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STAFF MEMORANDA

DOES PUBLIC CAPITAL CROWD OUT PRIVATE CAPITAL?

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I. Introduction

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This paper is an empirical investigation into the effects of government spending on private investment from a neoclassical perspective. The central focus of the paper is on the question: does higher public capital accumulation "crowd out" private investment in plant and equipment? On neoclassical grounds, the answer to this question is seen to depend upon two fundamental, opposing forces. On the one hand, higher public investment raises the national rate of capital accumulation above the level chosen (in a presumed rational fashion) by private sector agents; thus, public capital spending may crowd out private expenditures on capital goods on an *ex ante* basis as individuals seek to reestablish an optimal intertemporal allocation of resources. On the other hand, public capital—particularly infrastructure capital such as highways, water systems, sewers, and airports—is likely to bear a complementary relationship with private capital in the private production technology. Thus, higher public investment may raise the marginal productivity of private capital and, thereby, "crowd in" private investment. Isolating these separate effects will allow: (1) a test of the appropriateness of the equilibrium approach to fiscal policy (the former effect); (2) information on the productivity of public capital (the latter effect); and (3) a resolution to the query of whether or not public capital spending can affect the national capital stock to a substantive degree.

The earliest conventional macroeconomic analyses of the effect of public spending—specifically, public capital expenditures—on private investment emphasized an *ex post* crowding out via the effect of fiscal policy on interest rates; to the extent that an increase in the level of public expenditure created an excess demand for current resources, interest rates would rise and reduce the level of private capital spending. In classical, full-employment models of the economy, the reduction in private investment per unit of public spending would be equal to

$$-i_r/(i_r + c_r) \tag{1}$$

where i_r and c_r measure the sensitivity of private investment and consumption to a change in interest rates. In the extreme of a perfectly inelastic

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private savings schedule ($c_r = 0$), higher public spending would crowd out private investment on a one-to-one basis; given some elasticity of savings, however, part of the burden of higher public spending would fall on the present as the rise in interest rates induced a reduction in the current level of consumption spending.[1] At the opposite end of the spectrum, Keynesian models of the "sticky price" variety predicted a smaller negative effect of government spending on private capital accumulation as the interest sensitivity of money demand allowed a rise in output to be compatible with money market equilibrium and, therefore, less of a need for a higher level of interest rates to reestablish goods market equilibrium. In this case, the effect on private investment is given by

$$-i_r/[(i_r + c_r + (m_r{*}s_y)/m_y)] \qquad (2)$$

where m_r, m_y are the sensitivities of money demand to interest rates and income and s_y is the marginal propensity to save out of income. In the extreme case of infinitely interest sensitive money demand—the "liquidity trap"—interest rates would not rise pursuant to a rise in government spending and consequently there would be no effect on the level of private investment.

Indeed, the advent of accelerator (and, subsequently, flexible accelerator) theories of private investment led to the conclusion that fiscal policy, by stimulating aggregate demand and output, might "crowd in" capital spending by firms. Given the previous level of output, investment would be crowded in given that

$$|m_r|{*}i_y - |i_r|{*}m_y > 0 \qquad (3)$$

as in this case any negative effect on investment arising from a rise in interest rates would be dominated by the positive effect operating through a higher level of output and the consequent need for expanded capacity.[2,3]

Later discussion centered on the implications of changes in wealth associated with government debt issuance and, thereby, on consumption and asset demand. Assuming that the higher public expenditure is debt financed and that expansions of public debt raise wealth, both consumption and money demand were argued to rise. As the former effect tends to stimulate production but the latter effect to raise interest rates, their net impact on output and private investment would be ambiguous, a point discussed by Silber (1970). Blinder and Solow (1973) took such wealth effects as the starting point for their analysis of the effects of fiscal policies, but focused on the requirement that the budget be balanced in long-run equilibrium. In such an environment, bond-financed government spending was necessarily stimulative since a rise in income was required to finance interest payments on the higher level of public debt.

A dramatically different analysis of crowding out was pursued by David and Scadding (1974), in which they emphasized the possibility of an *ex ante* crowding out of private by public expenditure. Specifically, they argued that a rise in government bond issuance crowded out an equal amount of private investment because deficit finance is regarded as public investment and the latter substitutes for private capital spending. Tax-financed government spending, on the other hand, was taken as government consumption and to crowd out an equivalent amount of private consumption. Thus, fiscal policy was seen as having no effect on the level of aggregate demand. Of course, this argument is consistent with an "ultrarational" consumer only if public capital expenditures are, as a rule, debt financed.

More recently, Barro (1974) offered the possibility that the method of finance of public expenditure—whether by debt or taxes—is irrelevant to aggregate economic outcomes. As is now well known, this analysis involves private savings acting as a buffer against changes in the financial position of the public sector; a bond-financed tax cut (of a lump-sum variety) promotes an equal *ex ante* rise in private savings to match the implicit future tax liability with the result that interest rates, output, and the price level are left unaffected. The crucial point, however, is that to the extent that this "equivalence" between public finance methods holds, it makes sense to concentrate on the real aspects of fiscal policy—the temporal pattern of government purchases, changes in distortional tax rates, and—as in the current paper—alterations in the composition of public spending as potentially powerful channels of influence on the private sector economy.

The question of the degree to which public debt issuance is offset by private savings has been addressed by numerous authors. Boskin (1987), Feldstein (1982), Modigliani and Sterling (1986), and Poterba and Summers (1987), to name a few, present results that indicate private consumption is indeed stimulated by changes in the mix of tax and debt finance of government spending. On the opposite side, however, are papers by Aschauer (1985), Kochin (1974), Kormendi (1982), Seater (1982), Seater and Mariano (1985), and Tanner (1978, 1979). Other authors have studied the impact of government financial decisions on interest rates. While Hoelscher (1987) finds a positive effect of government bond issuance on long-term interest rates, Dwyer (1982), Evans (1985, 1986, 1987), and Plosser (1982, 1987) have found either no statistical relationship between debt finance and asset returns or, in some cases, even an inverse one. Given the diversity of these results, it seems supportable to maintain the position that real aspects of fiscal policy may easily be as important for aggregate macroeconomic outcomes as the decision regarding the means of finance of public expenditure.

Ahmed (1987) and Barro (1981, 1987) have emphasized the importance of the temporal intensity of government spending for output, interest rates, and the trade balance. Starting from the perspective of the permanent income hypothesis, a transitory rise in government spending creates an excess demand for contemporary goods and services; thus, some combination of a rise in output (Barro 1981), a surge in interest rates (Barro 1987), and a current account deficit (Ahmed 1987) is required to reestablish equilibrium. A more persistent rise in government purchases, however, is to lead to a drain on wealth and a substantial loss in effective permanent income, a fall in consumption and leisure and, finally, much more limited impacts on output, asset prices, and the current account position in the international balance of payments.

This paper follows this line of reasoning by focusing on the relationship between various forms of government spending—nonmilitary and military investment as well as government "consumption"—and private investment. The next section sketches out the primary theoretical considerations. Section III provides estimates of a parsimoniously specified model of investment, the rate of return to private capital, and public expenditure variables. Section IV illustrates the interactions captured by the estimated model with some fiscal policy simulations.

II. A Neoclassical Analysis

The theoretical analysis which follows assumes a competitive economy populated by similar, infinitely lived individuals. The discussion is heuristic; for detail the reader is referred to Arrow and Kurz (1970), Aschauer (1988a), Aschauer and Greenwood (1983), and Barro (1988).[4] The relationship between private investment and public spending which holds in general equilibrium may be expressed as

$$i = i(\phi, i^g, c^g) \tag{4}$$

where i = private investment, ϕ = the marginal product of private capital, i^g = public investment or capital account expenditure, and c^g = government consumption or current account spending. Here, a rise in the marginal product of private capital raises the level of private investment as individuals respond to the higher marginal return to future production by postponing consumption, raising savings, and, in equilibrium, increasing capital accumulation.

A unit increase in public investment, given the rate of return to private capital, will change private investment by the amount

$$-1 - (mpc/\phi)^*(f_{kg} - \phi) \tag{5}$$

where mpc = marginal propensity to consume out of wealth and f_{kg} = marginal product of public capital in private production.[5] In this formulation, higher public investment will crowd out an equivalent amount of private investment if there is no impact on wealth of such a change in public expenditure. A rise in public investment, in this case, would raise the national rate of capital accumulation over the optimal level chosen by private sector agents; in response, there would be a reduction in private savings and investment to return national investment to its former position.

However, given that the public capital stock is at a level such that the marginal products of private and public capital are not equated, a change in public investment—and a marginal change in the public capital stock—will affect the wealth of the private sector agents. Suppose that the public capital stock is "too low" so that $f_{kg} > \phi$. In such a situation, an increase in public investment and equal crowding out of private investment would raise future output, creating a positive future income effect. Consumers, in response to the improved allocation of resources, would raise current consumption and lower savings, with the result of a further decline in private capital accumulation.

The impact of public consumption spending on private investment depends on three considerations, namely: the extent to which the public sector goods and services substitute for their private sector counterparts; the persistence of the expenditure change; and the time profile of the marginal propensity to consume out of wealth. Let a change in current public consumption expenditure be followed by a change in future such purchases equal to a times the current change. Hence if the current shock is transitory, $a = 0$ while if permanent, $a = 1$. Then the effect of a one unit increase in public consumption spending on private investment is given by

$$-((1 - u_{gc} - f_{gc})/\phi)^*(mpc^f - a^*mpc) \tag{6}$$

where u_{gc} = marginal rate of substitution of public for private consumption goods and services, f_{gc} = marginal product of public current account spending in private production, and mpc^f = marginal propensity to consume in the future out of wealth.

Clearly, if $u_{gc} + f_{gc} = 1$ there is no effect of a change in the level of public current account spending on the agent's effective intertemporal consumption opportunities and private investment is left unaltered. The higher public expenditure crowds out private consumption spending and directly expands production to a degree such as to leave the intertemporal allocation of resources—and thereby, private savings and investment—undisturbed.

However, available empirical evidence suggests that public spending substitutes poorly for private consumption. Kormendi (1983) and Aschauer (1985) obtain estimates of u_{gc} in the range (.2, .4). The evidence also indicates that public expenditure may have a relatively minor direct effect on production. On the basis of British data Ahmed (1986) uncovers an estimate of f_{gc} of .39 while Aschauer (1988c) finds no discernable impact of public current account spending on total factor productivity. Accordingly, a rise in the level of government consumption would be expected to reduce the agent's effective consumption possibilities and potentially induce a change in private investment as the agent reallocates the "burden" of the public sector expansion intertemporally.

Assuming $0 < u_{gc} + f_{gc} < 1$, consider the case where the rise in public consumption is permanent, $a = 1$. Private investment will be unaltered if the time profile of the aggregate marginal propensity to consume is flat since the average agent would choose to bear the implied negative wealth effect equally over time. On the other hand, if the agent's marginal propensity to consume profile has an upward (downward) tilt, private investment will fall (rise) as he chooses to bear a relatively large proportion of the wealth effect in the future (present).

Finally, assuming that $0 < u_{gc} + f_{gc} < 1$ and $mpc = mpc^f$, but the change in public consumption spending is to some extent transitory, we have the impact on investment given by

$$-(1 - u_{gc} - f_{gc})^*(1 - a)/(1 + \phi) \tag{7}$$

so that a rise in public spending induces less than an equal decline in private investment.

Thus, on net, a rise in public consumption expenditure may have a negative impact on private capital accumulation, the effect being more probable (a) the more transitory is the rise in public purchases and/or (b) the less the publicly provided goods substitute for private consumption and yield direct productive benefits.

The marginal product of private capital is given by the expression

$$\phi = f_k(k, k^g, c^g) \tag{8}$$

where k = private capital stock, k^g = public capital stock, and c^g = public spending on current account. A distinctive feature of public capital—particularly infrastructure capital such as streets and highways, sewers, water systems, airports, and the like—is that it is likely to bear a complementary relationship to private capital. Specifically, a higher level of public capital of this type is expected to raise the marginal productivity of private capital, or $f_{k,kg} > 0$. Further, it would be reasonable to argue that military capital would have a smaller effect on the productivity of private capital. A rise in public spending on nondurables and services more likely has an ambiguous effect on the marginal product of private capital. While the current expenses of maintaining a police force and fire departments may lead to a higher rate of return to capital, expenditures on regulatory institutions and pollution control no doubt depress the return to capital as firms are forced to seek less (private) cost-effective methods of production.

Hence, along neoclassical lines a rise in public investment expenditure has an ambiguous effect on private investment. On the one hand, to the extent that public and private capital stocks are substitutable for one another in the private production technology, higher public investment crowds out an equivalent amount of private capital spending. On the other hand, the fact of government provision leads to a presumption that public capital yields substantial external effects by raising the productivity of private factors of production. Depending on their relative potency, the interaction of these two forces could result in either a decrease or increase in private capital expenditures.

The empirical analysis below seeks to evaluate the appropriateness of the neoclassical approach to the crowding out of public expenditure by unscrambling these conflicting effects of government spending on private investment. Specifically, it attempts to provide answers to the following questions: (1) Does a higher public capital stock--of either nonmilitary or military goods--raise the marginal product of private capital? (2) Given any effect of public capital accumulation on the return to private capital, does higher public investment crowd out private investment? (3) Does higher government consumption expenditure raise the marginal product of capital? Crowd out private investment? (4) What is the total impact of public capital expenditure on the level of private investment?

III. Empirical Analysis

The empirical analysis focuses on the effect of public expenditure on private investment and the rate of return to private capital. The private investment series is net fixed investment in nonresidential equipment and structures and is obtained from *Fixed Reproducible Tangible Wealth in the United States 1925-85*.[6] This annual series is computed along "perpetual inventory" lines by subtracting cumulative depreciation from the gross capital stock (cumulative gross investment minus discarded capital) in order to obtain the net capital stock. The net capital stock is valued in current, as opposed to historical prices and thus is a measure of the replacement value of the private nonresidential capital stock. The accuracy of this procedure, however, depends crucially on (a) the chosen depreciation methodology—straight-line, double-declining balance, etc.—and (b) the useful service lives employed for depreciation purposes. The particular series used in this paper is computed using straight-line depreciation over 85 percent of the service lives published in Bulletin F of the Treasury Department. This specific methodology lies behind most of the net investment series published in the

"National Income and Product Accounts" and elsewhere in the *Survey of Current Business.*

The rate of return variable is computed as the ratio of net (of depreciation) corporate profits plus net interest expenses to the total value of the net capital stock (net stock of equipment and structures plus inventories plus land). Corporate profits and net interest are obtained from various issues of the *Survey of Current Business,* the net capital stock from *Fixed Reproducible Tangible Wealth in the United States,* and inventories and land from the *Flow of Funds* of the Federal Reserve System. As computed, this variable measures the rate of return on nonfinancial corporate capital since the net of depreciation corporate profits series published in the *Survey of Current Business* presently is restricted to that legal category.

The public investment series consists of federal, state, and local expenditures on equipment and structures. Both nonmilitary and military capital will be considered in turn. Depreciation of this form of capital to derive a net capital stock series is based on comparisons with similar private capital, data from governmental agencies on actual service lives, and on the assumptions made by Goldsmith in a study on corporate stock ownership by institutional investors.

Two other variables will enter the empirical analysis as well. Government consumption or current account spending is measured by subtracting the net public investment series from total purchases of goods and services by all levels of government, the latter variable being taken from the *Survey of Current Business.* The capacity utilization rate of the manufacturing sector is from the *Federal Reserve Bulletin.*

Sample statistics for these variables over the period 1953 to 1986 are presented in Table 1. The flow expenditure variables are measured relative to the net private capital stock series to reduce the potential for a heteroscedastic error structure. Note, in particular, that on average public net investment was more than 50 percent as large as private investment (1.9 percent compared to 3.4 percent of the net private capital stock, or 1.6 and 3.0 percent of gross national investment, respectively) while being characterized by nearly the same amount of volatility, with a standard deviation of 0.9 percent as opposed to 1.1 percent of the net private capital stock. Further, the maximum value of public net investment, 4.0 percent (attained in 1953) is roughly two-thirds as large as the maximum value for private net investment, 5.7 percent of net private capital (achieved in 1966). Finally, on average net public investment accounted for roughly 6.7 percent of total government expenditures on goods and services.

Public consumption expenditures amounted, on average, to 24.6 percent of net private capital and varied from a low of 19.4 percent in 1979 to a high of 35.4 percent in 1953. During the recent period 1981-86, this variable has averaged 19.9 percent of the stock of private capital. The potential importance of the public expenditure variables for private investment in an intertemporal setting seems clear from these statistics.

A parsimonious empirical model capable of capturing the relationships of interest is composed of the following two equations:

$$i = c_0 + c_1{}^*i(-1) + c_2{}^*\phi + c_3{}^*i^g + e_1$$

$$\phi = c_4 + c_5{}^*t + c_6{}^*lnk + c_7{}^*lnk^g + c_8{}^*cu + e_2 \tag{9}$$

where $t =$ time, $lnk =$ natural logarithm of the net private capital stock, $lnk^g =$ natural logarithm of the net public capital stock, and $cu =$ capacity utilization rate.[7] The neoclassical model sketched out above implies $c_2 > 0$, $c_3 < 0$ (and close to a value of -1 given a public capital stock near its optimal level), $c_6 < 0$ (given $f_{k,k} < 0$), and $c_7 > 0$ (given $f_{k,kg} > 0$). A rise in the capacity utilization rate would be expected to raise the marginal product of capital if movements in the former variable were due to either demand-side or technological shocks, so $c_8 > 0$.

The reduced form of the structural model is given by

$$\begin{aligned} i = b_0 + b_1{}^*i(-1) + b_2{}^*t + b_3{}^*lnk + b_4{}^*lnk^g \\ + b_5{}^*cu + b_6{}^*i^g + u_1 \end{aligned} \tag{10}$$

$$\phi = b_7 + b_8{}^*t + b_9{}^*lnk + b_{10}{}^*lnk^g + b_{11}{}^*cu + u_2.$$

Estimation of the reduced form is undertaken by full information maximum likelihood methods to take into account the over-identifying restrictions implicit in the structural model. Specifically, these latter restrictions dictate that the stocks of private and public capital and the capacity utilization rate do not exert influence on the level of private investment apart from that operating on the marginal product of private capital. This will be the case provided that in the initial equilibrium the marginal utility of consumption is constant across time, the marginal product of capital equals the subjective rate of time preference, and movements in the capacity utilization rate do not invoke significant wealth effects.[8] However, it is to be emphasized that the more appropriate interpretation to give to the results of statistical tests involving these cross-equation restrictions is simply in terms of assessing the adequacy of the structural model in explaining the data rather than a direct test of an exactly specified theoretical model.

Table 2 provides estimates of the model. On all counts, the neoclassical approach to the crowding out of private by public investment spending appears to gain support. Consider first the results relating to private investment expenditure. Private capital accumulation responds positively to an increase in the rate of return to capital, with a one standard deviation rise in the latter variable (.019) inducing roughly a one and one third standard deviation rise in private investment (.015). In dollar terms, in 1986 a one percentage point increase in the return to capital would have been expected to bring forth some 29 billion (1982) dollars in additional private capital expenditures. More dramatically from the perspective of the validity of the neoclassical approach, however, is that the point estimate of the impact of public nonmilitary capital spending on private capital accumulation equals $-.99$. This coefficient is determined fairly precisely, with a 95 percent confidence interval given by $(-1.32, -.66)$. The adjusted coefficient of determination is high and the value of the Durbin h statistic does not allow a rejection of the null hypothesis of an absence of serial correlation in the estimated residuals of the investment equation.

The rate of return to private capital responds negatively to the net private capital stock and positively to the net public capital stock. A one percent increase in the private capital stock is estimated to lower the return to private capital by 27 basis points while a one percent rise in the public stock of nonmilitary equipment and structures is expected to increase the rate of return by 9 basis points. The latter estimate has a 95 percent confidence interval of (.07, .11). Again, the coefficient of determination is high and the value of the Durbin-Watson statistic does not indicate the presence of strong serial correlation.

It is interesting to note that the estimated rate of return equation includes a positive and statistically significant time trend, given the private and public capital stocks and the capacity utilization rate. There has been a concern in the literature about a "falling rate of profit" over the last fifteen or twenty years. An ocular inspection of the data probably would lead one to conclude that indeed the rate of return to private capital has trended downward throughout the post-Korean War period. Feldstein and Summers (1977), however, argued that the apparent slump in the profitability of nonfinancial corporate profit was in fact an illusion arising from a failure to take account of serial correlation and the low levels of capacity utilization during the 1970s.

Table 3 contains ordinary least squares regressions (with and without corrections for first order serial correlation) of the rate of return on various sets of explanatory variables. Equations (1) and (2) of Table 3 contain the same regressions run by Feldstein and Summers (1977) where the list of explanatory variables is restricted to time and the capacity utilization rate. On the basis of a sample including the latter half of the 1970s and the first seven years of the 1980s, one would now have to conclude that the rate of profit had indeed fallen regardless of the effects of generally lower capacity utilization and serial correlation in the residuals of the estimated equation.

Equations (3) and (4) of Table 4, however, reveal an interesting result in this regard. Allowing the stocks of private and public capital in the list of explanatory variables for the rate of return to capital reverses the sign of the time coefficient. This implies, in turn, that the basic cause of the falling rate of profit captured in the first two equations of Table 3 is to be found in the relative behavior of the net capital stocks over the period in question; while both the net public (nonmilitary) and private capital stocks rose without interruption, the ratio of public to private capital stocks climbed until 1968, peaking at .58, and then continuously tumbled to .44 in 1986.

As discussed previously, the presence of a set of cross-equation restrictions provides a test of the adequacy of the specification of the structural model. Specifically, we may estimate the reduced form in an unrestricted fashion and calculate the statistic $s = N^*(|V^c|/|V^u|)$, where N = sample size and V^c, V^u = estimated variance-covariance matrix of the constrained and unconstrained systems, respectively. This statistic is distributed as a chi-square variable with degrees of freedom equal to the number of over-identifying restrictions implied by the structural model. In the present case, s takes on a value of 5.96, well below the 95 percent critical point of the chi-square distribution with 3 degrees of freedom, 7.81.

An implication compatible with the neoclassical notion of quantities responding to price movements, then, is that it is not possible to reject at usual significance levels the hypothesis that the level of private investment is unaffected by the capacity utilization rate over and above the influence the latter variable has on the rate of return to private capital.

Table 4 contains estimates of the separate effects of nonmilitary and military investment on private investment as well as of the stocks of these two forms of capital on the return to private capital. The point estimate of the impact of military capital accumulation on private investment spending is such that a one dollar increase in purchases of military equipment and structures depresses investment by a mere 8 cents; furthermore, there is no statistical basis for rejecting the hypothesis of zero crowding out of private capital spending. The neoclassical interpretation of this result is that private agents take such spending as a poor substitute for private capital, and as such, as a drain on wealth; consequently, military capital expenditures work to crowd out consumption as opposed to investment.[9]

The results of Table 4 also indicate that the stock of military capital has no statistically discernable impact on the productivity of private capital. Even taking the point estimate of .02 as valid suggests that the influence of nonmilitary capital on the return to private capital is four times as large as that of military capital.

Table 5 presents the effects of public consumption expenditure on the level of private investment and the return to nonfinancial corporate capital. Note first that public consumption carries only marginal explanatory power for the level of private capital accumulation and for the return to capital. Indeed, accepting the point estimates at face value leads to the conclusion that public investment and capital are of much greater statistical and quantitative importance to an explanation of movements in the endogenous variables. Note also that the point estimate of the coefficient on public nonmilitary investment is reduced substantially in absolute value from the value in Table 2 of .99 to .72, while its associated standard error increases from .17 to .21. This appears to be due to the strong collinearity between public nonmilitary investment and public consumption expenditure; the simple correlation coefficient between these two variables equals .88 while that between public nonmilitary and military investment is equal to $-.15$.

The conclusions to be drawn from the empirical analysis are that public nonmilitary capital—much more than military capital or government consumption—has substantial explanatory power for the level of private investment in equipment and structures as well as for the average return to private capital. While higher investment by the government sector crowds out private investment nearly one-to-one given the return to capital, it also works to raise the productivity of capital which, in turn, crowds in private investment. In the following section, simulations are employed to illustrate the total impact of public capital expenditures on private investment.

IV. Public Investment, Private Investment, and the Rate of Return

An historical simulation over the sample period 1953 to 1986 was carried out for the estimated model of Table 2 above. Figures 1 and 2 contain the results of this exercise. Overall, the simple model appears to describe general movements in the level of private investment and the rate of return reasonably well. The root mean square simulation errors are .003 for the private investment variable (which has a sample mean of .034) and .007 for the rate of return to nonfinancial corporate capital (mean .093). The root mean square percentage errors are 1.59 percent for private capital accumulation and 1.25 percent for the rate of return. As can be seen, the model tracks the data well, capturing nearly all of the qualitative movements in both investment and the return to capital.

Figures 3 and 4 illustrate the effects of raising the level of nonmilitary public investment during the years between 1970 and 1986 from its actual level to the average level attained during the earlier period 1953 to 1969, 2.5 percent of the net private capital stock. Although the model is simple and ignores interactions between public investment and other aspects of the economy, the results of this experiment are nonetheless illuminating. The immediate effect of higher public capital spending is to lower the level of private investment by nearly the same amount since the positive effect on the rate of return, and thereby on private expenditures on plant and equipment, arises in subsequent periods. The crowding out is even more severe in the second year of the higher public investment as the direct effect of the public investment on private investment plus the effect due to the lower level of private investment in 1970 overwhelm the mitigating effect on the rate of return. After this point, however, the gap between the actual level of investment and the simulated level begins to dissipate as the rate of return is permanently raised above its actual level, as shown in Figure 4. Indeed, in 1985 the simulated level of private investment (.028 of net private capital) is roughly equal to the actual level (.030).

Figure 5 shows the effect of the higher public investment spending on the national level of productive investment (i.e., private investment plus public nonmilitary investment). For the first four years, the simulated national investment rate is lower than the actual rate; in all subsequent years the former exceeds the latter as the raised rate of return to capital—due to both the higher public capital stock as well as the lower private capital stock—stimulates additional private investment. In 1985 the experimental national investment rate is 5.3 percent of private capital as opposed to the historical value of 3.5 percent. Interestingly, visual inspection of the simulated rate of return and national investment levels leads one to the conclusion that the public investment policy would have brought both variables much closer to attaining the same average values as were achieved in the earlier portion of the sample period; indeed, the simulated national investment level and rate of return average 5.6 percent of the private capital stock and 9.8 percent, respectively, compared to the actual averages over 1953 to 1969 of 6.3 and 10.7 and over 1970 to 1986 of 4.9 and 7.9. Given the validity of the estimated model, it appears that public investment can have significant effects on the national level of investment, the national capital stock, and the profitability of private capital.

V. Conclusion

The United States has experienced a broad shift in public investment levels over the last thirty-five years. During the period 1953 to 1969 public nonmilitary capital accumulation averaged 1.5 percent of gross national product while during the subsequent years 1970 to 1986 the percentage of total output devoted to this purpose has fallen to a mere 0.4. Among other groups, the National Commission on Public Works Improvement has recommended that annual spending on infrastructure double, from $45 billion to $90 billion, by the end of this century. Clearly, then, an important question is the extent to which such additional public capital accumulation would crowd out private investment and, thereby, mitigate the impact of the public sector initiative on the national investment rate.

This paper has provided a preliminary, suggestive answer to this question. At a superficial level, an increase in public investment may be expected to reduce private investment nearly one-to-one as the private sector utilizes the public capital for its required purposes rather than expand private capacity. At a somewhat deeper level, however, a distinctive feature of public infrastructure capital is that it complements private capital in the production and distribution of private goods and services. Thus, public investment might be thought to raise private investment as the former raises the profitability of private capital stocks. The empirical results show that while both channels appear to be operating, the net effect of a rise in public investment expenditure is likely to be a relatively small fall in private investment. Consequently, the national level of investment is lifted; public investment policy by no means appears to be "neutral" in its effects on the real economy.

Footnotes

[1] In the alternative extreme case of a perfectly interest elastic investment demand schedule, higher public expenditure would crowd out private capital accumulation on a one-to-one basis. Carlson and Spencer (1975) refer to this as a "Knightian" case since, according to their interpretation of Knightian capital theory, "we should expect no diminishing returns from investment."

[2] This is a "static" model formulation as in the textbook treatment of Branson (1972).

[3] Among others, Robert Eisner (1986) holds strongly to the view that government deficits "crowd in" private investment. In his words, subsequent to public debt issuance, "business will be able to produce more to meet our demand for more bread today, and build a new bakery now, as well, to meet our demand for more bread tomorrow."

[4] For a critical view and theoretical discussion, see Bernheim (1987).

[5] This calculation is made on the basis of a two-period model, where the "future" has been aggregated into a single composite period. Work effort is taken to be perfectly inelastically supplied and normalized to unity.

[6] John Musgrave of the Bureau of Economic Analysis, Department of Commerce, has been very helpful in providing unpublished data.

[7] In preliminary regressions, neither time nor a lagged rate of return to capital were statistically significant in the investment and rate of return equations, respectively; in any case, entering these variables does not alter the conclusions of the analysis. Further, relating the rate of return to capital-labor ratios yields similar results.

[8] For a rise in the initial capital stocks to have no effect on private investment given the rate of return to private capital requires, in the two period model, $u = (o/p)^*uf$, where uf is the second derivative of the utility function evaluated at the future level of consumption.

[9] This assumes that shifts in military investment are permanent. If the sample period over which the empirical work was to be undertaken were to include years in which defense spending (particularly on capital goods) was extraordinarily high, it would be necessary to consider the implications of the temporary nature of such expenditures. For example, one would expect on neoclassical grounds that the large investment in military equipment and structures during World War II (reaching 22 percent of the private capital stock in 1943) would have been regarded as largely temporary and hence that it would have impinged dramatically on private saving and investment. In the sample period 1953-86, however, net military investment ranged only between .3 and .6 of one percent of the private capital stock.

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Table 1

Sample Statistics

1953-86

	mean	standard deviation	maximum	minimum
i	.034	.011	.057	.013
i^g	.019	.009	.040	.006
c^g	.246	.039	.354	.194
ϕ	.093	.019	.130	.056

NOTE: i = net private nonresidential fixed investment relative to net private nonresidential fixed capital stock

i^g = net public nonresidential fixed investment relative to net private nonresidential fixed capital stock

c^g = total government consumption spending, defined as total government purchases of goods and services minus net public nonresidential fixed investment, relative to net private nonresidential fixed capital stock

ϕ = rate of return to private nonfinancial corporate capital

Table 2

$$i = c_1 + c_2{}^*i(-1) + c_3{}^*\phi + c_4{}^*i^g + e_1$$

$$\phi = c_5 + c_6{}^*t + c_7{}^*lnk + c_8{}^*lnk^g + c_9{}^*cu + e_2$$

c_1 =	−.04 (−6.16)
c_2 =	.60 (9.65)
c_3 =	.79 (8.79)
c_4 =	−.99 (−5.66)
c_5 =	2.52 (5.80)
c_6 =	.63 (5.76)
c_7 =	−.27 (−7.34)
c_8 =	.09 (8.24)
c_9 =	.19 (8.45)

i		ϕ	
R^2 =	.921	R^2 =	.872
SER =	.003	SER =	.007
D-h =	.70	D-W =	1.49

$$V^c = \begin{array}{cc} 5.66(E(-6)) & -2.40(E(-7)) \\ & 3.56(E(-5)) \end{array}$$

$$N^* \log(|V^c|/|V^u|) = 5.96$$

NOTE:

i	=	See Table 1
ϕ	=	See Table 1
i^g	=	See Table 1
lnk	=	natural logarithm of net private nonresidential capital stock
lnk^g	=	natural logarithm of net public nonmilitary nonresidential capital stock
t	=	time*100
cu	=	capacity utilization rate in manufacturing
R^2	=	adjusted coefficent of determination
SER	=	standard error of regression
D-h	=	Durbin *h* statistic
D-W	=	Durbin-Watson statistic

Table 3

Dependent Variable = ϕ

const	t	lnk	lnk^g	cu	p	R^2	SER	D-W
2.73	.70	−.29	.09	.22	-	.885	.006	1.46
(4.36)	(4.16)	(−5.33)	(4.75)	(8.78)	-			
2.96	.75	−.31	.10	.20	.32	.889	.006	1.84
(3.22)	(3.05)	(−3.70)	(3.08)	(6.17)	(1.43)			
−.09	−.07	-	-	.24	-	.776	.009	1.02
(−3.26)	(−4.38)	-		(7.27)	-			
−.05	−.10	-		.19	.57	.845	.007	1.82
(−1.21)	(−3.05)	-		(4.49)	(2.86)			

NOTE: p = first order autocorrelation coefficient.

Table 4

$$i = c_1 + c_2{}^*i(-1) + c_3{}^*\phi + c_4{}^*i^g + c_5{}^*i^{gm} + e_1$$

$$\phi = c_6 + c_7{}^*t + c_8{}^*lnk + c_9{}^*lnk^g + c_{10}{}^*lnk^{gm} + c_{11}{}^*cu + e_2$$

c_1 =	−.04	(−5.81)		
c_2 =	.57	(9.06)		
c_3 =	.81	(8.36)		
c_4 =	−1.02	(−5.49)		
c_5 =	−.08	(−.48)		
c_6 =	1.74	(2.24)		
c_7 =	.48	(2.41)		
c_8 =	−.24	(−5.31)		
c_9 =	.09	(6.82)		
c_{10} =	.02	(1.02)		
c_{11} =	.19	(8.37)		

	i	ϕ
	R^2 = .918	R^2 = .871
	SER = .003	SER = .007
	D-h = .66	D-W = 1.52
V^c =	6.09(E(−6))	1.33(E(−6))
		3.67(E(-5))

$N^* \log(|V^c|/|V^u|) = 6.67$

NOTE: i^{gm} = net military investment relative to net private nonresidential capital
lnk^{gm} = natural logarithm of net military capital stock

Table 5

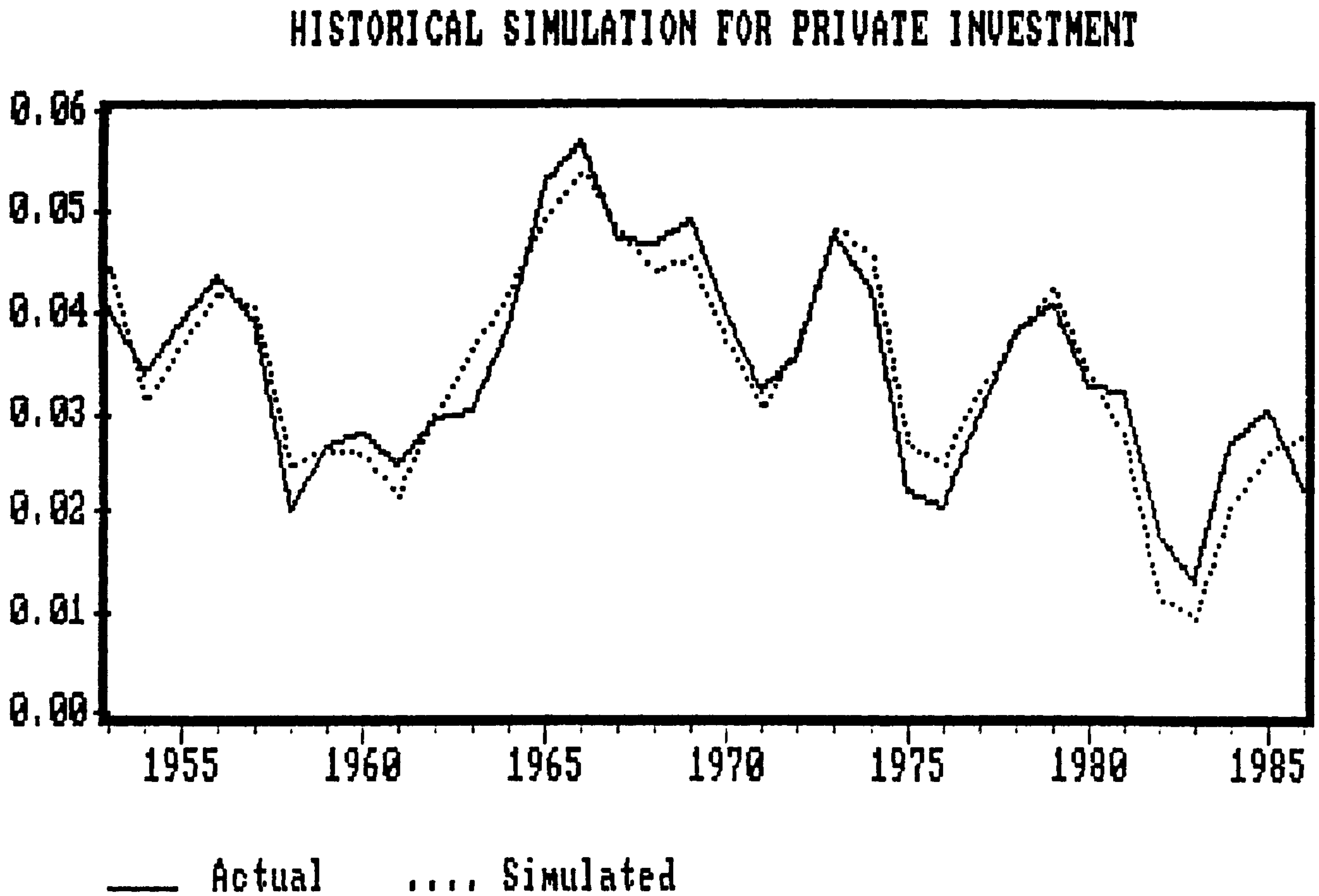
$$i = c_1 + c_2{}^*i(-1) + c_3{}^*\phi + c_4{}^*i^g + c_5{}^*c^g + e_1$$

$$\phi = c_6 + c_7{}^*t + c_8{}^*lnk + c_9{}^*lnk^g + c_{10}{}^*c^g + c_{11}{}^*cu + e_2$$

$c_1 =$	−.03	(−2.87)		i	ϕ
$c_2 =$	.56	(8.89)			
$c_3 =$	.81	(7.96)		R^2 = .922	R^2 = .865
$c_4 =$	−.72	(−3.29)		SER = .003	SER = .007
$c_5 =$	−.07	(−1.58)		D-h = .86	D-W = 1.52
$c_6 =$	2.00	(3.84)			
$c_7 =$	.51	(3.95)		5.83(E(−6))	8.89(E(−7))
$c_8 =$	−.22	(−4.69)	$V^c =$		
$c_9 =$	.08	(5.25)			3.84(E(−5))
$c_{10} =$	.05	(.89)			
$c_{11} =$	.19	(7.75)		$N^* \log(\lvert V^c \rvert / \lvert V^u \rvert) = 7.81$	

NOTE: c^g = See Table 1

FIGURE 1


HISTORICAL SIMULATION FOR PRIVATE INVESTMENT
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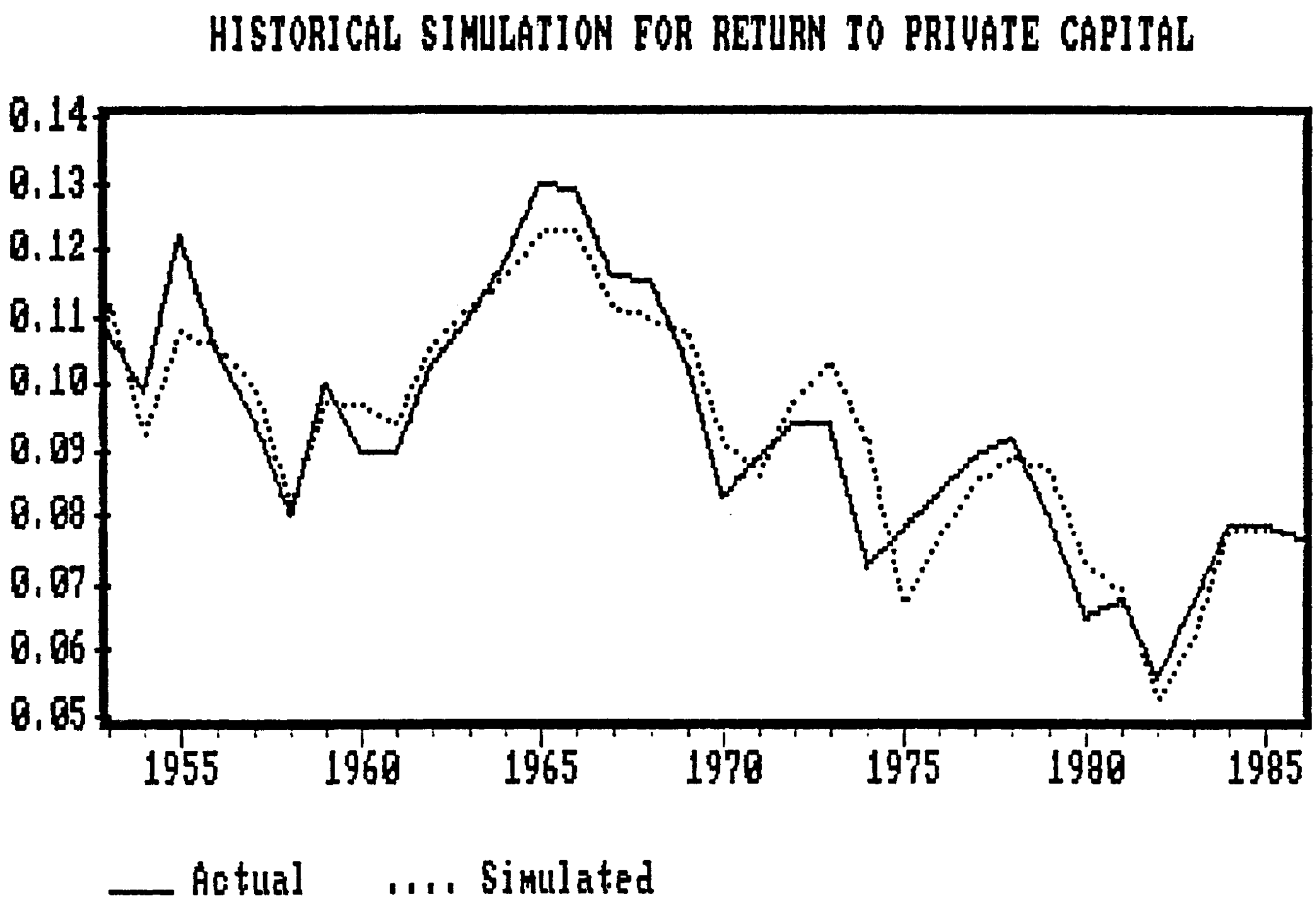
0.05
0.04
0.03
0.02
0.01
0.00
1955
1960
1965
1970
1975
1980
1985
Actual
.... Simulated

FIGURE 2


HISTORICAL SIMULATION FOR RETURN TO PRIVATE CAPITAL
0.14
0.13
0.12
0.11
0.10
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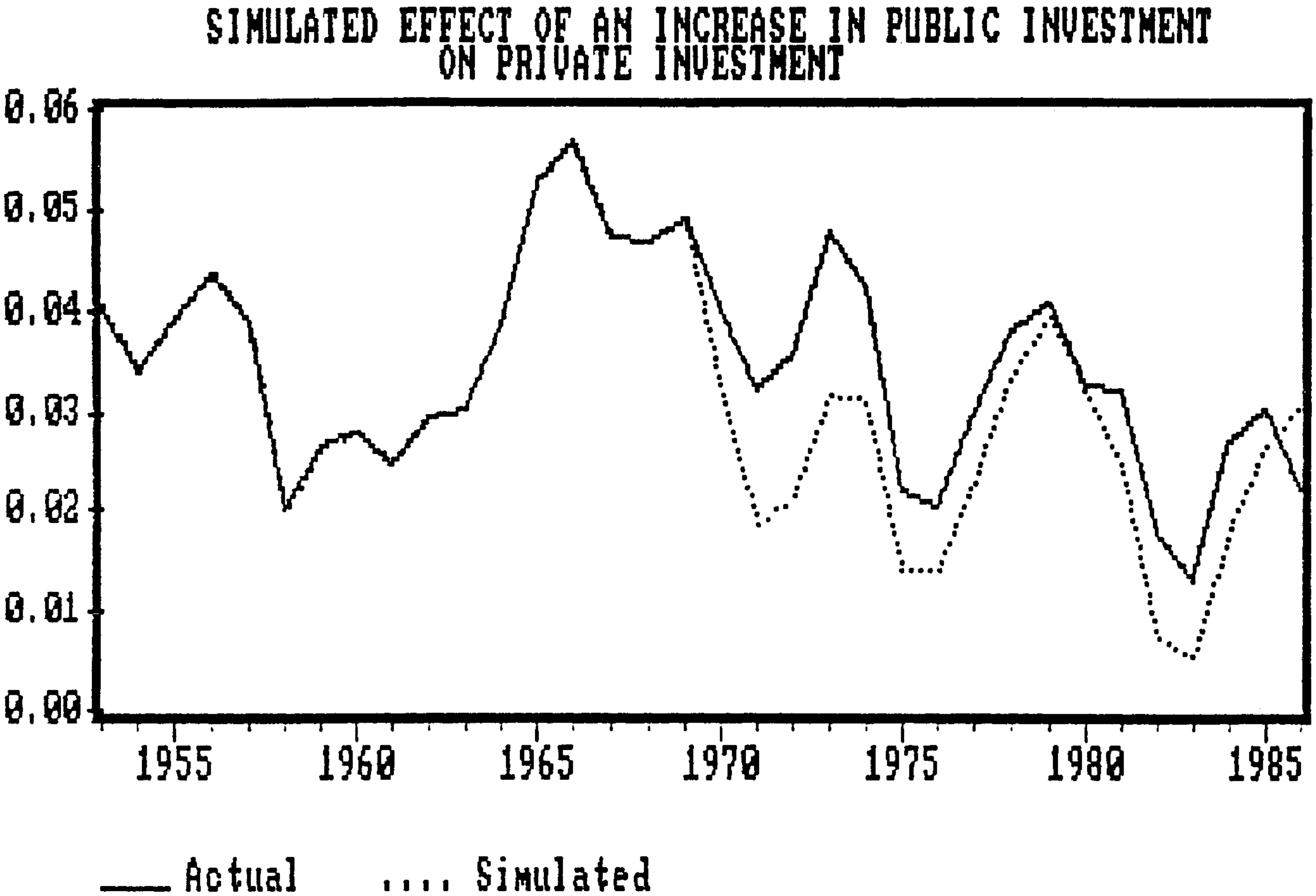
0.06
0.05
1955
1960
1965
1970
1975
1980
1985
Actual
.... Simulated

FIGURE 3


SIMULATED EFFECT OF AN INCREASE IN PUBLIC INVESTMENT
ON PRIVATE INVESTMENT
0.06
0.05
0.04
0.03
0.02
0.01
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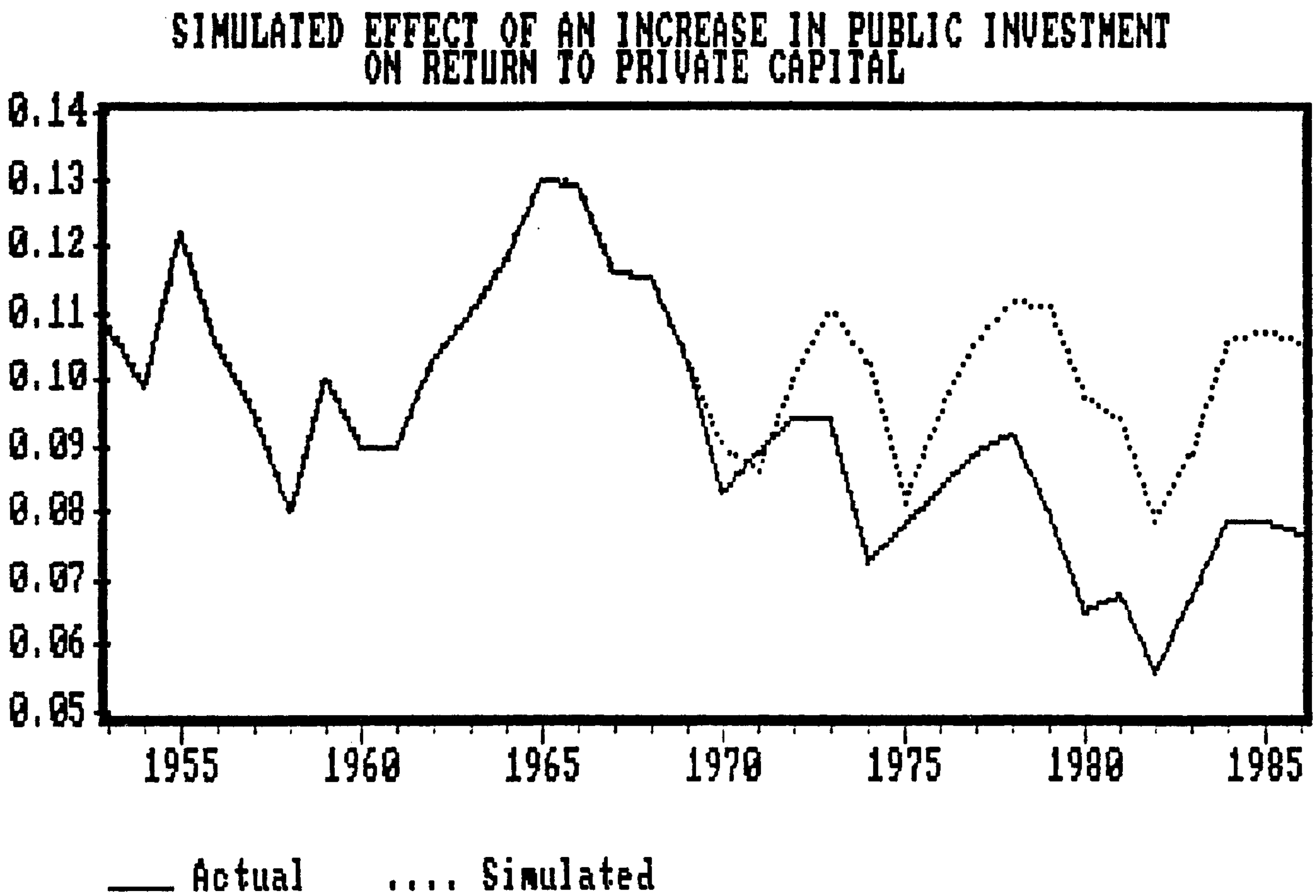
1955
1960
1965
1970
1975
1980
1985
Actual
.... Simulated

FIGURE 4


SIMULATED EFFECT OF AN INCREASE IN PUBLIC INVESTMENT
ON RETURN TO PRIVATE CAPITAL
0.14
0.13
0.12
0.11
0.10
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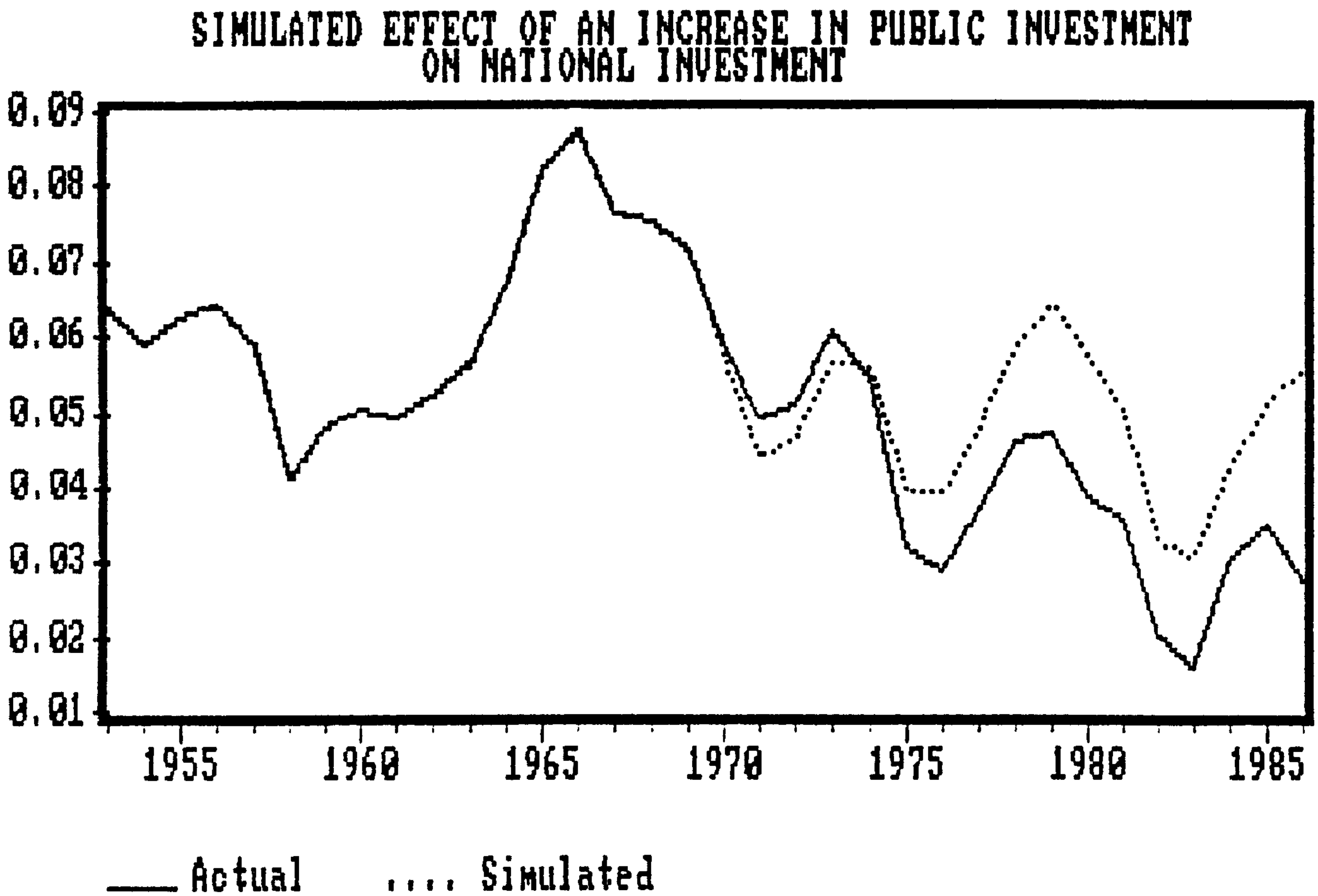
0.08
0.07
0.06
0.05
1955
1960
1965
1970
1975
1980
1985
Actual
.... Simulated

FIGURE 5



SIMULATED EFFECT OF AN INCREASE IN PUBLIC INVESTMENT
ON NATIONAL INVESTMENT
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1955
1960
1965
1970
1975
1980
1985
Actual
Simulated