Government Policy and Private Investment in Developing Countries

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PRIVATE INVESTMENT BEHAVIOR has been studied in detail, but the focus has almost exclusively been on industrial countries. Clearly it is equally important for policymakers in developing countries to be able to assess how private investment responds to changes in government policy—not only in designing long-term development strategies, but also in implementing shorter-term stabilization programs. Even if it can be assumed that an increase in private investment, other things being equal, has an unambiguous positive effect on output, it is still necessary to establish how private investment in developing countries is determined—in particular, what variables systematically affect it—before one can evaluate the influence that government can exercise over private investment decisions that change the current and future growth rate of the economy.[1] The interaction between government policy and private investment is also crucial for any analysis of the effects that a stabilization program involving elements of demand restraint may have on the real sector—a question that is still the subject of considerable controversy (see, for example, Khan and Knight (1981, 1982)).

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[1] There is by now considerable empirical evidence available on the relation between total investment and growth in developing countries; see Robinson (1971) and Goldstein and Khan (1982).

Although in recent years a broad consensus has emerged on the form of several key macroeconomic relations in developing countries (such as the aggregate consumption function, money demand, imports, and exports), no such convergence of views is apparent in the case of the investment function. The theoretical literature on investment is quite rich and has yielded a well-defined class of models of the flexible accelerator type. The most popular of these is the neoclassical model of investment associated with Jorgenson (1967, 1971) and Hall (1977), and variants of this model have been applied with a fair degree of success to several industrial countries (see Bischoff (1969, 1971), Hines and Catephoros (1970), Jorgenson (1971), and Clark (1979)). There is, however, quite a large gap between the modern theory of investment and the models that have been specified for developing countries. This gap is the result of a variety of causes, both analytical and pragmatic. Because of institutional and structural factors present in most developing countries—such as the absence of well-functioning financial markets, the relatively larger role of the government in capital formation, distortions created by foreign exchange constraints, and other market imperfections—the assumptions underlying the standard optimizing investment models typically are not satisfied in those countries. Furthermore, even if the standard models could be directly adapted to developing countries, severe data constraints arise when attempts are made to implement them empirically. For example, data on variables such as the stock of capital, the labor force, and wages simply do not exist for most developing countries, and in the absence of information on real financing rates (debt and equity) it is not possible to calculate easily the service price or user cost of capital. Moreover, there are serious conceptual problems in defining private investment in economies where autonomous state enterprises play a relatively important role; whether such enterprises should be classified as part of the public sector or part of the private sector is often unclear. By and large, it is probably fair to assume that these assorted problems have in the past tended to inhibit the modeling of private investment along standard theoretical lines for developing countries.

Some recent studies (for example, by Sundararajan and Thakur (1980) and by Tun Wai and Wong (1982)), however, have attempted to incorporate features of the neoclassical model into investment models for developing countries, taking into account the relevant data problems and other structural features. These

studies represent a starting point for this paper, which attempts to develop a simple framework for studying private investment in developing countries. The paper extends the previous work on the subject in two main directions. First, it focuses on the role of government policy and derives an explicit relationship between the principal policy instruments—variations in bank credit and in government expenditures (specifically, government investment)—and private capital formation. Within the framework of the model derived, questions relating to the effects of stabilization policies on growth and on other real variables in the economy may be treated directly. At the same time, the model allows an assessment of the extent of any "crowding out," financial or real, that may occur. Because the share of government investment in total capital formation can become quite large in developing countries, real crowding out takes on a special importance.[2] Second, in contrast to previous studies, the model attempts to make a distinction between public investment that is related to the development of infrastructure and government investment of other kinds. The rationale for this distinction is simply that the effect on private investment will depend on the type of public investment in question. To our knowledge, such a distinction has not hitherto been empirically made or tested.

The resulting model is estimated for 24 developing countries, with data pooled over the period 1971–79.[3] Since data on private investment (defined as total fixed capital formation less gross investment of the public sector, including that of the general government, autonomous institutions, and nonfinancial state enterprises) are in general not available in a convenient form for developing countries, a special data set had to be constructed from national sources (supplemented, where necessary, by Fund staff estimates). Considerable effort was made to ensure cross-country consistency in the specific definition of private investment, and the selection of the 24 countries was determined primarily by the

[2] For a general discussion of the effects of government expenditures on capital formation, see von Furstenberg and Malkiel (1977). Both the studies by Sundararajan and Thakur (1980) and by Tun Wai and Wong (1982) also stress the independent effects of government investment on private investment.

[3] The countries in the sample are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Haiti, Honduras, Mexico, Panama, Paraguay, Venezuela, Barbados, Trinidad and Tobago, Turkey, Singapore, the Republic of Korea, Sri Lanka, Malaysia, Indonesia, and Thailand. For information on data sources, see the Appendix.

availability of data. Some interesting cross-country patterns are evident in the data, and these patterns have been discussed in another paper (Blejer and Khan (1984)). For example, there is a positive relationship between the share of private investment in total investment and the ratio of total investment to income. In other words, it appears that countries in which the private sector has been allowed to take on a larger role in capital formation have managed to achieve relatively higher rates of investment. We also found (Blejer and Khan (1984)) that the larger is the share of private investment, the higher is the average growth rate of the economy. Such patterns clearly indicate the importance of private investment behavior in developing countries and provide the motivation for specifying and testing formal models of private capital formation.

The paper proceeds as follows. In Section I we discuss the derivation of the model under considerations relevant to developing countries. The estimates of this model for the 24 countries in the sample are presented in Section II. The concluding section summarizes the principal results and their main implications for the effectiveness of government policy.

I. Theoretical Specification of a Model of Private Investment

The model developed here is in essence a variant of the flexible accelerator model, adapted to incorporate some of the institutional and structural characteristics of a developing economy. Various problems tend to limit the applicability of a strict version of the neoclassical investment model, as set forth by Jorgenson (1967, 1971), Hall (1977), and others, to developing countries, although there have been some notable attempts in this direction.[4] The difficulties associated with the concept and measurement of the capital stock,[5] with the calculation of the rental price of capital, with the definition and estimation of production functions, and with general imperfections in financial and labor markets

[4] The study by Sundararajan and Thakur (1980) comes closest to directly applying the neoclassical model to two developing countries—India and the Republic of Korea.

[5] See Ward (1976) for a comprehensive discussion of this issue.

make it necessary to modify the basic model to place greater emphasis on the effects of the resource constraints, both financial and physical, faced by private investors in developing countries. (See Galbis (1979), Leff and Sato (1980), Fry (1980), and Tun Wai and Wong (1982).) The aim of this paper is to derive a theoretically consistent model of private capital formation within the flexible accelerator framework that will allow for such resource constraints and, at the same time, incorporate an explicit role for monetary and fiscal policies.

In the long-run representation of the accelerator model, the desired stock of capital can be assumed to be proportional to expected output:

$$KP_t^* = aYR_t^e \qquad (1)$$

where KP^* is the capital stock that the private sector wishes to have in place in future periods, and YR^e is the corresponding expected level of output.[6] This is a quite standard formulation and can be rationalized by assuming that the underlying production function has (technologically) fixed proportions among factor inputs, so that factor prices do not enter into the specification.[7] Whereas the parameter a is assumed to remain constant, we do allow KP_t^* to be affected by changing economic conditions, so that the model does fit into the flexible accelerator mode.

Lags in the adjustment of actual investment that arise because of the time it takes to plan, build, and install new capital can be introduced through a partial adjustment mechanism for the capital stock, whereby the actual stock of capital is assumed to adjust to the difference between the desired stock in period t and the actual stock in the previous period:[8]

[6] Strictly speaking, because we are considering private sector investment, the output variable should be the expected private sector output. For simplicity we assume that private sector output is proportional to total output and therefore work with total output throughout. An alternative approach, which would not change the analysis in any significant manner, would be to treat YR^e as future aggregate demand.

[7] See Klein (1974). Using an alternative production function—for example, a Cobb-Douglas function—would directly introduce the ratio of the rental price of capital to wages, or the ratio of the price of investment goods to the price of capital services, into equation (1). As we mentioned above, none of such variables can easily be calculated for developing countries. For this reason we have had to assume a somewhat restrictive model that does not admit the possibility of factor substitution.

[8] Dynamics can also be introduced by specifying a distributed-lag function for expected output; see Hall (1977).

$$\Delta KP_t = \beta(KP_t^* - KP_{t-1}) \tag{2}$$

or

$$KP_t = \beta KP_t^* + (1-\beta)KP_{t-1} \tag{2a}$$

where KP is the actual private capital stock, so that ΔKP is net private investment, and β is the coefficient of adjustment, $0 \leq \beta \leq 1$.

The formulation given by equation (2), or equation (2a), is in terms of net private investment, whereas the data on investment are available only in gross terms, including depreciation. Equation (2) must therefore be transformed into gross investment terms to enable derivation of an equation that can be empirically estimated. Such a transformation also permits one to eliminate the private capital stock variable from the specification, and thus to get around this data constraint as well. Gross private investment, IP_t, is defined as equal to net investment plus depreciation of the previous period's capital stock:

$$IP_t = \Delta KP_t + \delta KP_{t-1} \tag{3}$$

where δ is the rate of depreciation. In standard lag-operator notation, equation (3) can be conveniently written as

$$IP_t = [1-(1-\delta)L]KP_t \tag{4}$$

where L is a lag operator, $LKP_t = KP_{t-1}$. By simply inverting equation (4), we can relate the private stock of capital to gross private investment:

$$KP_t = \frac{IP_t}{[1-(1-\delta)L]}. \tag{5}$$

Substituting for KP_t and KP_{t-1} in equation (2a) by using equation (5), we obtain[9]

$$\frac{IP_t}{[1-(1-\delta)L]} = \beta K_t^* + (1-\beta)\frac{IP_{t-1}}{[1-(1-\delta)L]} \tag{6}$$

which has the solution

$$IP_t = [1-(1-\delta)L]\beta K_t^* + (1-\beta)IP_{t-1}. \tag{7}$$

[9] Given equation (5), the previous period's stock of capital is $KP_{t-1} = IP_{t-1}/[1-(1-\delta)L]$.

If we then proceed to substitute for K_t^* from equation (1) into equation (7), we can derive a basic dynamic accelerator model for gross private investment:

$$IP_t = \beta a[1 - (1 - \delta)L]YR_t^e + (1 - \beta)IP_{t-1}. \quad (8)$$

Equation (8) has an important advantage: although it is completely consistent with the original capital stock model given by equations (1) and (2), it does not require information, as mentioned above, on net investment or on the stock of capital. Therefore, equation (8) can be readily applied to available gross investment data in developing countries.

An alternative way of deriving equation (7), and then equation (8), would be to start by directly specifying a partial adjustment function for gross investment, as follows:

$$\Delta IP_t = \beta(IP_t^* - IP_{t-1}) \quad (9)$$

where IP^* is the desired level of investment. In the steady state, desired private investment is given by[10]

$$IP_t^* = [1 - (1 - \delta)L]KP_t^*. \quad (10)$$

Combining equations (9) and (10) and solving for IP_t yields an equation that is exactly the same as equation (7).[11]

To allow private investment to vary with underlying economic conditions, and thus to make the model consistent with the flexible accelerator framework, we follow the approach suggested by Coen (1971). In essence, the response of private investment to the gap between desired and actual investment, as measured by the coefficient β, is assumed to vary systematically with economic factors that influence the ability of private investors to achieve the desired level of investment. We hypothesize that the response of private investors depends on three main factors: (1) the stage of the cycle, (2) the availability of financing, and (3) the level of public sector investment. The phenomenon of crowding out, therefore, is captured through affecting the speed of adjustment rather than through directly changing the desired level of real private investment.[12]

[10] This equation requires that $KP_{t-1}^* = KP_{t-1}$. This equality would generally hold in the steady state.

[11] In addition, because $KP_t^* = aYR_t^e$, we can derive an equation identical to equation (8) from equations (9) and (10).

[12] The latter method, discussed later, turns out to yield an estimation equation that is similar to the one obtained by the method adopted here.

During the expansionary phase of the cycle, when demand conditions are buoyant, private investors can be expected to respond more rapidly to changes in desired investment.[13] If the trend or potential level of output is taken as an indicator of full capacity, however, then the reaction of investment to the discrepancy between the desired and actual rates of investment would tend to be smaller when actual output is above capacity and more strain is put on available resources, leading to an increase in input prices. Alternatively, investment could respond more rapidly in situations of excess capacity. It is, therefore, not entirely clear what effect, on average, cyclical factors can be expected to have on the change in private investment.[14]

The effect of the availability of financing on the coefficient of adjustment is less ambiguous. A clear consensus has emerged in recent years that, in contrast to developed countries, one of the principal constraints on investment in developing countries is the quantity, rather than the cost, of financial resources.[15] The rates of return on investment in these countries typically tend to be quite high, whereas real interest rates on loanable funds are kept low by governments for a variety of reasons. In such circumstances the investor cannot be expected to equate the current marginal product of capital to its service cost. Indeed, because the total amount of financing is limited and the price mechanism is not allowed to operate smoothly, it would seem legitimate to hypothesize that the private investor in a developing country is restricted by the level of available bank financing.[16] Any effect exerted by the rate of interest on private investment is not direct within this rationing framework but, rather, occurs via the channel of financial savings.[17]

[13] See von Furstenberg (1980). As noted in that paper, the cyclical response may itself involve lags arising from the difficulties in terminating ongoing investment projects as demand declines and in initiating investment rapidly as demand picks up.

[14] The situation is further complicated if expectations are introduced into the analysis. For example, if output is abnormally high, it may be expected to grow at rates below average in the future stages of the cycle, and thus current investment may decline.

[15] This view, associated with McKinnon (1973), has gained considerable currency in the literature on financial development.

[16] This may be somewhat restrictive for those developing countries in which firms can issue shares and obtain equity financing. In most developing countries, however, this form of financing is only a limited possibility.

[17] For a discussion of the effects of interest rates on investment, see Galbis (1979), and Fry (1980, 1982). It is interesting to note that, in the currently popular models of financial development, an increase in interest rates, by increasing financial savings, raises rather than lowers private investment.

The rudimentary nature of capital markets in developing countries limits the financing of private investment to the use of retained profits, bank credit, and foreign borrowing. Of these, the flow of bank credit to the private sector would perhaps tend to be quantitatively the most important. An increase in real credit to the private sector will in general encourage real private investment, and rolling over bank loans can sufficiently lengthen the maturity of the debt. The role of foreign capital flows in the domestic investment process, whether they are in the form of direct or portfolio investment, has also been documented (see Weisskopf (1972), Stillson (1976), and Tun Wai and Wong (1982)). The effects of foreign financing are broadly similar to the effects of variations in bank credit—both tend to increase investment because they expand the pool of financial savings.[18] Since control of total bank credit usually is the principal instrument of monetary policy in developing countries,[19] through varying the composition of credit between the public and private sectors the government can affect the speed and ability of private investors to respond to achieve their desired levels of investment. Monetary policy can thus have a direct and potent influence on the rate of private investment. In a similar vein, private investment can be influenced by interest rate and exchange rate policies that cause changes in private capital flows, which augment or reduce financial resources available to the private sector.

Finally, it is a well-accepted proposition that in developing countries private and public investment are related (see Galbis (1979), Heller (1975), Tun Wai and Wong (1982), and Sundararajan and Thakur (1980)), although there is considerable uncertainty about whether, on balance, public sector investment raises or lowers private investment.[20] In broad terms, public sector investment can cause crowding out if it utilizes scarce physical and financial resources that would otherwise be available to the private sector, or if it produces marketable output that competes

[18] A theoretical discussion of how an increase in foreign capital flows can increase total financial savings is contained in Khan and Knight (1982).

[19] Other tools of monetary policy, such as open-market operations, have a limited scope in economies where capital and bond markets remain relatively underdeveloped.

[20] See von Furstenberg and Malkiel (1977). There does not, however, seem to be much empirical support for the proposition discussed by David and Scadding (1974)—that the private sector perceives any addition to the government capital stock as potentially competing with its own and, therefore, that any increase in public sector investment is matched by an immediate and equal decline in the desired rate of private investment.

with private output. Furthermore, the financing of public sector investment—whether through taxes, issuance of debt, or inflation—will lower the resources available to the private sector and thus depress private investment activity. Yet public investment that is related to infrastructure and the provision of public goods can also clearly be complementary to private investment. Public investment of this type can enhance the possibilities for private investment and raise the productivity of capital, increase the demand for private output through increased demand for inputs and ancillary services, and augment overall resource availability by expanding aggregate output and savings.

The overall effect of public investment on private investment will, therefore, depend on the relative strength of these various effects, and there is no a priori reason to believe that they are necessarily substitutes or complements. Assuming that the possibility of financial crowding out is taken into account by the composite variable incorporating both the change in bank credit to the private sector and private capital flows, our specific concern here is with real aspects of public sector investment. If, on average, public and private investment are substitutes, we would expect that the coefficient of adjustment of private investment would become smaller as the rate of public investment increases; conversely, complementarity would imply a faster response of private investment.[21] Again, this allows us to relate private investment behavior to government policy, in this case given by changes in government capital expenditures.

On the basis of the arguments above, we can express the coefficient of adjustment in equation (9) as a function of cyclical factors and of monetary and fiscal policy variables. A linear representation of this relationship would be

$$\beta_t = b_0 + \frac{1}{(I_t^* - I_{t-1})}(b_1 GAP_t + b_2 \Delta DCR_t + b_3 GIR_t) \qquad (11)$$

where

GAP = cyclical factors, given by the difference between actual and trend output[22]

[21] Note that we have explicitly assumed that causation runs from public sector investment to private investment. It can be argued that causation also runs the other way if the government has a reaction function that allows public investment to respond to economic variables, including private investment. See Heller (1975).

[22] The trend level of output (TYR) is calculated as $TYR = YR_0 e^{g_1 t}$, where YR_0 is the initial value of output, g_1 is the average growth rate of YR, and t is a linear time trend.

ΔDCR = change in real bank credit to the private sector plus real net private capital flows
GIR = real public sector investment.

Equation (11) states that the response of private investment depends on the magnitude of these three factors, measured in relative terms with respect to the size of the discrepancy between desired and actual investment.[23] The signs of the parameters in this equation are expected to be:

$b_1 \gtrless 0$
$b_2 > 0$
$b_3 \gtrless 0.$

Substituting equation (11) into equation (9) yields

$$\Delta IP_t = b_0(IP_t^* - IP_{t-1}) + b_1 GAP_t + b_2 \Delta DCR_t + b_3 GIR_t. \quad (12)$$

From equations (10) and (1) we have

$$IP_t^* = [1-(1-\delta)L]KP_t^* = [1-(1-\delta)L]aYR_t^e$$

and, therefore, we can obtain a dynamic reduced-form equation for gross private investment that includes cyclical factors, the change in real bank credit, and real public sector investment as the explanatory variables:

$$IP_t = b_0 a[1-(1-\delta)L]YR_t^e + b_1 GAP_t + b_2 \Delta DCR_t + b_3 GIR_t + (1-b_0)IP_{t-1}. \quad (13)$$

Representing crowding out through allowing the parameter β to be variable, as is done here, is certainly not the only way to arrive at an expression such as equation (13). For example, one could easily specify desired private investment as a function of the output gap, changes in credit, and government investment, in addition to expected real output, as follows:

$$IP_t^* = a[1-(1-\delta)L]YR_t^e + c_1 GAP_t + c_2 \Delta DCR_t + c_3 GIR_t. \quad (14)$$

Substituting equation (14) into equation (9) and solving for IP_t, we obtain

$$IP_t = \beta a[1-(1-\delta)L]YR_t^e + \beta c_1 GAP_t + \beta c_2 \Delta DCR_t + \beta c_3 GIR_t + (1-\beta)IP_{t-1} \quad (15)$$

[23] See Sundararajan and Thakur (1980) for a similar formulation.

which, as an unrestricted reduced-form equation, is exactly the same as equation (13). The only difference between equations (13) and (15) would be the interpretation of the parameters of the explanatory variables.

A simple extension of equation (13) is to postulate that the coefficient of adjustment (β) depends on both the level (GIR) and the change in public sector investment (ΔGIR), with the effect of the change in public investment considered to be ambiguous. This extension would yield the following equation:

$$IP_t = b_0 a[1 - (1 - \delta)L]YR_t^e + b_1 GAP_t + b_2 \Delta DCR_t + b_3 GIR_t + b_4 \Delta GIR_t + (1 - b_0)IP_{t-1}. \quad (16)$$

In estimating equations (13) and (16) we would expect the coefficient measuring the strict accelerator, $b_0 a$, to be positive, and the long-run coefficient, a, to be close to unity. This result would ensure that in the steady state the capital-output ratio would be constant. The effects of government policy on private investment can be directly obtained from the estimates of b_2 and b_3 (and b_4). Whereas there is some empirical support for the hypothesis that an increase in the flow of credit to the private sector will benefit private investment, the results for the effect of public sector investment have been somewhat indeterminate.[24] Given the widespread belief that public sector investment plays a relatively important role in private capital formation in developing countries, the lack of empirical support for the relationship is quite surprising. Our basic contention is that this lack of evidence is not so much an indication of the absence of any statistical relation, but rather a reflection of the offsetting effects that different types of public investment—infrastructural and other—tend to have. Ideally, it would be more meaningful to separate out the infrastructural component of public investment and then to estimate the independent effects of the different categories. Unfortunately, since there is a great deal of overlap between the categories of public investment, it is not possible to make such functional distinctions in the data.

[24] For example, Sundararajan and Thakur (1980) found the coefficient of the public sector capital stock in the private investment equation to be statistically insignificant in both countries (India and the Republic of Korea) of their sample. Furthermore, the coefficient corresponding to b_3 was significantly different from zero at the 5 percent level in only one country (Greece) of the five studied by Tun Wai and Wong (1982). Similar insignificant results are also reported by Galbis (1979).

Recognizing that such distinctions are crucial in understanding the role of public sector investment, we experimented with various proxies for the infrastructural and noninfrastructural components of public sector investment. The central assumption underlying these proxies is that infrastructural investment is an ongoing process that moves in line with the pace of economic development. Because it usually has a long gestation period and reflects decisions made in the past, such investment cannot be rapidly adjusted. In contrast, it is assumed that other kinds of investment can be altered by the government more easily and with relatively greater speed. The first of the two approaches we adopt takes the trend level of real public sector investment (*TGIR*) to represent the long-term or infrastructural component and argues that *TGIR* should have a positive effect on gross real private investment.[25] Deviations of real public sector investment from the trend are assumed to correspond to noninfrastructural investment.[26] Using this distinction, we can specify the investment equation as

$$\begin{aligned} IP_t = {} & b_0 a[1-(1-\delta)L]YR_t^e + b_1 GAP_t \\ & + b_2 \Delta DCR_t + b_3 TGIR_t \\ & + b_4(GIR_t - TGIR_t) + (1-b_0)IP_{t-1}. \end{aligned} \tag{17}$$

The coefficient b_3 in equation (17) would be expected to be positive; b_4 would be negative in the case of real crowding out and positive in the case of "crowding in."

An alternative approach is to make the distinction between kinds of public investment on the basis of whether the investment is "expected" or not. Again, we argue that expected public investment is closer to the long-term component and would therefore exert a positive influence on private investment, whereas the effect of the unexpected or surprise component is uncertain.[27] To calculate expected real public investment we used an essentially

[25] The trend level of real public sector investment is calculated as $TGIR = GIR_0 e^{g_2 t}$, where GIR_0 is the initial value of real public sector investment, g_2 is the average growth rate of *GIR*, and t is a linear time trend.

[26] To the extent that public infrastructural investments are "lumpy" and there are replacement cycles following periods of high public investment, this type of trend approximation might be in error. For this reason, and others, we use different measurements for public infrastructural investment.

[27] It could also be argued in a rational expectations framework that, if there is a high degree of substitutability, the effect of expected public investment on the rate of private investment would be negative. Correspondingly, since private investors could not respond quickly to surprises, this negative effect may turn out to be insignificant. Ultimately, the issue is an empirical one.

empirical method; that is, fitting a first-order autoregressive process of the form

$$GIR_t = \rho_0 + \rho_1 GIR_{t-1} \tag{18}$$

where ρ_0 is the average level of GIR and ρ_1 is the autoregressive parameter.[28] The predicted values from equation (18) were defined as expected real public sector investment ($EGIR$); the residuals were defined as the unexpected component. With these two variables, the basic investment equation then becomes

$$\begin{aligned} IP_t = {} & b_0 a[1-(1-\delta)L]YR_t^e + b_1 GAP_t \\ & + b_2 \Delta DCR_t + b_3 EGIR_t \\ & + b_4(GIR_t - EGIR_t) + (1-b_0)IP_{t-1} \end{aligned} \tag{19}$$

with the following signs expected:

$$\begin{array}{ll} b_0 a > 0 & b_3 > 0 \\ b_1 \gtreqless 0 & b_4 \gtreqless 0. \\ b_2 > 0 & \end{array}$$

Using the alternative approaches outlined above to make a distinction between infrastructural and noninfrastructural public investment should prevent the results from being dependent on the specific approximation employed. Even so, these measures do not cover the many possible ways that public and private investment may be related. For example, it could be argued that this relationship may be a lagged one, and, although the lagged effect has not been modeled explicitly, both the trend and expected government investment variables should capture the delayed response of private investment indirectly. The basic point to stress is that, in the absence of actual information on the functional components of public investment, one should try to use different approximations, as we have done here.

The only remaining unobservable variable in equations (13), (16), (17), and (19) is expected output, and there are a variety of ways of generating it. Hall (1977) and Bischoff (1971), for example, use a general distributed-lag formulation that relates the current level of output to its past values. An alternative approach would be to use the adaptive expectations model of Cagan (1956), in which expected output is assumed to respond to the error

[28] This process was chosen arbitrarily, and no attempt was made to test for alternative, more complicated autoregressive schemes. With annual data and a limited number of observations for each country, the simple process given by equation (18) seemed to be appropriate.

between actual output and the output that was expected in the previous period:

$$\Delta YR_t^e = \lambda[YR_{t-1} - (1+g)YR_{t-1}^e] \tag{20}$$

where λ is the coefficient of expectations, $0 \leq \lambda \leq 1$, and g is the growth rate of output, equal to g_1. Using lag-operator notation, we can write equation (20) in terms of YR_t^e:

$$YR_t^e = \frac{\lambda YR_{t-1}}{[1-(1-\lambda)(1+g)L]}. \tag{20a}$$

Substituting for YR_t^e from equation (20a) in equations (13), (16), (17), and (19), we obtain the following:

$$\begin{aligned} IP_t[1-(1-\lambda)(1+g)L] &= \lambda b_0 a[YR_{t-1} - (1-\delta)YR_{t-2}] + [1-(1-\lambda)(1+g)L] \\ &\cdot [b_1 GAP_t + b_2 \Delta DCR_t + b_3 GIR_t + (1-b_0)IP_{t-1}] \end{aligned} \tag{21}$$

$$\begin{aligned} IP_t[1-(1-\lambda)(1+g)L] &= \lambda b_0 a[YR_{t-1} - (1-\delta)YR_{t-2}] + [1-(1-\lambda)(1+g)L] \\ &\cdot [b_1 GAP_t + b_2 \Delta DCR_t + b_3 GIR_t + b_4 \Delta GIR_t \\ &+ (1-b_0)IP_{t-1}] \end{aligned} \tag{22}$$

$$\begin{aligned} IP_t[1-(1-\lambda)(1+g)L] &= \lambda b_0 a[YR_{t-1} - (1-\delta)YR_{t-2}] + [1-(1-\lambda)(1+g)L] \\ &\cdot [b_1 GAP_t + b_2 \Delta DCR_t + b_3 TGIR_t \\ &+ b_4(GIR_t - TGIR_t) + (1-b_0)IP_{t-1}] \end{aligned} \tag{23}$$

$$\begin{aligned} IP_t[1-(1-\lambda)(1+g)L] &= \lambda b_0 a[YR_{t-1} - (1-\delta)YR_{t-2}] + [1-(1-\lambda)(1+g)L] \\ &\cdot [b_1 GAP_t + b_2 \Delta DCR_t + b_3 EGIR_t \\ &+ b_4(GIR_t - EGIR_t) + (1-b_0)IP_{t-1}]. \end{aligned} \tag{24}$$

II. Results

Equations (21) through (24) were estimated using annual data for 24 developing countries pooled over the period 1971–79.[29] Allowance was made for cross-country differences in the average

[29] This yielded 216 observations for each of the variables. The basic data are described in the Appendix.

level of private investment during the period by introducing country-specific dummy variables into the specification. It was assumed, however, that the basic economic parameters were the same in all the countries, so that the results can be treated as applying to an "average" developing country, rather than to any individual country.[30] The models are, of course, nonlinear in parameters, and as such have to be estimated by a restricted least-squares method that permits identification of the individual parameters. Specifically, these nonlinearities are created by the parameters λ, g, and δ. For the coefficient of expectations, λ, a grid search was performed by varying it over the interval (0, 1) in increments of 0.1 and then choosing the value that maximized the log-likelihood function. The parameter g was set equal to the average growth rate of real gross domestic product (GDP) for each country over the period 1971–79. Finally, since we do not have any direct estimate available for the rate of depreciation, δ, we used an arbitrary value of 5 percent a year to transform the output variable.[31] For given values of λ, g, and δ, the equations are linear and can be estimated by standard methods, although the results will be conditional on the chosen values of the parameters.

The results for the four equations are presented in Table 1. In general, the models seem quite well-specified and, on the basis of the values obtained for the coefficients of determination, appear to fit the data satisfactorily. In each of the specifications the log-likelihood function was maximized when $\lambda = 1$, so that from equation (20) expected real output in effect equals the lagged value of real output: $YR_t^e = YR_{t-1}$. It can be seen from the results that the change in output enters with the expected positive sign and that the estimated coefficient, $b_0 a$, is significantly different from zero at the 1 percent level of significance. Furthermore, the short-run accelerator coefficient tends to be quite similar across specifications. The long-run response of private investment to a

[30] Preliminary tests with an error-components model yielded similar results, so that for the sake of simplicity we stayed with the least-squares-with-dummy-variables procedure. From a computational point of view, using the latter has a decided advantage in models employing the adaptive expectations scheme, which, as has been shown in the previous section, introduces nonlinearities into the system.

[31] In other words, the lagged change in real GDP is defined as $\Delta YR_{t-1} = YR_{t-1} - 0.95YR_{t-2}$. This 5 percent value is close to the estimates obtained by Sundararajan and Thakur (1980). Some sensitivity analysis was performed by varying δ, but the results remained broadly the same as those discussed here in the paper.

change in output (as measured by the value of the parameter a) turns out to be very close to unity in all cases. The estimated models appear to satisfy the theoretical property that the capital-output ratio should be constant in the steady state. The coefficients of the lagged values of private investment—that is, $(1 - b_0)$—are also significantly different from zero at the 1 percent level, and the average time lags in the adjustment of private investment to variations in output—calculated as $(1 - b_0)/b_0$—are generally around two years.

The estimates of the cyclical response of private investment are fairly weak—the estimated coefficient for the *GAP* variable is significantly different from zero at the 5 percent level only in the simplest formulation, equation (21). The parameters are also consistently negative, implying support for the hypothesis that private investment is positively related to the degree of capacity in the economy. When output is above its trend level, the economy can be viewed as operating above capacity, and investment is constrained by resource availability. Because the estimates are clearly not very robust, however, we should not place too much weight on this explanation. The results in Table 1 could arise simply from multicollinearity, or for that matter may be due to the fact that the *GAP* variable, as we have defined it, is not an appropriate measure of cyclical conditions in the economy.

For the effect of financial flows on private investment, we can observe that the change in bank credit to the private sector and net private capital flows, ΔDCR, have a positive effect in all four equations, and the estimated coefficients are significantly different from zero at the 5 percent level. If the overall quantity of financial resources is given, then any attempt by the government to increase its share of either domestic or foreign financing at the expense of the private sector would lead to crowding out and to a decline in the level of private investment. In light of the cross-section results discussed in Blejer and Khan (1984), such a decline would most likely result in a fall in total investment as well. Because in most developing countries the control over domestic credit of the banking system remains the principal tool of monetary policy, these results carry some importance for the broader issue of the real sector's responses to changes in monetary policy. The estimates indicate that about one quarter of any change in real credit to the private sector will show up in changes in real private investment in the short run. Similarly, interest rate and exchange rate policy can presumably also have a significant influ-

TABLE 1. RESULTS OF ESTIMATED EQUATIONS: REAL PRIVATE INVESTMENT[1]

Equation	ΔYR_{t-1}[2]	GAP_t	ΔDCR_t	IP_{t-1}	GIR_t	ΔGIR_t
(21)	0.349	−0.144	0.197	0.661	−0.024	—
	(6.32)	(2.23)	(3.31)	(10.80)	(0.46)	—
(22)	0.356	−0.113	0.225	0.636	0.079	−0.271
	(6.71)	(1.81)	(3.94)	(10.80)	(1.41)	(4.27)
(23)	0.319	−0.091	0.257	0.574	—	—
	(5.82)	(1.41)	(4.23)	(8.80)	—	—
(24)	0.336	−0.083	0.213	0.634	—	—
	(6.56)	(1.36)	(3.88)	(11.19)	—	—

[1] T-values are shown in parentheses below the estimated coefficients; $\bar{R}^2$ is the adjusted coefficient of determination; and SE is the standard error of estimate for the equation.
[2] $\Delta YR_{t-1} = YR_{t-1} - 0.95YR_{t-2}$.

ence on private investment through their effects on private capital flows.

The estimate of the effect of aggregate public sector investment on private investment obtained from equation (21) is in general conformity with the estimates obtained in previous studies: the coefficient b_3 is very small and not significantly different from zero. As one proceeds to the expanded versions of the basic equation, however, a pattern does begin to emerge. The results for equation (22) show that the level of public sector investment has a positive effect on private investment, whereas the change in government investment has a negative effect. On the basis of these particular results, it could be argued that it is not the level of public investment that crowds out the private sector, because the coefficient, though carrying a positive sign, is not statistically significant; rather, it is the change in public investment that appears to have a strong crowding-out effect.

The results for equations (23) and (24) are the most interesting from the point of view of the empirical relationship between public and private investment in developing countries. The estimates for equation (23) indicate that the trend component of real public investment exerts a positive influence on the level of real private investment, whereas deviations from the trend have the opposite effect. Both estimated coefficients b_3 and b_4 are significantly different from zero at the 5 percent level. These results are consistent with the maintained hypothesis that public infrastructural investment (as proxied by the longer-term trend level of real public

$TGIR_t$	$GIR_t - TGIR_t$	$EGIR_t$	$GIR_t - EGIR_t$	λ	$\bar{R}^2$	SE
—	—	—	—	1.0	0.930	360.5
—	—	—	—			
—	—	—	—	1.0	0.936	344.9
—	—	—	—			
0.158	−0.191	—	—	1.0	0.934	351.4
(2.09)	(2.64)	—	—			
—	—	0.244	−0.284	1.0	0.941	332.9
—	—	(3.62)	(4.28)			

investment) is complementary to private investment, whereas other kinds of public investment would tend to be substitutes for private investment. Provided that its trend level were not affected, an increase in real public investment would lead to a fall in real private investment in the short run, but the degree of substitutability is by no means perfect because the coefficient is significantly less than unity.[32]

The same pattern is apparent in the estimates for equation (24), where the distinction is made between the expected and unexpected components of public sector investment. Here an expected increase in public sector investment would raise the rate of private investment, but an unexpected increase would have adverse effects on private capital formation. Because the coefficients of these variables are of similar orders of magnitude and have opposite signs, it is not surprising to find an insignificant coefficient for the aggregate level of public sector investment (equation (21)). Also noteworthy is that equation (24) has the best fit of the four equations, in the sense that it yields the lowest value for the log-likelihood function.

Because the units of measurement differ somewhat for the variables in the equations reported in Table 1, an alternative way of determining the relative influence of the explanatory variables is to calculate the relevant Beta coefficients. These coefficients, as is well known, measure the change in real private investment, other things being equal, for a unit change in each of the exogenous variables. Since all the variables are expressed in standard deviations, the Beta coefficients are independent of units of mea-

[32] The negative sign for the nontrend public investment could also reflect countercyclical public investment policy rather than crowding out per se.

TABLE 2. VALUES OF BETA COEFFICIENTS

Variable	Equation (21)	(22)	(23)	(24)
ΔYR_{t-1}	0.225	0.229	0.205	0.216
GAP_t	−0.054	−0.042	−0.034	−0.031
ΔDCR_t	0.088	0.100	0.114	0.095
IP_{t-1}	0.594	0.572	0.516	0.510
GIR_t	−0.026	0.083	—	—
ΔGIR_t	—	−0.087	—	—
$TGIR_t$	—	—	0.162	—
$GIR_t - TGIR_t$	—	—	−0.049	—
$EGIR_t$	—	—	—	0.248
$GIR_t - EGIR_t$	—	—	—	−0.076

surement and can thus be compared directly both within and across equations.[33] The calculated values for the Beta coefficients corresponding to the four equations are presented in Table 2.

Abstracting from the case of the lagged dependent variable, we can observe from Table 2 that the change in real income is the most important explanatory variable in the first three equations. In equation (24), expected government investment shows up as having the strongest effect relative to the other variables. The financing variable has about half the effect of the change in output and turns out to be very similar across the estimated equations; the influence of the cyclical variable is marginal at best. Finally, an interesting result from equations (22) through (24) is that variables approximating noninfrastructural investment have a substantially smaller effect than the infrastructural component. This can be interpreted to imply that, for the period under consideration, the complementarity between public and private investment has, on average, outweighed the substitution effect.

III. Conclusions

Two principal conclusions emerge from this study. First, it is possible to identify a well-behaved empirical function for private investment in developing countries. The traditional view that standard investment theory is not relevant for such countries has

[33] The one drawback associated with Beta coefficients is that their statistical distribution is not known. As such, one cannot perform formal tests of significance, and any inferences necessarily have to be casual.

increasingly been challenged in recent years, and the analysis here lends support to that trend. By adapting elements of modern investment theory to certain special features of developing economies, we were able to derive a simple yet theoretically consistent model of investment for a developing country. Econometric tests with variants of this model on a pooled time-series, cross-section basis for a group of 24 developing countries have demonstrated the empirical validity of the model. The generally robust nature of the results that were obtained indicates that there may be a significant payoff to investigating the investment relationship further for individual countries. It would be particularly profitable to expand the data base so as to remove some of the restrictions on specification that are forced on the researcher by the lack, or weakness, of data in developing countries. For the time being, however, the results presented here can be taken as indicative of the relationship between public and private investment in an average developing country and can perhaps be utilized in lieu of actual estimates for any specific country.

Second, the study was able to establish a direct empirical link between government policy variables and private capital formation. The results provide further evidence that private investment in developing countries is constrained by the availability of financing, and that monetary policy, by varying the flow of credit to the private sector, can thus directly change private investment decisions. Furthermore, in contrast to previous studies undertaken for developing countries, we were also able to establish a quantitatively important role for public sector investment in the process of private capital formation. The effect appears to depend on the way in which public investment is introduced into the model, and meaningful results are obtained only when a distinction is made between long-term, or infrastructural, and short-term public investment. In either case the government of a developing country does appear to be in a position to alter the pattern of private investment by changing its own investment strategy.

The policy implications of the exercise are straightforward. The tightening of monetary policy, which is a typical element of a stabilization program, would be expected to have adverse effects on the level of private investment and to lead to a reduction in economic growth unless the authorities are careful to ensure that the flow of real credit to the private sector is not curtailed. In general, attempts by the public sector to absorb a larger share of domestic financial resources would tend to crowd out private in-

vestors to some degree. By the same token, if the total supply of foreign financing to an individual developing country is limited, then the amount available for the private sector would tend to grow smaller as the public sector borrowing increases. Although this latter type of crowding out may not be quantitatively large in relation to domestic financial crowding out, nevertheless the government must be conscious of the possibility. Furthermore, the flow of foreign capital may also be affected by inappropriate exchange rate and interest rate policies, and these may have equally harmful effects on private investment.

In contrast, the effects of a contractionary fiscal stance are not that obvious. If the policy takes the form of a cut in real public sector investment that is not related to infrastructure, then one may well observe an increase in private investment as the private sector begins to make use of physical resources, such as capital and labor, released by the government. This beneficial effect, however, can be offset if there is a reduction in infrastructural investment, which would negatively affect private capital formation. As a general principle, the authorities should, if at all possible, direct the cuts in investment to fall only on investments that are not directly related to the development of infrastructure. This is, of course, difficult to do because of the problems associated with properly identifying infrastructural investment, and the government may not have the latitude to select the components of public investment to cut. Even so, government authorities should at least be aware of the consequences for private investment and long-term growth of across-the-board reductions in capital expenditures that involve cutbacks in infrastructural investment.

APPENDIX

Definitions and Data Sources

The basic source for the data used in this study is *International Financial Statistics* (IFS), International Monetary Fund (Washington), various issues. This source was augmented, when necessary, by Fund staff estimates. Gross private and public investment data are based essentially on national sources. The data were all deflated by the GDP deflator (1975 = 1.00) to express them in real terms. For current values of the variables, the period covered was 1971–79; lagged values of the variables, therefore, were defined over the period 1970–78.

The 24 developing countries in the sample were Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Haiti,

Honduras, Mexico, Panama, Paraguay, Venezuela, Barbados, Trinidad and Tobago, Turkey, Singapore, the Republic of Korea, Sri Lanka, Malaysia, Indonesia, and Thailand.

The definitions of the variables (with the IFS line numbers, where relevant) are as follows:

IP = gross private fixed capital formation (in real terms)

GIR = gross public sector fixed capital formation (in real terms; for most countries the public sector is defined to include general government, principal autonomous agencies, and nonfinancial state enterprises)

YR = GDP in constant 1975 prices (line 99b.*p*)

TYR = trend value of real GDP, calculated as

$$TYR_t = YR_{1970} e^{g_1 t}$$

where YR_{1970} is the 1970 value of real GDP, and g_1 is its trend growth rate over the period 1970–79

GAP = deviation of real GDP from its trend value; that is,

$$GAP = YR - TYR$$

ΔDCR = change in credit to the private sector (line 32d) in real terms, plus real net private capital inflows (taken from *Balance of Payments Statistics Yearbook,* International Monetary Fund (Washington), Vol. 33, Parts I and II (1982))

$TGIR$ = trend value of real gross public sector investment, calculated as

$$TGIR_t = GIR_{1970} e^{g_2 t}$$

where GIR_{1970} is the 1970 value of real public sector investment, and g_2 is the average growth rate of GIR over the period 1970–79

$EGIR$ = expected real gross public sector investment, calculated as

$$EGIR = \rho_0 + \rho_1 GIR_{t-1}$$

where ρ_0 and ρ_1 are autoregressive parameters estimated for each country over the period 1970–79.

The dummy variables for the 24 countries, which took a value of unity for the nine observations corresponding to a particular country and a value of zero elsewhere, were entered into the equations in the order in which the countries are listed above.

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