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PUBLIC AND PRIVATE INVESTMENT AND THE GROWTH PROCESS IN DEVELOPING COUNTRIES*

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I. INTRODUCTION

In recent years, there has been an increasing discussion in policymaking and academic circles of the respective roles of public and private investment in the growth process in developing countries. There appears to be a general consensus now that these two components of investment can have a differential impact on economic growth. For instance, public investment in infrastructure and in human capital formation may increase the productivity of private capital and be beneficial for growth. It can also, however, crowd out private investment by using scarce resources and thus have an adverse effect on growth. Thus, for policymakers in the developing world concerned with growth, it is not only the total level of investment that matters, but also how it is split between its public and private components.

The empirical evidence on the relative effects of public and private investment on growth has been limited. A number of recent studies have concluded that private investment has a larger positive impact on growth than public investment (Khan and Reinhart, 1990; Coutinho and Gallo, 1991; Serven and Solimano, 1990). However, since these studies have used relatively small samples of countries and limited time periods, how robust this conclusion is, remains an open question. Moreover, to answer the question a number of other important issues related to differences in the two components of investment across developing country regions or across countries in different income groups need to be investigated. Finally, other determinants of growth such as human capital and macroeconomic instability, which have received considerable attention in the recent literature, have to be taken into account when assessing this issue.

An analysis of the relative effects of public and private investment is of interest both from a policy and a theoretical perspective. Insofar as policy

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is concerned, if private investment does have a markedly stronger impact on growth, it would further underscore the need to rationalize public investment, as well as provide additional support for the privatization of state-owned activities. From a theoretical perspective, in the recent literature on long-run growth and convergence in real per capita incomes across countries, the role of aggregate investment has been emphasized (Barro, 1991; Barro and Sala-i-Martin, 1992; Mankiw, Romer and Weil, 1992). If it is the case that the two components of investment have a differential impact on growth, it would have important implications for the determination of the steady-state growth path as well as the rate at which the steady-state is reached, namely the convergence rate.

The empirical analysis in this paper is based on a sample of 95 developing countries for the period 1970–90. This is the largest sample of developing countries used in any study of public and private investment to date, and accounts for over 90 percent of the GDP of developing countries during the late 1980's. The large sample allows for consideration of the hypothesis that there are significant differences in the differential effects of the two components of investment for four developing country regions — Africa, Asia, Europe and Middle East, and Latin America — as well as for countries in different income groups.[1]

The rest of the paper is structured as follows: Section II discusses the extent to which public and private investment may be complementary or substitutes, and develops a theoretical framework within which their respective roles in the growth process can be analyzed. Section III discusses the main empirical results. While the bulk of the empirical analysis is undertaken using cross-sectional data and single equation estimation techniques, estimation using pooled-time series data, with growth computed over different time horizons, and instrumental variable techniques to take into account the simultaneity between private investment and growth, was also undertaken. Finally, Section IV contains a summary of the main findings and some of the relevant policy implications of the study.

II. GROWTH, AND PUBLIC AND PRIVATE INVESTMENT

The salient features of the growth process in developing countries during the last two decades are contained in Table 1. It is evident that there has been a significant variation in growth of both real GDP and real GDP per capita across the four developing country regions during the last two decades. For instance, during the 1980's, per capita real GDP was virtually stagnant in Africa and declined by an average of 1 percent per annum

[1]The diversity in performance among developing country regions has become particularly evident during the 1980's; see, for instance, Ossa (1990), and Kumar (1992).

TABLE 1
Investment and Growth in Developing Countries, 1970–90
(unweighted average)

		1970–80						*1980–90*						*1970–90*					
	No. of countries	*GDP growth*	*GDP growth per capita*	*Investment as a ratio of GDP*			*Pop. growth*	*GDP growth*	*GDP growth per capita*	*Investment as a ratio of GDP*			*Pop. growth*	*GDP growth*	*GDP growth per capita*	*Investment as a ratio of GDP*			*Pop. growth*
				Total	*Public*	*Private*				*Total*	*Public*	*Private*				*Total*	*Public*	*Private*	
Developing countries	(95)	4.6	2.3	20.4	10.4	10.1	2.4	2.8	0.3	20.2	9.8	10.6	2.4	3.7	1.3	20.3	10.0	10.2	2.5
Africa	(46)	4.0	1.3	19.7	10.9	8.8	2.7	2.7	−0.1	19.9	10.4	9.5	2.8	3.4	0.6	19.7	10.6	9.1	2.7
Asia	(14)	5.3	3.5	18.8	7.8	11.0	2.0	5.0	2.8	22.4	9.5	12.8	2.1	5.2	3.2	20.5	8.6	11.9	2.1
Latin America	(24)	4.8	2.5	20.4	8.4	12.0	2.3	1.0	−1.0	18.3	7.4	11.0	2.1	2.9	0.7	19.3	7.9	11.4	2.2
Europe and Middle East	(11)	6.0	4.2	25.3	15.8	9.5	1.8	3.8	1.9	25.3	12.3	11.4	2.0	4.8	3.0	24.5	14.1	10.4	1.9

Notes: For sample of countries, see Appendix.

in Latin America — both regions with relatively low initial per capita real GDP — while in Asia it increased by over 2.5 percent per annum.[2]

One striking piece of information in Table 1 is that the share of public investment in developing countries accounts for nearly half of total investment. In industrial countries, by contrast, public sector investment accounts for less than one fifth of the total (of around 18 percent of GDP).[3] To the extent that the needs of developing countries for infrastructural and related capital are greater than those of the industrial countries, and given the indivisibilities and risks involved in the provision of such capital, the share of public investment might be expected to be higher. Nevertheless, these data raise questions concerning the efficiency of public investment relative to private investment and its contribution to long-run growth in developing countries.

In general, some components of public investment may be complementary to private investment and so would be beneficial for growth, while others may be substitutes and have a less positive, or even negative, effect on growth. The complementarity may arise in the case of public investment in infrastructure which increases the marginal product of private capital. This is most likely to be true in those developing countries where the existing stock of infrastructure capital is inadequate.[4] In this regard, it is worth noting in Table 1 that the share of public investment in countries in Africa and Europe and Middle East groups is higher than that of private investment; in Asian and Latin American countries private investment has a higher share. It is increasingly acknowledged, however, that public investment in infrastructure may not automatically have a beneficial impact on private investment and growth. In many of the Latin American countries, for instance, public infrastructure investment projects in the late 1970's were of dubious quality. There were examples of this in the 1980's in Asia and Africa as well; for instance, electric power plants, built at enormous cost, were either not operated or were operated far below capacity; similarly, many countries undertook ambitious transportation projects, including roads and railways, which were either not completed or were grossly underutilized.[5]

In addition to investment in infrastructure, a large part of public investment in developing countries is undertaken by state-owned enterprises.

[2]Since the main objective of the paper is to analyze the effects of public and private investment across countries, these data are unweighted averages. However, the broad picture remains unchanged if weighted averages, with weights corresponding to the countries' relative income levels, are used.

[3]This is based on an unweighted average for the OECD countries (excluding Turkey) for the 1980's.

[4]See Blejer and Khan (1984). For industrial countries, Aschauer (1989a, b) finds that investment in infrastructure has had a very strong positive effect on private sector productivity. However, these findings remain controversial largely because the marginal productivity of infrastructure implied by his estimates is implausibly high (see, for example, Ford and Poret (1991), and Rubin (1991)).

[5]See Krueger and Orsmond (1990).

Here there may be complementarity between public and private sector investment if output of public enterprises, say in the capital goods industries, forms an essential input for investment in the private sector. In addition, capacity expansion by public enterprises may lead to an increase in private investment undertaken for the purpose of satisfying the additional demand. Such complementarity may have been encouraged through the granting of selective incentives for directing private investment to fulfill public investment plans.[6]

However, public enterprises may also produce goods and services which compete directly with the private sector so that the two forms of investment become substitutes. In addition, an increase in public investment could have an adverse effect on private investment indirectly via the public sector budget constraint. If, for example, public investment is financed by increasing taxes, it may further exacerbate distortions in the economy and increase the costs of inputs, leading to an adverse effect on expected output growth and private investment. Where it is financed by market borrowing, public investment could have an adverse effect on the availability of credit, as well as on the real cost of capital to the private sector. Finally, in the case of the use of the inflation tax to finance public investments, crowding out occurs less directly via an increase in the inflation rate, which creates uncertainty with regard to the expected returns from investment.

To provide a framework for examining the impact of private and public sector investment on growth, the analysis below utilizes the basic neoclassical framework which has been extended by Barro (1991) and Mankiw, Romer and Weil (1992) to examine issues related to convergence of per capita growth across countries, and the role of human capital in determining the rate of convergence. It bears emphasizing that unlike these studies, this paper is not concerned with testing the validity of the 'endogenous growth' models which assume constant or increasing returns to a broad concept of reproducible capital. The key feature of many such models is the role played by human capital, which, according to Lucas (1988) and Romer (1989), affects the productivity of all other factors of production, or generates new products or ideas that underpin technological progress. This paper takes the importance of human capital as given, and incorporates various measures of it in the estimating equations. However, in order to focus on the role of private and public capital, only these two forms of capital are distinguished in the following theoretical model which also identifies the role of population growth, and technical change, as determinants of growth of real per capita income.

[6] See, for instance, Chibber and van Wijnbergen (1988), who discuss the case of Turkey in the 1980's, where despite very high real interest rates, private investment boomed because of investment by public sector enterprises.

1. *Steady-state Income Per Capita*

Assume a Cobb–Douglas production function, with production at time t given by:

$$Y(t)=Kg(t)^{\alpha}Kp(t)^{\beta}(A(t)L(t))^{1-\alpha-\beta} \quad \alpha+\beta<1 \tag{1}$$

where Y, L and A denote the levels of output, labor, and technology, respectively; Kg and Kp denote public and private sector capital stock. L and A are assumed to grow exogenously at rates n and γ; therefore $N=LA$, which can be interpreted as effective labor or labor measured in efficiency units. Therefore, N grows at a rate $n+\gamma$, i.e.,

$$\frac{\dot{N}}{N}=n+\gamma \tag{2}$$

Let Sg and Sp be the share of income invested in public and private capital respectively. Following Blejer and Khan (1984), assume that both types of capital stock depreciate at the same rate δ.[7] That is,

$$\dot{kg}=Ig-\delta kg \tag{3a}$$

$$\dot{kp}=Ip-\delta kp \tag{3b}$$

where Ig and Ip denote public and private sector investment, respectively.

In equilibrium, aggregate savings equal aggregate investment. Define kg and kp as the stock of public and private capital per effective units of labor, i.e., $kg=Kg/AL$ and $Kp=Kp/AL$; and let y be the level of output per effective unit of labor, $y=Y/AL$. The evolution of kg and kp is given by the following:

$$\dot{kg}=SgY-(n+\gamma+\delta)kg \tag{4a}$$

$$\dot{kp}=SpY-(n+\gamma+\delta)kp \tag{4b}$$

In steady state, $\dot{kg}=\dot{kp}=0$ and the two types of capital stock converge to k_g^* and k_p^*. That is,

$$k_g^*=\left(\frac{S_g^{1-\beta}S_p^{\beta}}{n+\gamma+\delta}\right)^{(1/1-\alpha-\beta)} \tag{5a}$$

$$k_p^*=\left(\frac{S_g^{\alpha}S_p^{1-\alpha}}{n+g+\delta}\right)^{(1/1-\alpha-\beta)} \tag{5b}$$

Substituting (5a) and (5b) in the production function and taking logs gives the following equation for income per capita in the steady state

[7] It might be argued that public capital stock, especially in infrastructure, depreciates at a different rate compared with the private capital stock. While such an extension complicates the analysis, it does not change the conclusions significantly. For simplicity, therefore, the restriction of equality of depreciation rates is maintained.

$$\ln(y^*)=\frac{\alpha}{1-\alpha-\beta}\ln(Sg)+\frac{\beta}{1-\alpha-\beta}\ln(Sp)-\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+\gamma+\delta) \quad (6)$$

To obtain an estimating equation in terms of income per capita, rather than in terms of income per unit of effective labor as above, note that $A(t)=A(o)e^{\gamma t}$. In the standard neoclassical framework, γ, which reflects primarily the advancement of knowledge, is assumed to be constant across countries. In contrast, $A(o)$ reflects, in addition to technology, resource endowments, institutions and other variables likely to differ across countries. So $\ln A(o)=a+\varepsilon$, where a is a constant and ε is a country-specific variable. Substituting for A in $y=Y/AL$, gives:

$$\ln\left(\frac{Y}{L}\right)=a+\gamma t+\frac{\alpha}{1-\alpha-\beta}\ln(Sg)+\frac{\beta}{1-\alpha-\beta}(Sp)$$

$$-\frac{\alpha+\beta}{(1-\alpha-\beta)}\ln(n+\gamma+\delta)+\varepsilon \quad (7)$$

Thus, income per capita depends on public and private saving (equal to investment), population growth and technological progress. If there is no distinction between private and public sector investment, equation (7) reverts to the basic Solow (1956) model. In such a case income per capita is simply a function of the aggregate saving rate, population growth, and exogenous technological change. That is,

$$\ln\left(\frac{Y}{L}\right)=a+\gamma t+\frac{\alpha}{1-\alpha}\ln(S)-\frac{\alpha}{1-\alpha}\ln(n+\gamma+\delta)+\varepsilon \quad (8)$$

where α now refers to the share of aggregate capital in come, and S is the aggregate saving (and investment) rate. This equation has become the mainstay of empirical growth analysis.

2. Transition to Steady-state

The specification of equations (7) and (8) is based on the rather strong assumption that all countries are at their steady states. However, it is also possible to utilize a more general framework that allows estimation of the effect of various explanatory variables on per capita growth rates (rather than on the cross-sectional variation in income per capita).

Following Mankiw, Romer and Weil (1992) the transition to the steady-state is approximated by the following equation:

$$\frac{\mathrm{d}\ln(y(t))}{\mathrm{d}t}=\lambda[(\ln(y^*(t))-\ln(y(t))] \quad (9)$$

where $\lambda=(n+\gamma+\delta)(1-\alpha-\beta)$ is the speed of convergence; $y(t)$ is the actual output per effective worker at time t; and y^* is the steady-state level of income at time t as given by equation (7). Equation (9) can be rewritten as follows:

$$\ln(y(t))=(1-e^{-\lambda t})\ln(y^*)+e^{-\lambda t}\ln(y(o)) \tag{10}$$

where $y(o)$ is income per effective worker at some initial date.

Subtracting $\ln y(o)$ from both sides gives:

$$\ln(y(t))-\ln(y(o))=(1-e^{-\lambda t})\ln(y^*)-(1-e^{-\lambda t})\ln(y(o)) \tag{11}$$

Substituting for y^* from equation (7), yields:

$$\ln(y(t))-\ln(y(o))=(1-e^{-\lambda t})\left[\frac{\alpha}{1-\alpha-\beta}\ln(Sg)+\frac{\beta}{1-\alpha-\beta}\ln(Sp)\right.$$
$$\left.-\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+\gamma+\delta)-\ln(y(o))\right] \tag{12}$$

where the left-hand side of the equation is the growth of per capita income.

Equation (12), which is broadly similar to the transitional equation estimated by Mankiw *et al*. (1992), forms the basis for the following empirical analysis of the effect of public and private investment on per capita growth. In estimating this equation, an attempt is also made to allow for cross-country differences in γ, reflecting technical change, as well as differences in human capital and macroeconomic stability. Concerning technical change, it is sometimes suggested that in the long-run, both the 'disembodied' and the 'embodied' technical change in a country are related to its exposure to foreign trade and investment. Several recent theoretical and empirical contributions link such exposure to foreign markets, managerial techniques, etc. This link allows for not only a one-time shift in production possibilities, but also for sustained increases in growth rates due to dynamic scale economies and learning by doing (Grossman and Helpman, 1990; Edwards, 1992).

Instead of assuming γ to be constant across countries, in the empirical specification it is allowed to vary as a function of a country's trade orientation and the inflow of foreign direct investment. The specific procedure adopted is to assume that for the average of the sample the value for γ assumed by Mankiw, Romer and Weil (1992) — 2 percent a year — holds. Deviations from this average value are then related to trade orientation measured by the average share of exports and imports to GDP, and to the inflows of foreign direct investment relative to GDP.

Two additional explanatory variables were also included in the estimating equation. First, following the earlier discussion, human capital, as proxied by three different measures identified by Barro and Lee (1994),

was included. These measures are as follows: total gross enrollment ratio for three categories of education (primary, secondary and higher education); the percentage of schooling completed in the total population for the three categories; and averaging schooling years in the total population.[8] Second, macroeconomic instability, which has been shown to adversely affect growth, was also considered.[9] One of the key measures of such instability — budgetary deficits, measured as the fiscal balance of the general government as a proportion of GDP — was introduced into the equation as an additional explanatory variable. Aside from representing macroeconomic instability, if high deficits are associated with high public investment, by not taking them into account in the empirical estimation, one may obtain biased results of the effect of such investment on growth.

III. EMPIRICAL RESULTS

1. Basic Results

Before examining the differential impact of public and private investment obtained by estimating equation (12), consider as a benchmark the empirical results for the model with aggregate investment as the main explanatory variable and technological change invariant across countries. Table 2 provides these results for three different periods — 1970–90, 1970–80, and 1980–90.[10] Column (1) shows that for the 1970–90 period as a whole, the fit of this equation is quite good; nearly a third of the cross-country variation in per capita GDP growth over the past two decades is explained by the variation in the investment ratio, initial per capita income, population growth, and human capital (proxied by secondary school enrollment ratio).[11] All the variables have the expected signs and are statistically significant. The variable of special interest is the investment ratio. The estimated coefficient suggests that a one percentage point increase in the investment ratio across developing countries is associated with an increase in per capita GDP of three-quarters of a percentage point.[12]

Now consider the separate role played by public and private sector investment in determining per capita growth. As indicated in column (4)

[8] For a discussion of these variables see Barro and Lee (1994).

[9] For an analysis of the relationship between macroeconomic instability and growth, see Frenkel and Khan (1990) and Fischer (1993).

[10] For the sample of developing countries and data definitions and sources, see Appendix.

[11] In the empirical estimation, only secondary school enrollment ratio, and average years of schooling at the secondary level, were statistically significant; other measures of human capital noted earlier were insignificant and were not considered further.

[12] Note that from the initial income variable, one can obtain the rate of convergence among developing countries, which turns out to be 0.01. This implies that once the cross-country variation in the investment and population growth variables is taken into account, the poorer developing countries (measured by their per capita income in 1970) narrowed the gap between them and the richer countries at a rate of roughly 1 percent a year. For further details, see Khan and Kumar (1993).

TABLE 2
Determinants of Per Capita Growth

	Average per capita growth during					
	(1) 1970–90	*(2) 1970–80*	*(3) 1980–90*	*(4) 1970–90*	*(5) 1970–80*	*(6) 1980–90*
Constant	3.06[a]	−1.55[a]	−1.61[a]	−1.72	−1.23[a]	−1.45[a]
	(0.78)	(0.52)	(0.48)	(0.83)	(0.51)	(0.47)
Initial per capita GDP	−0.19[a]	−0.04	−0.14[a]	−0.23[a]	−0.03	−0.18[a]
	(0.06)	(0.04)	(0.03)	(0.06)	(0.05)	(0.04)
Implied rate of convergence	0.011	0.004	0.015	0.013	0.003	0.020
Investment (total)	0.78[a]	0.46[a]	0.35[a]			
	(0.12)	(0.09)	(0.08)			
Investment (public)				0.29[a]	0.21[a]	0.13[a]
				(0.09)	(0.06)	(0.05)
Investment (private)				0.40[a]	0.22[a]	0.21[a]
				(0.09)	(0.05)	(0.05)
Population and technical change	−0.90[a]	−0.30	−0.61[a]	−0.79[a]	−0.29	−0.78[a]
	(0.30)	(0.19)	(0.19)	(0.39)	(0.19)	(0.19)
Human capital enrollment ratio (Secondary)	0.54[b]	0.39[a]	0.43			
	(0.39)	(0.16)	(0.31)			
Average years of schooling (Secondary)				0.02[a]	0.04[a]	0.02[a]
				(0.01)	(0.02)	(0.01)
Fiscal balance				0.03[a]	0.03[a]	0.03
				(0.01)	(0.01)	(0.005)
R^2	0.36	0.25	0.28	0.44	0.26	0.31
s.e.e.	(0.34)	(0.26)	(0.23)	(0.29)	(0.20)	(0.21)

Notes:
For detailed description of the data see the Appendix. Standard errors in brackets; *a* and *b* denote statistically significant at the 5 and 10% levels respectively. For the human capital variable, various measures identified earlier were included in the initial estimation. In general, only the enrollment ratio and the average years of schooling at the secondary level were significant. Given the high correlation between these proxies for human capital, the first proxy was included in the total investment regression while the second was included in the regressions distinguishing between public and private investment; the substantive results are virtually unchanged if the proxies are interchanged in the regressions.

of Table 2, while both types of investment had a positive impact in the estimates for the full period 1970–90, their *magnitude* differed considerably, with private investment having a much stronger impact than public sector investment.[13] However, the results for two sub-periods diverge markedly: during the 1970's, both public and private investment had a similar effect and it was only during the 1980's that the greater impact of private sector investment emerged. One explanation for this difference could be that in the earlier period the stock of infrastructural capital was lower in most developing countries, and thus the returns from such investment were higher. Put this way, it can be argued that there was much more complementarity between private and public investment than was the case during the last decade.[14]

An attempt was made next to investigate whether allowing technical change to vary across countries alters these basic results. Assuming a given *average* rate of technical change, it was postulated that technical change was a function of a country's trade orientation and the flow of foreign direct investment, and a country-specific proxy was accordingly constructed. In none of the estimates of equation (12) did this proxy appear significant, or lead to any change in the relative effect of public and private investment, compared to the original assumption of no cross-country variation. When the foreign trade and the foreign direct investment ratios were entered independently in the regression equation, they had a positive but statistically weak effect that did not alter the earlier results.

The above results also illustrate the extent to which taking into account human capital and budgetary position affects the basic conclusions. Both these variables enter the regression with the expected signs, are statistically significant, and generally improve the explanatory power of the equation. More interestingly, however, although their inclusion leads to a slight decline in the coefficient on private investment, the coefficient on public investment is virtually identical, leaving the earlier conclusions unchanged.[15]

Two extensions were made to the above analysis: first, to take into account the correlation between the right-hand-side variables, such as

[13] Note that from equation (12), given the speed of adjustment (λ) one can also compute the elasticities with respect to public and private capital. For instance, for the period 1980–90 (column 7), this yields values for public and private capital ($\hat{\alpha}$ and $\hat{\beta}$ respectively) of around 0.23 and 0.38.

[14] The above results are obtained without imposing the restriction that the sum of the coefficients on (S_g) and (S_p) is equal in magnitude and opposite in sign to the coefficient on ($n+\gamma+\delta$), although the restriction was not rejected by the data. In any case, imposing it gives results which are similar to the ones reported in the text.

[15] Similar results were obtained for the two sub-periods. The average rate of consumer price inflation was also considered as a proxy for macro-economic instability. It had the correct sign and was statistically significant when it was included by itself; however, when it was included together with the budgetary balance, it became insignificant. Since the fiscal position and inflation are generally closely related, particularly in developing countries, this result is not altogether surprising.

private investment and the error term, estimates using Two-Stage Least Squares (TSLS) were also obtained.[16] These suggested conclusions are broadly similar to those obtained using the OLS: private investment has a decidedly higher effect on growth compared to public investment, and the human capital variable has a positive coefficient that is not statistically significant. Secondly, the relationship between public and private investment and growth was examined using pooled time-series cross-section data. Since the use of annual data would be inappropriate for analyzing the growth process, and in any case exhibit excessive noise, the procedure adopted was to average growth, and the explanatory variables, over a period of three and five years.[17] The results reinforced the earlier conclusions using cross-sectional data but also indicated that given the shorter time horizon, there was now virtually no relationship between initial GDP and subsequent growth.

2. Regional Variation and Rates of Return

The empirical estimates allowing for regional differences are shown in Table 3, which reports results of estimating equation (12) with slope dummies for both private and public investment for each of the four regions. As column (1) in this table shows, for the 1970–90 period, the regional slope dummies increase considerably the explanatory power of the equation, which now accounts for over half the cross-country variation in per capita growth of real GDP. The 'F' test of no differences in the impact of public and private sector investment is clearly rejected. The regional differences are interesting and accord with standard priors. For Africa, and to some extent for Europe and the Middle East, both types of investment exercise a similar impact, while in Latin America public investment appears to have had, on average, very limited impact and private investment a pronounced positive effect.[18] In Asia, public investment is statistically significant, but has an effect on growth about half that of private investment.

A somewhat different picture emerges for the two sub-periods. During the 1970's, public investment had a statistically insignificant impact in both Asia and Latin America, but a significant one in Africa, where the

[16] The instruments were the lagged values of the explanatory variables (except initial income) over the preceding five years. Thus both for 1970–90, and 1970–80, averages over the period 1965–69 were used as instruments while for 1980–90, averages over 1975–79 were used.

[17] When the average is for three years, there are six observations per country giving a pooled sample for the 95 countries of 570 observations. With a five-year average, there are four observations per country giving a sample of 380 observations.

[18] It is interesting to note that for both Africa and Middle East the coefficients on the components of investment are larger for the 1970–90 period as a whole than for either of the two sub-periods. This result is, of course, quite possible in view of the cross-sectional regression utilized in this paper, and it further suggests structural differences between the 1970's and 1980's.

size of the coefficient exceeded that on private investment, as well as in Europe and the Middle East grouping. During the 1980's, for both Africa, the Europe and Middle East groups, the size and significance of the coefficients of public investment declines, while for the other two regions

TABLE 3
Regional Variation in the Impact of Investment on Growth

	(1) 1970–90		*(2) 1970–80*		*(3) 1980–90*	
Constant	−1.51[a] (0.77)		−0.49 (0.53)		−0.88 (0.50)	
Initial per capita GDP	−0.24[a] (0.07)		−0.12[a] (0.06)		−0.17[a] (0.04)	
Implied rate of convergence	0.014		0.012		0.019	
Population and technical change	−0.72[a] (0.29)		−0.21 (0.19)		−0.53[a] (0.19)	
Human capital enrollment ratio (Secondary)			0.32[a] (0.15)			
Average years of schooling (Secondary)	0.016[b] (0.009)				0.02[a] (0.01)	
Fiscal balance	0.007[a] (0.004)		0.02[b] (0.01)		0.03[a] (0.01)	
Investment ratio dummies	*Public*	*Private*	*Public*	*Private*	*Public*	*Private*
Africa	0.32[a] (0.10)	0.32[a] (0.08)	0.23[a] (0.07)	0.18[a] (0.06)	0.14[a] (0.07)	0.16[a] (0.06)
Asia	0.26[a] (0.14)	0.51[a] (0.12)	0.14 (0.11)	0.31[a] (0.10)	0.12[a] (0.10)	0.27[a] (0.09)
Latin America	0.01 (0.11)	0.65[a] (0.11)	0.12 (0.09)	0.35[a] (0.09)	0.02 (0.07)	0.28[a] (0.07)
Middle East	0.37[a] (0.11)	0.48[a] (0.12)	0.27[a] (0.09)	0.29[a] (0.09)	0.19[a] (0.08)	0.19[a] (0.09)
R^2	0.55		0.41		0.46	
s.e.e.	(0.30)		(0.24)		(0.22)	

See *Notes* to Table 2.

there is no noticeable change. This result implies that the difference between the impact of private and public investment across all developing countries during the last two decades is largely due to variations in the effects in the African and Middle Eastern regions.

The next step was to see whether the above regional differences are associated with differences in income and the level of development across developing countries. It could be argued that in low-income countries, regardless of the region, the need for infrastructure public investment is likely to be greater than in the high-income countries. Furthermore, in the high-income countries, the private sector is likely to be sufficiently developed to provide many of the goods and services which otherwise would have to be provided by the public sector. Hence, in the low-income countries the impact of public investment may be greater than in the high-income countries. This hypothesis was tested by re-estimating equation (12) by including two slope dummies for public investment: one for countries in the low-income group (defined as the bottom one-third of all countries ranked by per-capita GDP in 1970) and the other for countries in the high-income group. The results showed that the impact of public investment in the low-income group was noticeably greater than in the high-income group — the slope coefficients had values of 0.33 and 0.25 respectively — but it still remained less than the effect of private investment.

Finally, it is possible to use the estimates of the effects of the two types of investment to derive the rates of return to private and public investment.[19] From the derivation of the estimating equation, it can be seen that the impact of the two forms of investment on growth reflects the shares of the Cobb–Douglas production function. These shares depend not only on the relative productivity of the two types of investment but also on the relative supplies of public and private capital stocks (*Kg* and *Kp*).[20] A higher share for private investment, for instance, may simply reflect a higher share of private relative to public capital stock. Hence, evidence on the rates of return on the two types of investment can provide useful complementary information on the relative contribution of public and private investment to growth.

In order to calculate the rates of return, annual data on private and public capital stock for each of the countries in the sample were obtained using the perpetual inventory method (see Appendix for details). These data were then used in conjunction with the estimated elasticities for public and private investment obtained in Tables 2 and 3 to obtain the rates of return for each country for each year. The average values of these rates of return (returns to private investment relative to public

[19] We are grateful to Xavier Sala-i-Martin for suggesting this idea.

[20] Thus the rates of return to public and private capital stock are given by $\text{share}_g * Y/Kg$ and $\text{share}_p * Y/Kp$ respectively where share_g and share_p are the elasticities for public and private investment, and Y is real GDP.

investment) and the relative supplies of capital for the four regions and the overall sample are shown in Table 4. As columns (2) and (3) in this table indicate, the relative amounts of private and public capital stock have differed considerably across the four regions. During the 1980's, for instance, the stock of private capital was very similar to the stock of public capital in Africa, but it greatly exceeded the public capital stock in Asia and Latin America. However, as columns (5) and (6) indicate, despite these differences, the returns to private investment relative to public investment have in general been higher. The higher returns are particularly marked for the Latin American and the Middle Eastern countries, and appear to have increased somewhat during the 1980's. This evidence thus appears to further reinforce the conclusions obtained earlier regarding the relative contribution of private and public investment to growth.

IV. CONCLUSIONS

This paper has examined a number of key issues concerning the extent to which public and private investment exert a differential effect on long-run

TABLE 4
Estimates of Private and Public Capital Stock and Rates of Return[a]

	Ratio of private to public capital stock			*Ratio of rate of return return of private to public investment*[b]		
	(1) 1970–90	*(2) 1970–80*	*(3) 1980–90*	*(4) 1970–90*	*(5) 1970–80*	*(6) 1980–90*
Africa	0.996	1.008	0.982	1.493	1.235	1.608
Asia	1.629	1.731	1.526	1.328	0.813	1.424
Latin America	2.094	2.658	1.515	1.959	1.920	2.037
Middle East and Europe	0.780	0.820	0.734	2.925	2.521	2.237
All developing countries	1.286	1.332	1.237	1.823	1.676	1.874

Notes:
[a] Estimates for both capital stock and rates of return are averages based on estimates for individual countries and years. Capital stocks were obtained using the perpetual inventory method (see Appendix for details). The sample excludes four countries (Togo, Oman, Nicaragua, and Zambia) for which reliable public capital stock series could not be constructed.
[b] In estimating rates of return, the coefficient estimates in Tables 2 and 3 were used respectively for the full sample, and the regions.

growth of developing countries. The analytical framework used for investigating these issues took account of other determinants of per capita growth, including population growth, human capital formation, trade orientation, and measures of macroeconomic instability.

Utilizing a large sample of 95 developing countries over the period 1970–90, a variety of empirical tests were undertaken. The main results can be summarized as follows:

(a) There is a substantial difference in the impact of private and public sector investment on growth, with private investment having a much larger impact than public investment, especially during the 1980's. This relationship holds up even when other determinants of per capita growth are taken into account.
(b) An analysis of the rates of return, taking into account the relative supplies of public and private capital, suggest generally higher returns to private capital, which appear to have increased over time.
(c) There are, however, significant regional variations in both the effect of public and private investment on growth, and in the associated rates of return. The difference between the effects is most apparent for Latin America and Asia, but much less pronounced for Africa, Europe and the Middle East country groupings. There is also a significant difference across income groups, with evidence of higher rates of return to public investment in low-income countries than in high-income countries.
(d) The above findings are robust to the use of alternative estimation techniques, as well as the use of panel data with growth measured over different time horizons.

There are several important implications of these results for economic theory and policy. Concerning theory, the results support the basic neoclassical framework, with emphasis on savings and population growth, for analyzing long-term growth performance of developing countries. But they suggest it is important to make a distinction between the respective roles played by public and private investment. The results also offer some support to the emerging literature suggesting that outward-oriented policies, by increasing competition and exposure to foreign technology, have dynamic effects on growth, rather than just static efficiency gains.

The key policy implication concerns the role of public and private capital in the growth process in developing countries. The evidence suggests a clear need to improve the productivity of public sector investment by identifying much more rigorously the types of investment that have positive net returns and are likely to be complementary to the private sector. At the same time, policymakers should be undertaking measures to stimulate private investment. This can be done in part by structural reforms in the financial sector, which facilitate the mobilization of savings and help allocate funds to productive private sector investment,

and in part by ensuring a stable macroeconomic environment. Furthermore, an increased emphasis on education, and the adoption or maintenace of outward-oriented policies, are likely to play an important role both in stimulating private investment and in spurring sustainable long-term economic growth.

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APPENDIX: SAMPLE AND DATA DEFINITIONS

1. Sample of Developing Countries

The sample consists of 95 developing countries. The countries included are:

(a) Africa

Algeria, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Djibouti, Equatorial Guinea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Mauritania, Morocco, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zaire, Zambia and Zimbabwe.

(b) Asia

Bangladesh, China, Fiji, India, Indonesia, Korea, Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Sri Lanka and Thailand.

(c) Latin America

Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Surinam, Trinidad and Tobago, and Venezuela.

(d) Europe and Middle East

Cyprus, Egypt, Hungary, Jordan, Malta, Oman, Poland, Syria, Turkey, Yemen, and Yugoslavia.

2. Data Definitions and Sources

y	real GDP per capita (in 1985 international prices).
n	population growth.
I	ratio of total fixed investment to GDP.
Ig	ratio of public sector fixed investment to GDP (public sector includes general government, nonfinancial state enterprises, and principal autonomous agencies).
Ip	ratio of private sector fixed investment to GDP.
H	human capital: three sets of proxies were utilized: (i) gross enrollment ratio for primary, secondary and higher education; (ii) percentage of schooling completed in the total population at primary, secondary, and higher education level; and (iii) average schooling years in the total population over age 25.
FDI	ratio of foreign direct investment to GDP.
T	trade orientation defined as the ratio of the average of exports and imports to GDP.
GBG	public sector balances as a percent of GDP.
K_g, K_p	public and private capital stocks respectively (1987 prices).

For Tables 2 and 3, all ratios and growth rates are averages for the period 1970–80, 1980–90, and 1970–90; H^p and H^s are for the beginning of each period.

Data on y were obtained largely from Summers and Heston (1988, 1991) for the period up to 1985 and were extended to 1990 using per capita growth rates from the IMF's *World Economic Outlook* (WEO) database; for some low-income countries data were obtained from Ahmad (1992). Data on n, FDI, and T were from the WEO database. Data on I, Ig, Ip, K_g and K_p were obtained from the World Bank's 'DEC Analytical Database', supplemented by data from the International

Finance Corporation database on private investment and from the WEO database. Data for human capital proxies were obtained from Barro and Lee (1994). Estimates of public and private capital stock were obtained using the perpetual inventory method, data on public and private gross investment, and estimates of initial capital stocks in 1960. The depreciation rate for the two types of capital stock was assumed to be similar and varied between 4 and 5 percent per annum.