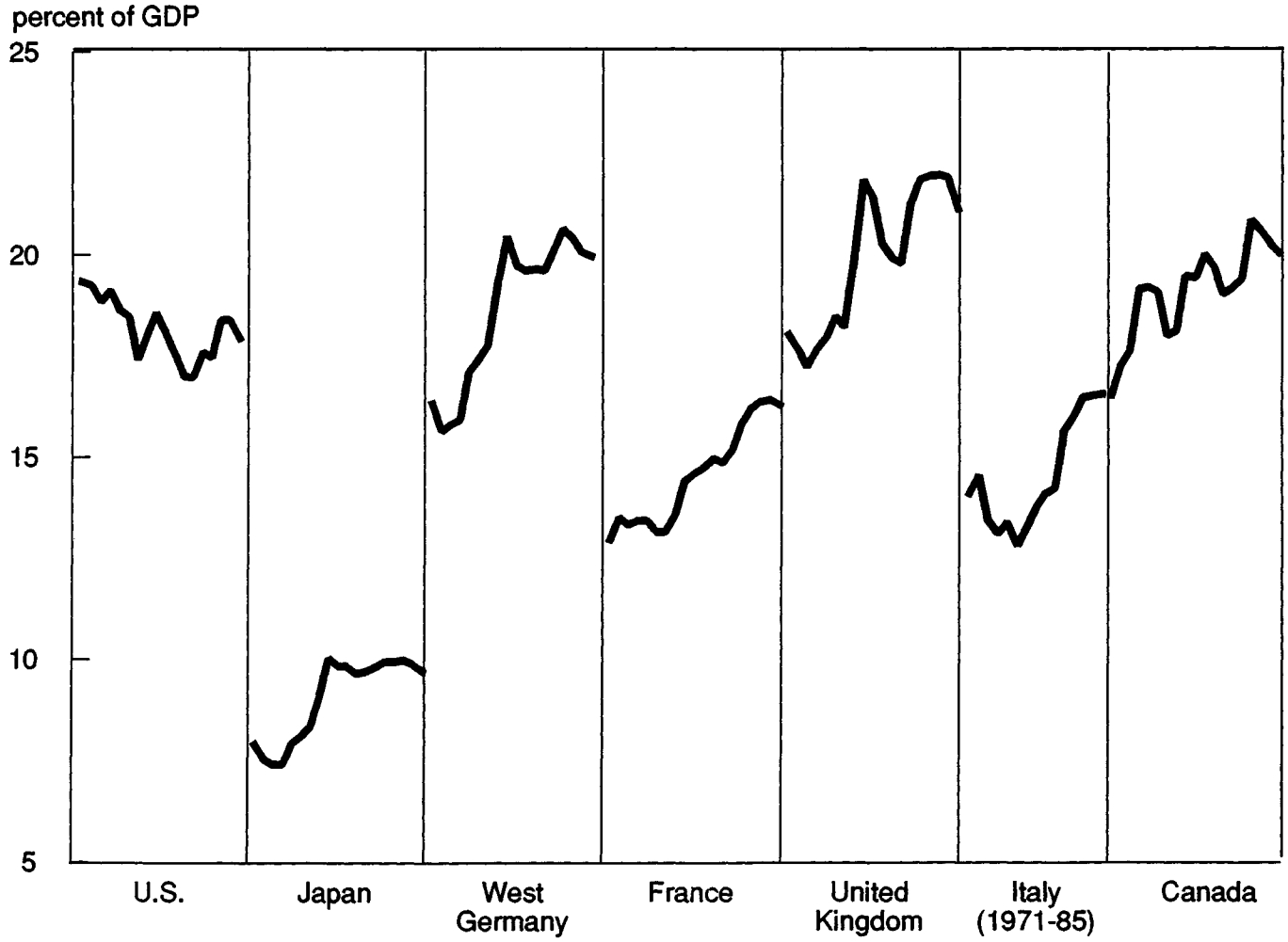
productivity of labor should be boosted, so we expect b_2 and b_3 to be positive. Further, it is likely that the capacity utilization rate--proxying for technological shocks as well as converting capital stocks into flows of capital services--will enter the above expression positively.

Figure 1
Public investment as a share of gross domestic product
1967-85



SOURCE: National Accounts (OECD)

Figure 2
Public consumption as a share of gross domestic product
1967-85



SOURCE: National Accounts (OECD)

Table 1
Public investment and productivity growth in the Group of Seven

Dependent variable: Dp

	1	2	3	4	5	6
c	.68	-.21	.02	-.33	-.21	3.02
	(.41)	(.41)	(.66)	(-.46)	(.39)	(1.63)
gir	.73	.44	.59	.51	.41	.34
	(.14)	(.13)	(.18)	(.21)	(.13)	(.14)
ir		.22	.13	.20	.24	.12
		(.06)	(.07)	(.08)	(.05)	(.07)
e		-.35	-.29	-.64	-.32	-.35
		(.08)	(.09)	(.17)	(.08)	(.08)
cu		1.61	1.28	1.67	1.58	1.51
		(.15)	(.16)	(.21)	(.14)	(.15)
d74					-1.83	
					(.60)	
d79					-1.26	
					(.60)	
gcr						-.13
						(.06)
$\bar{R}^2$	.17	.58	.46	.48	.61	.59
SER	2.21	1.57	1.46	1.47	1.51	1.55
NOB	129	129	91	72	129	129

Column 1 displays the basic relationship between public investment and productivity growth
Column 2 is the basic equation in the text
Column 3 excludes Japan and the United States from the sample
Column 4 excludes Japan, the United States, and Canada from the sample
Column 5 allows dummy variables to capture the effects of oil shocks
Column 6 allows a separate effect of government consumption spending

Table 2
Cyclically adjusted investment and productivity growth in the Group of Seven

Dependent variable: Dp

	1	2	3	4	5
c	2.34	.62	.54	2.51	2.88
	(.20)	(.44)	(.43)	(.17)	(1.62)
gir	.72	.42	.38	.53	.37
	(.13)	(.11)	(.11)	(.12)	(.11)
ir		.23	.25	.14	.15
		(.05)	(.05)	(.06)	(.01)
e		-.29	-.27	-.21	-.30
		(.08)	(.08)	(.09)	(.08)
cu		1.54	1.51	1.46	1.48
		(.15)	(.15)	(.16)	(.15)
d74			-1.65		
			(.60)		
d79			-1.11		
			(.59)		
gcr					-.09
					(.07)
$\bar{R}^2$	.21	.59	.61	.53	.59
SER	2.14	1.55	1.49	1.64	1.54
NOB	121	121	121	121	121

Column 1 displays the basic relationship between cyclically adjusted public investment and productivity growth
Column 2 is the basic equation in the text with cyclically adjustmented public investment
Column 3 allows dummy variables to capture the effects of oil shocks
Column 4 is the basic equation with cyclically adjusted private and public investment
Column 5 allows a separate effect of government consumption spending

Table 3
Public spending and private investment

Dependent variable: ir

	1	2	3	4
c	5.04	17.46	-.06	6.20
	(.46)	(1.34)	(.21)	(.98)
gir	2.50	1.40	2.27	1.66
	(.16)	(.17)	(.15)	(.16)
gcr		-.59		-.38
		(.06)		(.06)
$\bar{R}^2$	.65	.79	.65	.74
SER	2.58	1.98	2.28	1.97
NOB	129	129	129	129

Column 1 shows the basic relationship between public and private investment
Column 2 displays a separate effect of government consumption
Column 3 and 4 duplicate columns 1 and 2 but with cyclically adjusted investment variables