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DYNAMICS OF INVESTMENT AND GROWTH IN DEVELOPING COUNTRIES DURING THE 1980s

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Abstract:

Since the outbreak of the debt crisis in 1982 growth and investment in developing countries have been persistently low by historical standards. Most of the adjustment processes undertaken during the 1980s included strong devaluations and fiscal adjustment relying heavily on lower public investment. The assessment of the consistency of these policies with expected increases in private investment and growth has been based up to now mainly on static cross-country models that show contradictory results, specially with regard to the role of foreign debt, the real exchange rate, and public investment.
This paper discusses why static approaches are inappropriate for an essentially dynamic problem and proposes the estimation of a VAR-panel data model which may help clarify the relations between private investment and growth. The simulations of growth and investment responses to changes in the real exchange rate and the level of public investment show that dynamic responses through lagged effects differ substantially from what available static models suggest.

I. Introduction

Since the outbreak of the debt crisis in 1982, and its sequel of low growth and low investment in developing countries, there has been a renewed interest in what determines investment –specifically, private investment– and to what extent output growth depends on high rates of private and/or public investment. The question, of course, is crucial not

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only by itself but also for the design and implementation of any adjustment process a country may undertake. Aside from traditional variables affecting investment, like the business cycle and the user cost of capital, the degree of capital mobility and financial repression and the debt overhang are usually introduced to obtain a better understanding of the behaviour of capital formation in developing countries.

In this context two issues have captured the interest of researchers. First, much effort has been devoted to analyze whether private and public investment are substitutes (that is, if public expenditures on capital goods crowds out private investment) or complements (the government invests in infrastructure, hence raising private capital efficiency). The relationship is certainly important in the context of macroeconomic adjustment since adjustment programs turned out to induce strong public investment cuts in most countries, instead of increasing saving. Second, the role of the real exchange rate (RER) in determining private investment has been at the core of recent investment research. Large devaluations were implemented in developing countries with the purpose of restoring external balance via increasing export competitiveness, purposely inducing higher investment rates. Not all countries, however, experimented the expected significant expansion of economic activity after a devaluation but rather a period of growth stagnation, showing at least temporary contractionary effects.

The empirical literature on aggregate investment in developing countries consists mostly of country-specific studies which differ substantially in scope, methodology, and sample period, so that their results are difficult to compare when trying to assess the behavior of developing countries as a group. In this paper I focus on he reduced number of multi-country studies that are available. Rather surprisingly for a dynamic problem most of the estimated models are static or at best one equation dynamic models (with an ad-hoc adjustment process), generally relying upon strong implicit assumptions about the structural relationship, causality and the variable exogeneity and, generally, disregarding the implicit dynamics of the estimated model.

On the other hand, the literature on growth has experienced in the recent past an impressive expansion under the influence of new theories of "endogenous" long-run growth. In contrast to the classical Solow growth model, where steady-state growth is determined exogenously by a constant saving rate, the new growth literature emphasizes the presence of externalities to human or physical capital as a way to avoid diminishing returns to fixed factores (Sala-i-Martin, 1990). The main difference between old and new neoclassical growth theories in terms of their implications is that in the former, with growth exogenous, only the output level can be affected by policy changes, while in the latter policies may affect both the level and the long-run rate of growth[1].

Empirical testing of these theories for groups of developing countries is still at an early stage but, again rather surprisingly, most of the estimated models assume that investment, a key variable to explain growth differentials, is a deterministic variable. A recent survey of cross-country growth models (Levine and Renelt, 1991a) discovered that in 36 out of 44 papers investment is a crucial variable to explain growth rates differentials. However, most of the papers were not estimated in a simultaneous equation framework. In addition, most of the papers include total rather than private investment. Since the processes that determine the level of public and private investment are not similar –the former responds more to policy considerations than to profit rationality– results may be distorted or misleading if they are based on total investment.

The purpose of this paper is to estimate a dynamic model of private investment and growth which avoids the simultaneity bias and lack of dynamic structure of the existing literature. The methodology follows the "encompassing approach" in economics

(Clements and Mizon, 1991) and the econometric model is an extension of the methodology of Holtz-Eakin, Newey and Rosen (1985) for estimating autoregressive panel data models. The results show that the ongoing discussion of the relationship between key variables (public-private investment and RER-private investment) has been oversimplified in static models and the dynamic links are far more complex than expected. The main question to be discussed is how private investment and growth are affected by their mutually dependent evolution and especially by changes in other variables that allegedly have played an important role during the last decade in developing countries, such as public investment, the RER, economic instability, and foreign debt[2].

The paper is organized as follows. Section II presents a brief summary of macroeconomic performance in developing countries during the last fifteen years. Section III provides a theoretical discussion of the relations between the main macroeconomic aggregates, growth and private investment, highlighting the differences between the economic behavior of developed and developing countries. Previous empirical work in investment functions in developing countries is critically revised. Section IV describes the methodology and dynamic specification for investment and growth and the technique for estimating VAR-panel data models. The empirical part of the paper is developed in three stages: causality analysis, lag-length determination and estimation of a consistent full information VAR-panel data model. The section stands as an illustrative example of the dynamics of investment and growth. The estimations are based on a 21 country data set the 1982-1989 period of adjustment to the debt crisis and international recession. Also, the dynamics of the model are analyzed by simulating impulse-response functions and computing long run multipliers. Section V presents the main conclusions and suggestion for further research in this framework. An appendix describes the data base.

II. Performance of developing countries in the 1980s

The 1980s have been defined as "the lost decade" for investment and growth in an important subset of developing countries, particularly highly-indebted and Latin American countries, which often overlap[3]. Part of the countries' inability to grow is connected with the advance external environment that characterized the early 1980s. The increase in interest rates and sudden reduction in external financing reduced markedly capital inflows to developing countries. In addition, the 1982-84 international recession depressed export prices (mainly of non-manufactured goods) and increased the cost of imported investment components.

Additionally, the internal conditions in these countries magnified the adverse effects of the crisis. In many of them domestic imbalances called for deep structural adjustment to reduce large fiscal deficits which resulted in high inflation and/or unsustainable current account deficits. These adjustment programs were not always as successful as expected, and in certain countries their failure worsened the original situation (e.g., the Cruzado Plan in Brazil or the Austral Plan in Argentina)[4]. As a result, lack of confidence in public policies were widespread and private investment faced further disincentives. Table 1 shows basic performance indicators for the 21 countries used in this paper (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, India, Kenya, Korea, Mexico, Peru, Philippines, Pakistan, Singapore, Sri Lanka, Pakistan, Singapore, Thailand, Turkey, Uruguay and Zimbabwe)[5].

TABLE 1

MACROECONOMIC INDICATORS
FOR 21 DEVELOPING COUNTRIES

		All Countries	Less[6] Indebted	Highly Indebted
Real GDP Growth (in percentage)	1975-81	4.0	4.8	3.9
	1982-89	3.4	5.1	2.8
External Debt (as % of GDP)	1975-81	29.4	21.2	38.2
	1982-89	50.9	33.6	68.3
Total Investment (as % of GDP)	1975-81	20.2	20.9	15.7
	1982-89	14.9	17.1	9.8
Private Investment (as % of GDP)	1975-81	11.8	9.3	6.2
	1982-89	8.9	7.6	3.5
Public Investment (as % of GDP)	1975-81	8.4	11.6	9.5
	1982-89	5.9	9.5	5.3
Real Exchange Rate (1980 = 100)	1975-81	100.3	95.6	105.1
	1982-89	120.1	110.5	131.4

Source: Pfeffermann and Madarassy (1990) and The World Bank (1990).
Note: Depreciation of the real exchange rate index are shown as an increase in the index.

Figure 1 shows the evolution of real GDP growth from 1975 to 1989. The sharp break in growth performance of highly indebted countries (HICs) during the recession of 1982-1983 is striking, when growth was on average negative. Less indebted countries (LICs), by contrast, show a far more stable path and no effects of the international recession.

The evolution of external debt to GDP ratio is depicted in figure 2. It is striking how the HICs, slightly more indebted in 1975 than the LICs, started to increase sharply their indebtedness after 1979, while the other countries group followed a more conservative path. However it is interesting to note that external debt to GDP ratio started to fall in both country groups after 1986.

Figure 3 presents the time pattern of investment[7] for the whole group of countries. The reduction of investment as percentage of GDP during the early stages of the debt crisis is notorious as well as the fact that it has not yet regained its previous level. Less aggregate data suggests strong behavioral differences between both types of countries. While in the HICs the fall in private investment has been dramatic (see Figure 4), it is less pronounced in the LICs (Figure 5), where the negative shock was not only less intense, but also was offset by an increase in public investment during 1981-1984.

Finally, figure 6 presents the evolution of the RER. The cycle of appreciation during the 1979-81 period of capital inflows and the subsequent massive depreciations in the aftermath of the debt crisis is clearly reflected in the HICs[8].

FIGURE 1

GDP GROWTH
(In real terms)

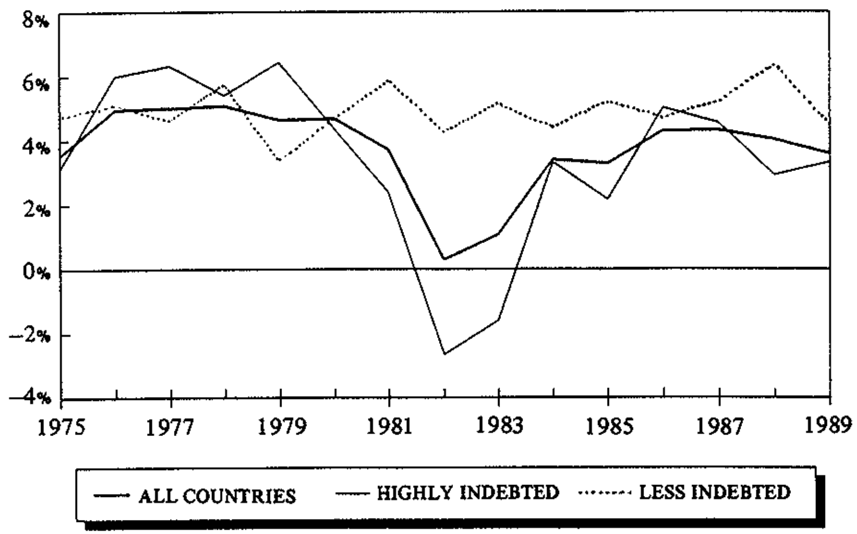


FIGURE 2

EXTERNAL DEBT
(as percentage of GDP)

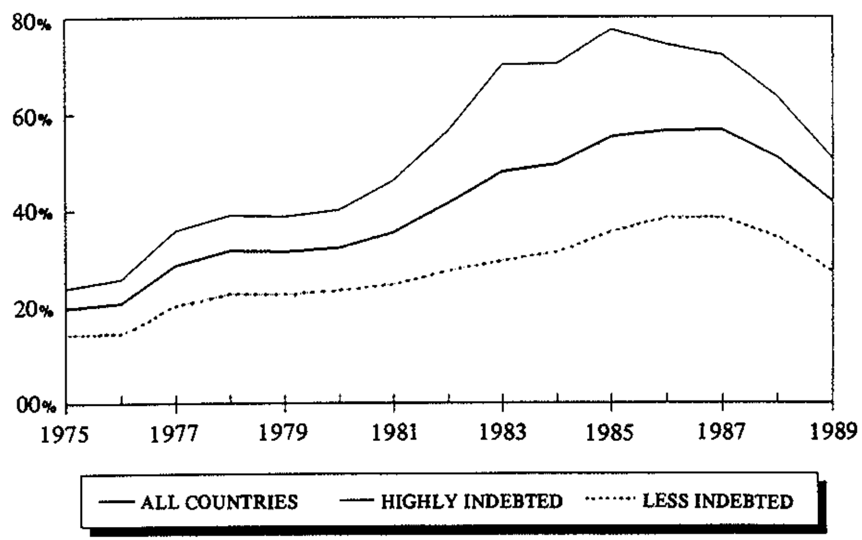


FIGURE 3

TOTAL, PUBLIC AND PRIVATE INVESTMENT

ALL COUNTRIES
(as percentage of real GDP)

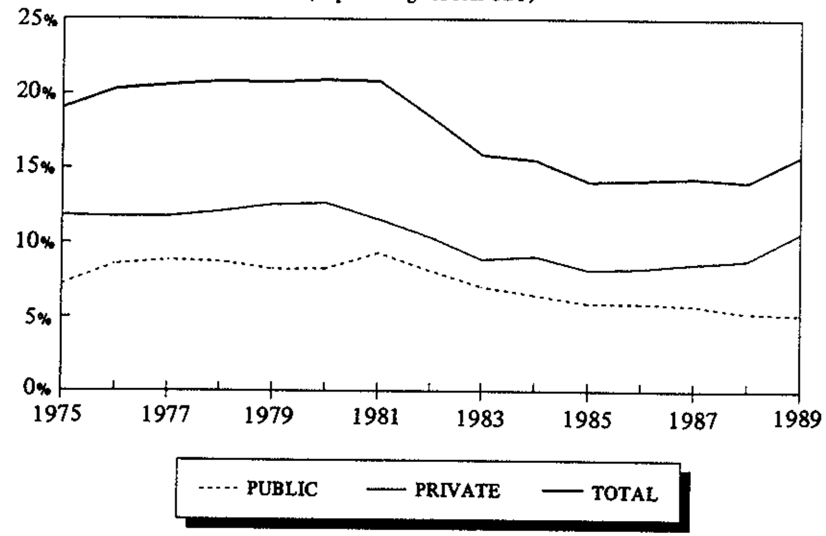


FIGURE 4

TOTAL, PRIVATE, AND PUBLIC INVESTMENT
HIGHLY INDEBTED COUNTRIES

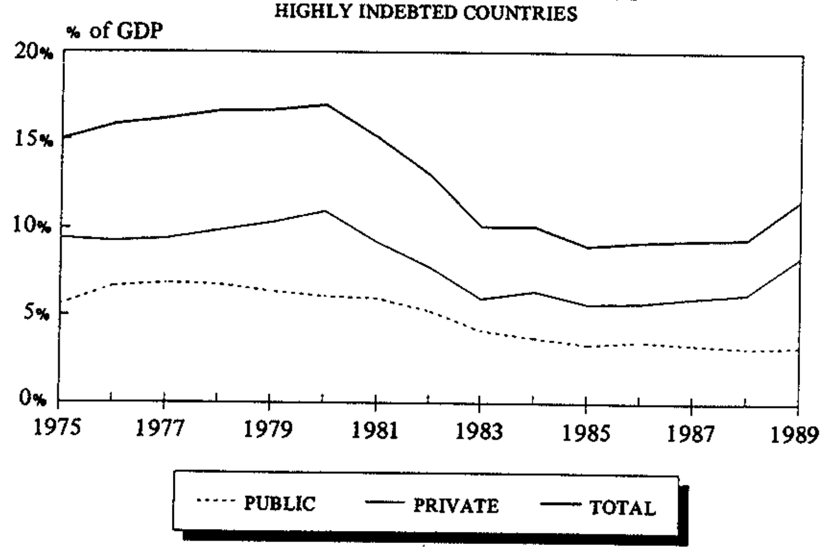


FIGURE 5

TOTAL, PUBLIC AND PRIVATE INVESTMENT
LESS INDEBTED COUNTRIES

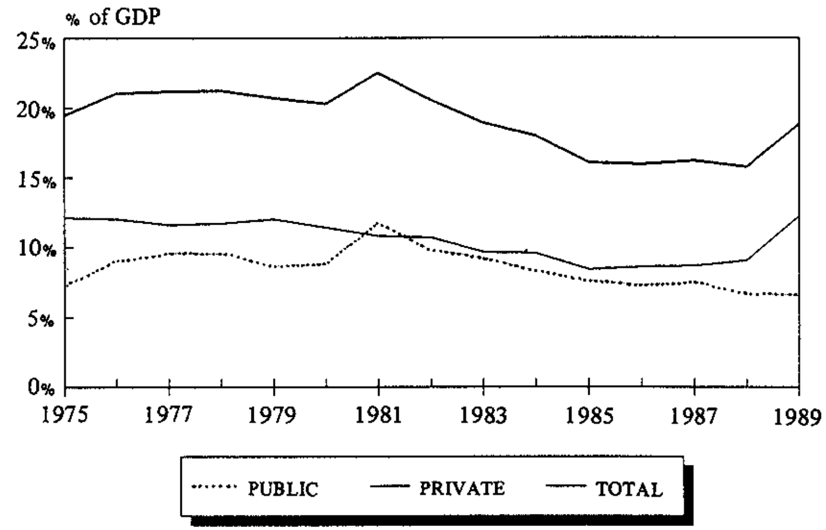
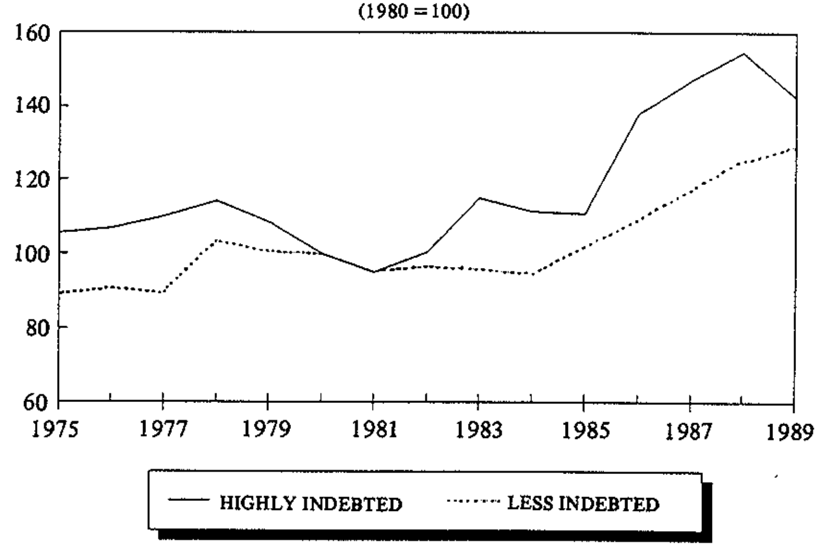


FIGURE 6

REAL EXCHANGE RATE
(1980 = 100)



III. Investment and growth theory and evidence for developing countries

Investment theory was dominated for many years by Jorgenson's (1963) neoclassical flexible accelerator model, where the firm decides its desired capital level based on equalizing the marginal return of capital to its cost. Several papers have attempted to prove the basic implications of the model, i.e., that investment is positively related to output and negatively related to interest rates[9]. During the late 1970s and early 1980s, Abel (1979) and Hayashi (1982), among others, gave microeconomic foundations to this model by introducing explicit adjustment costs into an intertemporal optimization framework. However, since the mid 1980s new issues put this framework under severe criticism, focusing on the irreversibility of capital investment (Pindyck, 1991), the role of uncertainty (Abel, 1983) and the excessive response of investment to transitory output shocks (Blejer and Khan, 1984).

The performance of the Jorgenson model has been disappointing in developing countries –even if we do not take into account these recent criticisms– because of the failure of its key assumptions, in particular, perfect markets and no government intervention. Earlier attempts to modify its structure led to the "financial repression" literature (McKinnon, 1973). In this approach most firms are credit rationed so their investment must be financed internally through retained earnings, while only some firms benefit from low cost credit. The key implication in this case is that investment depends on the availability of funds so an increase in the interest rate may induce an expansion in investment because if interest rates increase saving, exactly the opposite prediction of the traditional neoclassical models.

It is important to distinguish between the relevant results for saving from those referred to investment in developing countries. McKinnon's hypothesis of saving mobilization as a consequence of higher real interest rates has been seriously cast in doubt by significant empirical evidence (see Giovannini (1985), Corbo and Schmidt-Hebbel (1991) and Schmidt-Hebbel, Webb and Corsetti (1992)), which show that saving is insensitive to the real interest rate in developing countries. The effects of the interest rate on investment is mixed. Some papers find a negative relationship (Greene and Villanueva (1991); de Melo and Tybout, (1986)), due to two elements. First, an increase in interest rates raises the real cost (service) of the credit used to finance capital acquisitions and, second, a rise in the interest rate also increases the alternative cost of retained earnings, a major source of resources to finance investment. Other studies find, however, no evidence of correlation between interest rates and investment which is explained by the fact that in financially repressed economies investment depends on the stock of available credit (van Wijnbergen, 1982).

In connection with this last effect it has also been suggested –and empirically substantiated by Balassa (1988) and Khan and Reinhardt (1990)– that the use of resources in the form of public investment may lead to a private investment crowding-out. The opposite hypothesis is that infrastructure in developing countries is a binding constraint for productive purposes, implying that public investment is necessary complement of private investment. Empirical evidence has been found, among others, by Blejer and Khan (1984), Easterly and Schmidt-Hebbel (1991), Greene and Villanueva (1991) and Serven and Solimano (1991b).

Apart from the above mentioned determinants of investment, the stock of external debt may affect investment through, at least, two channels: first, by imposing further restrictions on the availability of foreign currency, and second, the debt may be visualized as a future tax payment (Borensztein (1989)). Hence a negative relationship is expected and found, for example, in Faini and de Melo (1986).

The RER plays also an important role by affecting the profitability of investment projects and the cost of imported intermediate or capital goods. Two forces are present on the real side of devaluations: the (expansionary) increase in export returns and import substitution and the (contractionary) increase in the cost of imported capital (Krugman and Taylor (1978), Solimano (1986) and Serven (1991)).

Finally, economic instability is a key feature of macroeconomic behavior in developing countries. Changes in relative prices, induced by inflation or devaluations, along with continuous changes in government policies reduce the ability of investors to forecast the environment and to asses the profitability of investment. Serven and Solimano (1991b) found that volatility in inflation and the RER affect more investment in developing countries than their level.

Two recent papers (Serven and Solimano (1991a) and Rama (1990)) survey the extensive econometric literature on investment in developing countries. As a general conclusion one may state that there is no theory able to encompass all the complexities of the investment process and, therefore, most of the empirical work is based on particular theories about the agent behavior under certain more or less restrictive conditions. In this context it is no surprise that the findings differ substantially and, in some cases, yield opposite results for the effects of a particular determinant of private invetment. Nevertheless, growth is often found as an important determinant of investment.

Most of the literature on empirical investment functions presents serious methodolgical shortcomings. First, although the existence of slow adjustments in the capital stock is recognized at a theoretical level, static models are usually implemented or, at best, implicit adjustment lags are captured by adding one lag of the endogenous variable[10]. Second, traditional "dynamic" panel data models[11], as those used in all the papers discussed above, are one-equation models which seem to be inappropriate in the case of investment functions because of simultaneous determination of investment with other variables, especially with GDP. The simultaneity problem is rarely taken into account and/or discussed and for that reason the results can be severely biased.

On the other hand, explaining growth in developing countries has never been an easy task. The rather restrictive neoclassical Solow-type growth model, with growth exogenous, applied to developing countries did not produce results as successful as in the case of developed countries[12], leading to the introduction of country-specific factors to explain large growth differentials. Among these specific factors policy-induced distortions affecting resource allocation (Krueger, 1978) and financial distortions (Gelb, 1989) are the most important.

A less restrictive set-up is allowed under the new endogenous growth literature and the special features of developing countries can be more easily analyzed. Easterly (1991) attempts to measure the effect of different distortions on per capita GDP growth using a set of variables which includes financial repression, inward orientation and other distortions. One of his findings is that investment affects growth even if distortionary policies do not affect investment and saving. Romer discusses the determinants of growth in 112 countries within a model that allows for endogenous technological change and finds that "the key determinant of the growth rate in less developed countries is the rate of expansion of investment opportunities" (Romer (1989), p. 34).

Levine and Renelt (1991a) survey 44 multicountry studies of growth reporting that the above set of variables is used in most of them (for example, only 6 studies did not include investment as a independent variable). Further, Levine and Renelt (1991b) criticize the results of most of the existing literature on developing-country growth on the basis that the results are not statistically robust, usually because of incomplete specification of the growth process. Once again, simultaneity and dynamic misspecification are likely to be present as the source of this lack of robustness.

Finally, a common feature of both investment and growth cross-country studies is that what is usually tested is the long-run (or steady state) relationship between variables. Short-run dynamics are ruled out and the length of transition periods is seldom discussed or evaluated. As a result, policy recommendations based on these estimated models, even if they are correct for the long-run, may lead to serious underestimations of adjustments costs. This is clearly the case of some stabilization processes during the 1980s, like in Bolivia, where the costs in terms of reduced private investment and growth lasted far more than what was expected at the start of the liberalization process (Muller (1991)).

Based on the above discussion of the determinants of private investment and growth and the econometric biases of existing studies, this paper uses a dynamic VAR-panel data framework to analyze more rigorously the above questions. The main reason for chosing this technique is that panel data models, apart from increasing substantially the degrees of freedom available for estimation purposes, are a powerful tool for deriving general conclusions from the analysis of country groups. On the other hand the VAR framework places no priors on the causality and exogeneity of variables and also allows to discuss their interactions and simulate the effects of changes in key variables. The technique focuses on the short-run relationship and model implications should not be taken as indicative of the long-run determinants of economic growth; rather, its purpose is to show that short to medium-run dynamics can be far different than what theoretical models suggest and that policy implications of these models may be of little guidance when designing economic policies.

IV. Econometric approach, specification and estimation procedure

During the last decade economists have witnessed one of the more interesting debates in economics concerning the appropriateness of alternative ways of using empirical evidence in simultaneous equation models. Traditional structural econometric models (SEMs) have been challenged by vector autoregressive models (VARs), which have proven to be superior when forecasting economic variables but have remained controversial when testing "structural hypotheses".

In the former approach the model is usually build up from explicit theories of optimizing behavior by agents, so all or nearly all of the model parameters have interpretation in terms of tastes and technology (Sims, 1991). This particular way of modelling imposes a large amount of, as critics say, "incredible restrictions" when interpreting the economic meaning of the estimated parameters. On the contrary, VAR models impose restrictions neither on the "structure" of the relations between variables, nor in their dynamic linkages. However, critics usually point to the fact that economic interpretation of VAR results is difficult since no economic meaning can be attached to any estimated parameters (since they are unknown combinations of underlying fundamental parameters), and thus dynamic properties can only be obtained by simulating responses to different shocks.

Although both approaches have different, and perhaps irreconcilable, methodological foundations, there have been some attempts of developing mixed techniques, by com-

bining a VAR framework with a priori (or theoretical) restrictions in order to get economically meaningful interpretations[13]. In addition, Bayesian VARs can also handle structural restrictions in the form of priors to be introduced to the VAR estimation (Sims, 1988).

Finally, Hendry and Mizon (1990) develop in detail what has been called the "encompassing approach in econometrics" in which a general (VAR) model is reduced to a particular (SEM) model under the guidance of theoretical and statistical restrictions. The methodology can be summarized into four stages (according to Clements and Mizon (1991)):

(i) Take the relevant information from the economic theory.
(ii) Estimate a (parsimonious) VAR.
(iii) Reduce it to a structural econometric model according to suggestions from the theory, and
(iv) Check whether the SEM encompasses the VAR.

In this paper I follow in essence the latter methodology. As a starting point I estimate a VAR model for the variables which theoretically are closely linked to the growth-investment relations, i.e., growth, private investment, public investment, the RER, and external debt (see section II). The estimation is performed to first-differenced variables (to avoid fixed effects biases)[14] without a formal check for unit roots of the series because traditional tests, like Dickey-Fuller and Phillips-Perron, are not applicable in this panel context. Nevertheless recent evidence provided by Rudebusch (1991) and Christiano and Eichenbaum (1990) demonstrates that it is nearly impossible to determinate the presence of unit roots in a series because conventional tests lack sufficient power. Basic indicators of residuals' properties are summarized in Table 2.

TABLE 2

UNRESTRICTED VAR RESULTS

	Private Investment	GDP Growth	Public Investment	DEBT-GDP Ratio	RER
Serial Correlation Tests (*)	18.24	17.50	24.54	22.20	20.43
Standard Deviation of Residuals	0.22	0.04	0.17	0.17	0.15

(*) Critical values for 95% and 99% confidence are 20.16 and 26.15, resp.

Additionally, Granger causality tests were performed in order to check whether a-priori independence assumptions, like those discussed in section II, were rejected by the data[15]. The main interest resides in determining whether public investment, external debt and the RER are Granger caused by growth or private investment. Table 3 presents the results.

TABLE 3

GRANGER CAUSALITY TESTS
FOR THE UNRESTRICTED VAR

Variable	Lags of Private Investment	Lags of GDP Growth	Lags of Public Investment	Lags of DEBT-GDP Ratio	Lags of RER
Private Investment	–	1.97*	1.08	4.11***	1.91*
GDP Growth	0.66	–	0.21	1.98*	2.54**
Public Investment	1.07	0.65	–	2.08*	1.26
DEBT (as % of GDP)	0.39	0.58	2.28*	–	8.17***
Real Exchange Rate	2.87**	1.45	1.32	3.30**	–

*, ** and *** denote significant at 90%, 95% and 99%, confidence levels resp.

The results are straightforward. The hypotheses mentioned above cannot be empirically rejected in this data: first, the external debt seems to be independent of the two key variables in this model and Granger-cause both growth and investment, and second, on the contrary, no causality is found with regard to public investment, which may reflect the proposition that public it is dominated by political and institutional restrictions, as suggested in section I. With respect to investment and the RER it is found that they are mutually causative while RER Granger-cause growth. Mutual causation is found in the relationship between real exchange rate and debt, which is at the core of the discussion on the role of capital inflows in supporting overvaluated exchange rates and accumulating debt, and also in the relation between public investment and debt. On the other hand, no causation is found between RER and public investment.

In general, the analysis suggests the presence of two "blocks" in the dynamic relations of these variables. The first block is formed by the RER, debt and public investment which have their own relations and are not affected by growth or investment. The other block, including growth and investment, are mutually dependent and are affected by the rest of the variables. Therefore I will treat the former group as a set of stochastically independent variables (or deterministic for this problem), to be included in a restricted VAR.

Based on this analysis the unrestricted VAR model for growth and investment is restated as follows[16]:

$$I = f\,[\beta(L)I,\ \alpha(L)G,\ PUB,\ RER,\ D,\ VOL] + \epsilon y$$

$$G = g\,[\tau(L)G,\ \Omega(L)I,\ PUB,\ RER,\ D,\ VOL] + \epsilon g$$

where $\alpha(L)$, $\beta(L)$, $\tau(L)$ and $\Omega(L)$ are lag functions, I is the share of private investment in GDP, G is the rate of growth of real GDP, PUB is the share of public investment to GDP, D is the stock of external debt as percentage of GDP, RER is the real exchange rate, VOL is an inflation instability index and ϵy and ϵg are white noise error terms for investment and growth, respectively.

The specification presents two useful features. First, lags of both left-hand side variables are included to capture the dynamic relations between investment and growth, not only lags of the current dependent variable, as most SEMs specification do. The trajectories of private investment and growth are also affected by shifts in the stochastically independent variables, as usually in near-VAR models. Second, the use of ratios by scaling investment and debt to GDP tends to reduce the impact of heteroskedasticity and spurious correlation among variables and, more important, eliminates any problem derived from exchange rate conversions.

Estimation Technique

The methodology to estimate the model relies heavily on Holtz-Eakin, Newey and Rosen (1985), Holtz-Eakin (1986) and Chamberlin (1984). The only extension in this paper is the inclusion of a set of deterministic variables.

Essentially, the purpose is to estimate the above system for private investment and growth with the following form (assuming that there are N cross-sectional units observed over T periods and where i, t is an index for individual and time, respectively:

$$(1)\qquad I^i_t = \beta_0 + \sum_{j=1}^{m} \alpha_j I^i_{t-j} + \sum_{k=1}^{n} \delta_j G^i_{t-k} + \sum_{f=1}^{o} \phi_f Det^{if} + \mu^y_t$$

$$G^i_t = \beta_1 + \sum_{j=1}^{m} \pi_j I^i_{t-j} + \sum_{k=1}^{n} \sigma_j G^i_{t-k} + \sum_{f=1}^{o} \tau_f Det^{if} + \mu^g_t$$

where the β coefficients are constants, the α, δ and ϕ (π, σ and τ) coefficients are parameters and the lag lengths m, n and o (p, q and r) are sufficient to ensure that μy (μg) is a white-noise error term. In the last term of each equation "Det" represents the group of deterministic variables. While it is not essential that m equals n (or p equals q), typically they are constrained to be identical; also, deterministic variables could be lagged.

To perform any parametric test, there must be sufficient observations on x and y to obtain consistent parameter estimates in both equations. Panel data usually does not have the required number of time observations. Instead, there is often a high number of cross-sectional units. To estimate the set of parameters, data from different units is usually pooled, imposing the constraint that structure is common across different units.

A natural temptation is simply to stack all time series-cross section observations together and use them to estimate system (1). The main problem of such a procedure is that it ignores the possibility that each unit has an individual effect, reflected in its own intercept, hence yielding inconsistent estimates. The two standard methods to eliminate the individual effects are taking deviations from the mean or first-differencing. However, the former is inappropriate in dynamic models because the time means are correlated with the error terms for each cross-sectional unit. Applying first differences to (1) obtain:

$$(2)\qquad I^i_t = \sum_{j=1}^{m} \alpha_j I^i_{t-j} + \sum_{k=1}^{n} \delta_j G^i_{t-k} + \sum_{f=1}^{o} \phi_f Det^{if} + \mu^{iy}_t - \mu^{iy}_{t-1}$$

$$G^i_t = \sum_{j=1}^{m} \pi_j I^i_{t-j} + \sum_{k=1}^{n} \sigma_k G^i_{t-k} + \sum_{f=1}^{o} \tau_f Det^{if} + \mu^{ig}_t - \mu^{ig}_{t-1}$$

A quick examination of (2) indicates that I_{t-1} depends on μ^{iy}_t so the error term $(\mu^{iy}_t - \mu^{iy}_{t-1})$ is correlated with the regressor I_{t-2} (the same applies to G_{t-1} and $(\mu^{ig}_t - \mu^{ig}_{t-1})$ in the other equation). This well known simultaneity problem is usually addressed by using an instrumental variables estimator. In this VAR-panel data framework this is also appropriate, but it is implemented in a different way because instead of a fixed set of instruments, here the variables which are legitimate candidates for instrumental variables change with different lag lengths.

In addition heteroskedasticity arising from the presence of unscaled variables (e.g. the instability index) is probably a problem in the panel context since different units may be expected to have error terms with unequal variances. Efficient estimation (correct estimation of standard errors) requires that heteroskedasticity be taken into account.

The lagged variables available as instruments, i.e., those that are uncorrelated with the error term, are the realizations of x and y observed before the longer lag present in the system (i.e., the max(m, n, p, q) + 1) so the model is to be estimated and thus representative of the last k = T-m-2 periods of time. In this study the available data sample is 1975-1989 but due to the latter point the model is estimated from 1982 on. The lag structure then becomes crucial: as more lags are added a larger number of lagged observations are necessary for use as instrumental variables. Under limited data availability and without prior knowledge of the true lag structure, all specifications are potentially open to the problem of inconsistency of the parameters that arises from an incorrect lag specification. This "lag truncation problem" was first described by Holtz-Eakin, Newey and Rosen (1985)[17].

Estimation Procedure

To estimate this model one has to consider that, in order to obtain consistent parameter estimates, the available set of instrumental variables is different for every order of the VAR. For the sake of clarity I follow matrix notation and concentrate on the investment equation. Hence the model is re-written as:

$$(3) \qquad I = WB + V$$

where I is the vector of observations of private investment, B is the matrix of coefficients for the equations, V is the matrix of transformed residuals and W is a matrix containing all right-hand side variables.

The crucial difference with classical simultaneous-equation systems is that in this technique the predetermined variables –which serve as instrumental variables– are not the same for each lag specification. The matrix of variables which qualify for use as instrumental variables (since they are not correlated with the error term) in period t is:

$$(4) \qquad Z = [e,\ I_{T-m-2}, \dots\ I_1,\ G_{T-m-2}, \dots\ G_1,\ det_{T-m-1}, \dots\ det_1]$$

where e is the first stage vector of constants, det is a vector of deterministic variables and T is the total number of observations available. To estimate B we apply the classical instrumental variable procedure, i.e., premultiply (4) by Z and the consistent instrumental variables estimator is formed by applying Generalized Method of Moments (GG) to this result (Hansen, 1982):

$$(5) \qquad Z'I = Z'WB + Z'V$$

As usual, such an estimator requires knowledge of the covariance matrix of the (transformed) disturbances, Z'V. This covariance matrix, Ω, is given by:

$$(6) \qquad \Omega = E(Z'VV'Z)$$

which is not known and therefore must be estimated. To do so, the preliminary consistent estimator of B is obtained by estimating the coefficients of the equations applying two-stage least squares (2SLS) on each equation, with the corresponding list of instrumental variables. With these preliminary estimates, the vector of residuals for period t is obtained ($u_t = I_t - w_t B_t$). A consistent estimator of (Ω/N) is then obtained as $\Omega^* = Z'uu'Z$ and, finally, Ω^* is used to form a GMM estimator of the entire parameter vector, B, using all the available observations:

$$(7) \qquad B^* = [W'Z(\Omega^*)^{-1}\ Z'W]^{-1}\ W'Z(\Omega^*)^{-1}\ Z'$$

To summarize the estimator and the variance-covariance matrix are obtained in three steps:

(i) estimate each equation using 2SLS,
(ii) estimate the joint covariance matrix using the residuals and the matrix of instruments, and
(iii) estimate all parameters jointly using GLS on the stacked equations.

V. Empirical results

This section provides an empirical example of the misleading results one can obtain when using traditional one equation methods or dynamically misspecified equations for growth and/or investment functions. The methodology is developed in two stages: first, I optimize the lag structure inside the restricted VAR model, and second, I estimate the model with a consistent covariance matrix for the system by a Three Stage Least Squares (3SLS) estimation.

Lag-length Selection

Table 4 presents the tests performed to determine the appropriate lag length of the model. Several lag selection criteria were used (Hansen (1982), Schwartz (1978) and Akaike))[18], but the results did not differ among them. For space reasons I reported below the results for Schwartz procedure which is slightly more restrictive than the Akaike statistical. It is based on minimizing the following expression:

$$\text{Log}(SSR) + K(\log T)/T$$

where SSR is the sum of squared residuals, T is the number of observations and K is the number of regressors in each equation. From the table it is clear that the above expression is minimized in both equations at the same lag length. Therefore the model will be estimated with two lags on both endogenous variables. The results, however, do not change in any significant fashion if lags were increased from two to three.

TABLE 4

LAG LENGTH TESTS
Schwartz Criterion

Number of Lags	Investment Equation	Growth Equation
1	2.870	9.126
2	2.745	8.652
3	2.755	8.962
4	2.815	8.780

Estimation Results

Before presenting the 3SLS estimation results two issues are noteworthy. First, Holtz-Eakin, Newey and Rosen (1985) recommend the joint estimation of the equations that form the VAR to build the consistent covariance matrix, instead of the 2SLS equation-by-equation estimation.

Second, the election of the matrix of instruments proves to be crucial, because a "wrong" selection affects strongly the standard deviation of the parameters (and thus the significance tests). To avoid the latter I used all the information available at time T that was uncorrelated with growth or private investment. This means that all lagged values of the deterministic variables (debt, RER, etc.) are included in addition to lags of the dependent variables of order m + 2 (where m is the lag length, i.e., 2).

When analyzing the estimation results two issues should be taken into account. First, in a VAR model the t-statistics of lagged endogenous variables need not to be significant for each and every lag, since colinearity is expected to be present. If one of the lags in the sequence is not significant this is not a problem if, as a block, all of them are different from zero. For this reason only block F-tests are reported. Second, due to the methodological requirement of testing on the first differences of the variables, the overall fit of the equations is significantly lower than that of the specification in levels. Hence reported R statistics of the first differences equations are quite low.

A fairly general model was estimated but failed to find any significant effect of the real interest rate and the level of inflation on both growth and investment functions[19]. The restricted model excludes both variables. Exclusion of the real interest rate can be justified on the grounds that the ex-post deposit rate is not a good proxy for the cost of capital. Also its link with output may be weak under financial repression. In the case of inflation I substituted its level by a moving average of its coeficcient of variation, as a proxy of instability[20]. Table 5 presents estimation results for the restricted model[21].

Growth

Figures 7 and 8 presents the dynamic trajectories of GDP growth to own and cross transitory shocks[22], obtained by computing the moving average representation of the VAR system estimated above. A negative sign in the first own lag induces the characteristic oscillatory path of the current response, where the effects of the shock are insignificant after 4 to 5 periods ahead[23]. The more interesting result, however, is presented by the

TABLE 5

REGRESSION RESULTS
(21 Developing Countries, 1982-1989)

$$GRT_t = \sum_{i=1}^{2} \alpha_i GRT_{t-i} + \sum_{i=1}^{2} \beta_i INV_{t-i} + \sum_{i=0}^{1} \delta_i PUB_{t-i} + \sum_{i=0}^{1} \tau_i DEB_{t-i} + \sum_{i=0}^{1} \Phi_i RER_{t-i} + \phi VOL_{t-1}$$

	Estimated Coefficient	T-Statistic	Block F-Statistic
Endogenous Variables			
Lags of Private Investment			3.31*
Lags of GDP Growth			21.62**
Stochastically Independent Variables			
Public Investment	6.39	2.16**	
Lagged Public Investment	−6.02	−1.54	5.63**
External Debt	−12.46	-2.96**	
Lagged External Debt	5.32	1.21	6.85**
Real Exchange Rate	2.92	0.85	
Lagged Real Exchange Rate	4.91	1.46	5.62**
Inflation Instability	−1.19	−1.93	

Adjusted R : 0.35 — Degrees of Freedom: 177
Durbin-Watson Stat: 2.26 — Q Test (39): 41.7

$$GRT_t = \sum_{i=1}^{2} \alpha_i GRT_{t-i} + \sum_{i=1}^{2} \beta_i INV_{t-i} + \sum_{i=0}^{1} \delta_i PUB_{t-i} + \sum_{i=0}^{1} \tau_i DEB_{t-i} + \sum_{i=0}^{1} \Phi_i RER_{t-i} + \phi VOL_{t-1}$$

	Estimated Coefficient	T-Statistic	Block F-Statistic
Endogenous Variables			
Lags of Private Investment			6.52**
Lags of GDP Growth			3.17*
Stochastically Independent Variables			
Public Investment	0.38	2.95**	
Lagged Public Investment	0.23	2.63**	17.6**
External Debt	−0.91	−4.29**	
Lagged External Debt	−0.57	−2.31*	13.1**
Real Exchange Rate	−0.17	−2.85**	
Lagged Real Exchange Rate	0.19	0.99	12.7**

Adjusted R : 0.33 — Degrees of Freedom: 179
Durbin-Watson Stat: 1.85 — Q-Test (39): 17.81

Note: Both equations estimated by 3SLS, all variables in first differences of the logs, except growth and the volatility index. * and ** mean significant at 95% and 99%, levels respectively.

FIGURE 7

RESPONSE OF GROWTH TO OWN SHOCKS
(normalized responses)

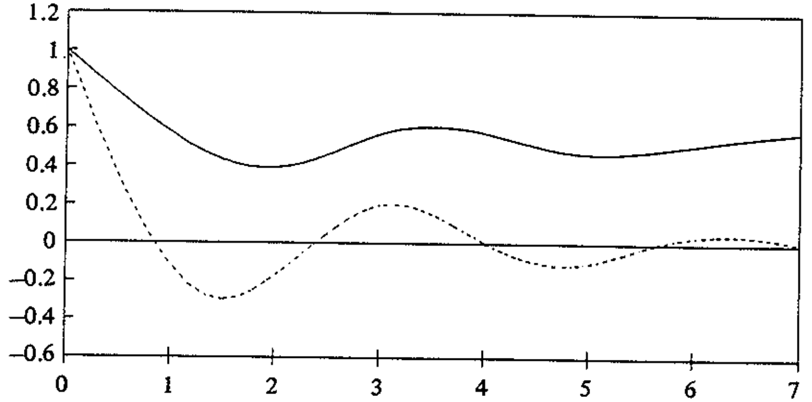
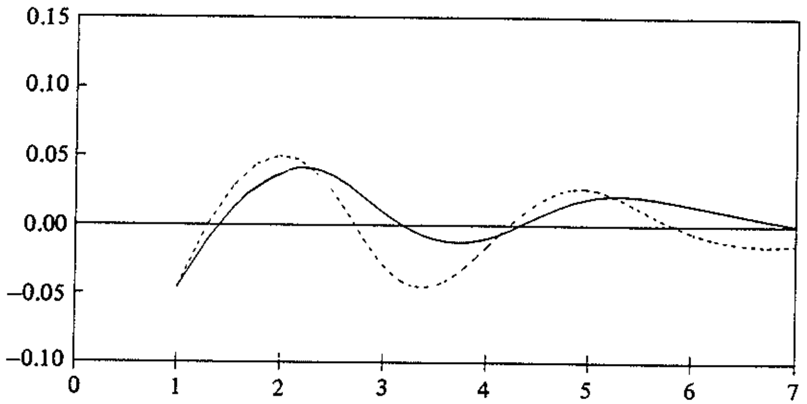


FIGURE 8

RESPONSE OF GROWTH TO INVESTMENT SHOCKS
(normalized responses)



behavior of the cumulative response, which shows evidence of some persistence in levels, of one half of the original shock. This result is no surprise in he context of the sample underlying this estimations: during the post-1982 period most of the countries included here were experiencing, with more or less success, a recovery from the 1981-82 recession and their economies were characterized by excess capacity and unemployment. Therefore shocks are able to induce output expansions for rather long periods of time[24].

In the case of investment shocks the initial response in growth is moderately negative; in the second period the response is a mix of the positive effects on lagged movements in both growth and private investment. Successive waves of expansion and contraction in the growth rate follow for approximately 4 to 5 periods after which they level off. In this case the effect of the shock is not only smaller than above but also completely transitory in the growth rate.

The results with respect to growth dynamics, however, should not be extended outside the limits of the technique and the period for which the results are representative. This model does not bring light on the long-run relationships between growth and investment; on the contrary, it is designed precisely to account for the short to medium-run interaction between both variables.

Most of the estimated parameters of the deterministic variables proved to be block-significant with 95% of confidence. The fact that they were not significant by themselves reflects the presence of collinearity. The significance of the volatility index appears to be low (significant at the 13% level) although it presents the expected negative sign for an instability variable[25]. The sign of the contemporaneous debt variable is negative, as expected for the period, with a quite high magnitude. Surprisingly the sign for its first lag appears to be positive. Both the contemporaneous and lagged RERs present positive sign, which is consistent with observed expansionary effects of devaluations.

The most interesting result refers to public investment. The sign for its contemporaneous effect is positive, but its first lag presents a rather unexpected negative sign, which will induce a more complicated dynamic path of growth and investment after a shock.

Investment

Figures 9 and 10 depict the dynamic trajectories of GDP growth to own and cross transitory shocks obtained as above. Again the negative sign in the first own lag induces the characteristic oscillatory path of the current response but in this case the effects of the shock disappear faster than in the case of growth. Persistence is similar in terms of magnitude. When analyzing the response of investment to growth shocks the classical positive relationship is found. Although the final effect is zero (when computed over 10 periods) the effect of growth shocks to investment lasts for a rather long period of time.

With respect to the deterministic variables, those not significant should be removed to get efficient estimates of the parameters, so the volatility index was dropped. This may reflect the fact that investment in developing countries reacts to other forms of instability (interest rates, credit supply or RER volatility) or, alternatively, that instability is transmitted through reduced growth (as the corresponding negative sign in growth equation reveals). The coefficients associated to debt are negative, as expected for the period after the 1982 crisis.

Another surprise is the contemporaneous negative relation between private investment and the RER. One may expect a positive sign if most of the investment goes into tradable sectors which benefit from RER devaluations. However, it seems that the

FIGURE 9

RESPONSE OF INVESTMENT TO GROWTH SHOCKS
(normalized responses)

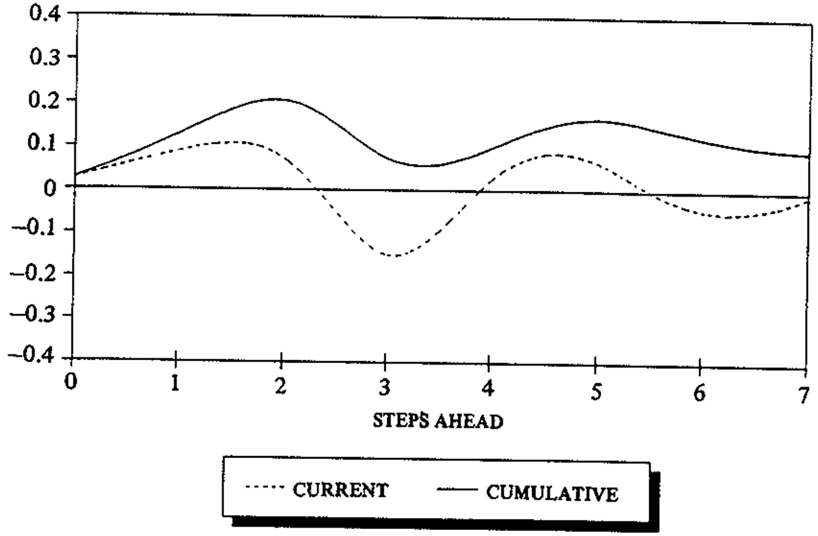
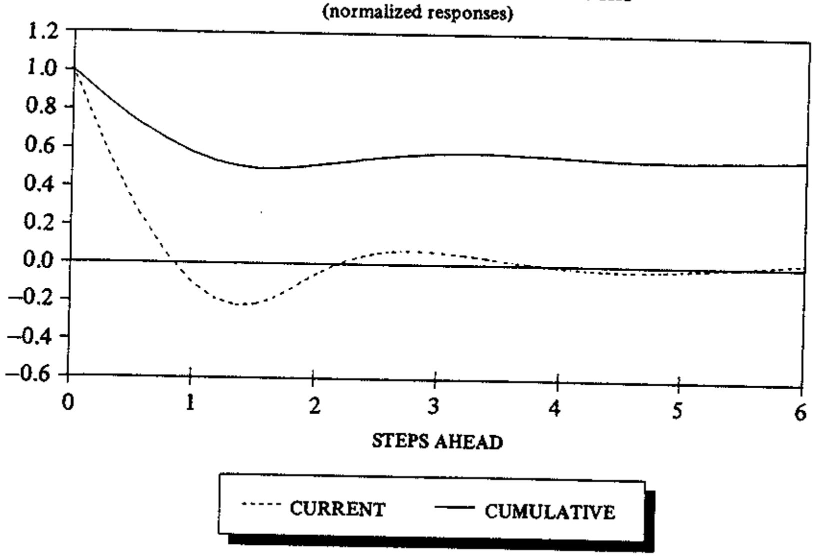


FIGURE 10

RESPONSE OF INVESTMENT TO OWN SHOCKS
(normalized responses)



importable components of private investment (plus the profit shrinkage of non tradable sectors) result in a net contractionary effect, at least in the short run and for this sample. Again the impulse-response function may bring light on this topic. A similar comment applies to public investment, where the positive sign suggests some public-private investment complementarity. However, as the lagged response of growth to increasing public investment is negative, the definitive relationship must be postponed for the simulation carried out below.

It is also important to discuss the results in the light of alternative traditional models of the type criticized in section III. Table 6 presents results for a similar specification based on a traditional OLS-IV static model, which excludes the lagged endogenous variables for investment or growth in developing countries, because of the presence of lags in the (now exogenous) cross variable and in the stochastically independent variables.

The results are seriously affected by the omission of lags of the endogenous variable: most parameters of the deterministic variables are not significant (individually or as a block) and misleading results are obtained with regard to the role of lagged private investment (coefficients are now negative) in growth, where in addition public investment and the RER are not significant. In the investment equation the biases are also apparent. The parameters associated with growth are not significant at all nor is the contemporaneous effect of the RER. Finally, the growth equation presents some autocorrelation problems of high (unknown) order as is evidenced by Q-tests.

We may conclude that this comparison is suggestive of the magnitude of the potential biases underlying most available cross-country studies of investment and growth in developing countries. Nevertheless, the following dynamic simulation of shocks to a deterministic key variable (public investment) may help us to understand the often contradictory results in the existence literature.

Dynamic Simulation of an Exogenous Shock

The dynamic relationships in this case is analyzed by assessing the simulated response of both endogenous variables to permanent shocks given to a deterministic variable. The size of the shock was arbitrarily set equal to 1 and figures 11 and 12 depict the response of growth and private investment to public investment shocks.

In the case of a permanent depreciation the dynamic responses are simple to assess. The hump-shaped effect on growth reaches its peak of 1.1 after one year, while the following decay effects are mild and display a persistence of about 0.75. The response is in line with the "contractionary effect" literature in the sense that the current response of output to devaluations (i.e., the first derivative of the curve in figure 11) are negative in periods 2 and 3. On the other hand, there is no hump in the response of private investment but a slow decay from the impact level (1.04) to a stationary level of 0.65 with mild oscillatory effects. Note in this case the absence of a contemporaneous shock case due to the decomposition ordering (growth-investment).

The dynamic response in this case is a clear example of how different results the two econometric approaches render. The SEMs coefficient interpretation would suggest, as stated above, that some contractionary effect of devaluation on investment can be expected since the estimated sign of the contemporaneous parameter is negative. The dynamic simulation proves that this is inaccurate because, although the impact response is negative, the medium run relation is positive.

The analysis of the response to public investment shocks is also enlightening. The growth response presents again an oscillatory pattern but shocks disappear rather fast

TABLE 6

ALTERNATIVE REGRESSION RESULTS
(21 Developing Countries, 1982-1989)

$$GRT_t = \sum_{i=1}^{2} \beta_i INV_{t-i} + \sum_{i=0}^{1} \delta_i PUB_{t-i} + \sum_{i=0}^{1} \tau_i DEB_{t-i} + \sum_{i=0}^{1} \Phi_i RER_{t-i} + \phi VOL_{t-1}$$

	Estimated Coefficient	T-Statistic	Block F-Statistic
Stochastically Independent Variables			
Lags of Private Investment			5.26**
Public Investment	2.42	1.15	
Lagged Public Ivestment	-1.70	-0.73	0.78
External Debt	-4.66	-2.11*	
Lagged External Debt	2.47	0.86	2.24*
Real Exchange Rate	-2.18	-0.98	
Lagged Real Exchange Rate	3.71	1.56	1.66
Inflation Instability	-0.96	-1.43	
Adjusted R : 0.15	Degrees of Freedom: 177		
Durbin-Watson Stat: 2.75	Q Test (39): 43.3		

$$INV_t = \sum_{i=1}^{2} \alpha_i GRT_{t-i} + \sum_{i=0}^{1} \delta_i PUB_{t-i} + \sum_{i=0}^{1} \tau_i DEB_{t-i} + \sum_{i=0}^{1} \Phi_i RER_{t-i}$$

	Estimated Coefficient	T-Statistic	Block F-Statistic
Stochastically Independent Variables			
Lags of GDP Growth			2.21
Public Investment	0.12	1.19	
Lagged Public Investment	0.16	1.41	2.39*
External Debt	-0.91	-4.77***	
Lagged External Debt	-0.57	-0.87	15.1***
Real Exchange Rate	0.12	1.10	
Lagged Real Exchange Rate	-0.04	-0.33	0.5
Adjusted R : 0.21	Degrees of Freedom: 179		
Durbin-Watson Stat: 2.18	Q-Test (39): 14.06		

Note: Both equations estimated by OLS, all variables in first differences of the logs, except growth and volatility index. *, ** and *** mean significant 90%, 95% and 99%, respectively.

FIGURE 11

RESPONSE OF OUTPUT TO PERMANENT SHOCKS IN PUBLIC INVESTMENT AND R.E.R.

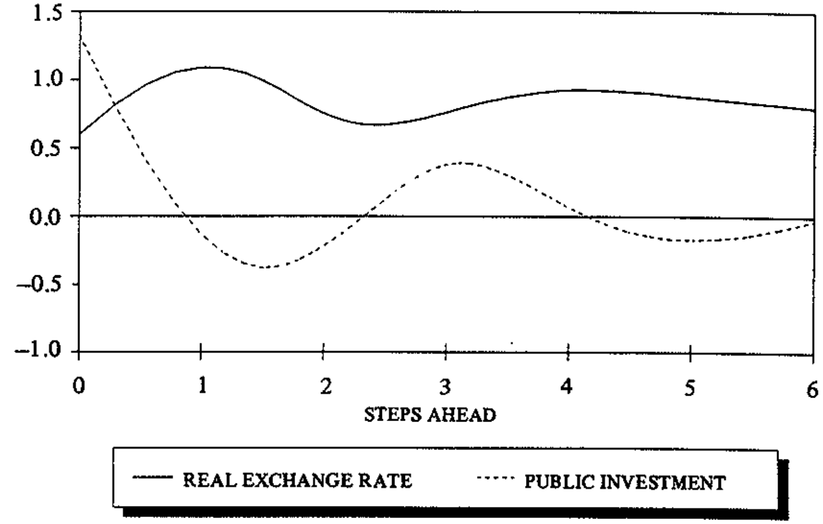
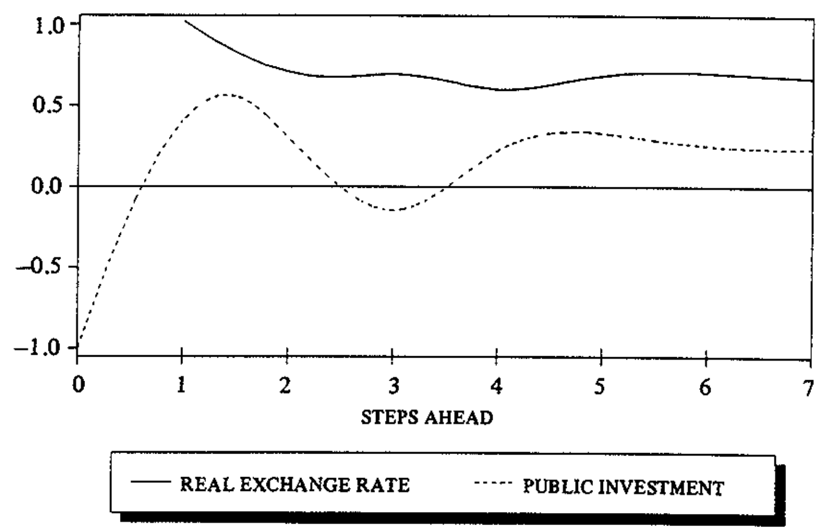


FIGURE 12

RESPONSE OF INVESTMENT TO PERMANENT SHOCKS IN PUBLIC INVESTMENT AND R.E.R.



with no evidence of significant persistence. The negative initial response of private investment might be a reflection of a short-run crowding out effect, while the medium-run positive (cumulative) relation may reflect some degree of complementarity between the two types of capital.

The more interesting fact that emerges from this exercise is in connection with static (or dynamically misspecified) models. If we estimate a static model of private investment omitting the lags of public investment we obtain a permanent negative response of 4% (not presented for space limitations), thus concluding that there is an undesirable crowding-out effect. On the other hand, if we estimate the model only with public investment lags we conclude that private and public investment are complements. If the model presented in this paper is to be considered a more realistic representation of growth and accumulation processes, then it follows that static models that usually find either a permanent positive or negative correlation between public investment and growth or private investment may be seriously biased.

One final comment that can be drawn from the model is that transition periods appear to be important (at least 4 years) and that their length depends on the nature of the shock (RER, growth, public or private investment), a fact usually not considered by traditional models.

VI. Conclusions

This paper presents evidence on the importance of estimating investment and growth functions that address both simultaneity problems and the dynamic interaction of key variables. Simple static models may lead to serious biases in estimating the effects of public investment and the real exchange rate on private investment and growth. One-equation dynamic models also yield distorted parameter estimations and hence of the trajectories of the variables, although the bias appears to be smaller than in simple static models.

The dynamic model estimated here sheds new light on the determinants of private investment and growth. The presence of dynamic oscillatory effects in growth and investment suggests not only that static estimations may be strongly biased if the lag structure is not appropriately incorporated, but also and more important, that specification problems may be underlying the long discussion on the complementarity/substitutability of private and public capital and the expansionary/contractionary effects of real exchange rate devaluations. Finally, the model did not find significant effects of the real interest rate or the level of inflation on growth and investment, while price volatility appears connected to investment only indirectly via changes in the growth rate.

Apart from exploring the feasibility of implementing a variable-parameter estimation, two extensions seems to be warranted. First, the model specification could be extended to include additional determinants of private investment and growth such as credit constraints other risk measures. Second, a distinction between transitory and permanent shocks as resulting from fundamental shock (tastes and technologies) would throw more light on country experiences. The latter case, however, needs to be undertaken under a more explicit theoretical framework, in which the identification of shocks through restrictions derived from the relations between variables could be fully justified.

APPENDIX I

DATA SOURCES AND DEFINITIONS

Summers and Heston (1988) provides one of the few sets of aggregate annual data on main macroeconomics indicators, including investment and GDP, for a large group of countries. However, a cross comparison between this and other sources at a country specific levels shows serious differences with information from national accounts sources and, as Cardoso (1991) notes, estimates for real investment to GDP ratios in Argentina, Chile and Brazil are out of proportion when compared to several other studies. Apart from this problem, Summers and Heston did not provide information on the shares of private and public investment and any interpolation may be misleading.

For this reason, the series contained in Pfeffermann and Madarassy (1991) were used in this paper. This latter data set provides series for nominal investment (total, private and public investment) for 40 countries for the 1970-1989 period, on annual basis. Data is mainly nominal ratios to GDP (with some exceptions), so in order to obtain real ratios deflators for the GDP and investment were used. Other real variables (like external debt, real exchange rates and others) were obtained from World Bank publications (World Debt Tables and World Tables, various issues). The real interest rate is from IMF publications (International Financial Statistics, various issues) and from Greene and Villanueva (1991).

Data series were collected for the 21 countries listed in section II. The series, constructed for the 1975-1989 period, refer to the following variables: gross domestic output; total, private and public investment; the GDP and investment deflators; external debt (DOD); the real exchange rate and the nominal interest rates (only the deposit rate was available for the period).

The generated variables are;: real ratios of private and public investment to GDP, debt to GDP (in nominal terms), inflation (from the GDP deflator). The real interest rate was calculated from the annualized nominal interest rate and the actual annual inflation, thus it is the ex-post real interest rate. The volatility index was built as a moving average of order three of the coefficient of variation for each country. Special effort was devoted to make the series as homogeneous as possible.

The countries covered in the paper are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, India, Kenya, Korea, Sri Lanka, Mexico, Pakistan, Peru, Philippines, Singapore, Thailand, Turkey, Uruguay and Zimbabwe.

APPENDIX II

GENERAL MODEL REGRESSION RESULTS

$$GRT_t = \sum_{i=1}^{2} \alpha_i GRT_{t-i} + \sum_{i=1}^{2} \beta_i INV_{t-i} + \sum_{i=0}^{1} \delta_i PUB_{t-i} + \sum_{i=0}^{1} \tau_i DEB_{t-i} + \sum_{i=0}^{1} \Phi_i RER_{t-i} + \phi INF_t + \Theta TIR_t$$

	Estimated Coefficient	T-Statistic	Block F-Statistic
Endogenous Variables			
Lags of Private Investment			14.58**
Lags of GDP Growth			47.55**
Stochastically Independent Variables			
Contemp. Public Investment	1.23	0.42	
Lagged Public Investment	–5.42	–3.02**	2.37
External Debt	–5.17	–1.38	
Lagged External Debt	–7.08	–2.54*	15.71**
Real Exchange Rate	2.41	0.92	
Lagged Real Exchange Rate	1.60	0.70	0.77
Inflation	–0.011	–0.31	
Real Interest Rate	2.71	0.96	

Adjusted R : 0.31 — Degrees of Freedom: 177

Durbin-Watson Stat: 2.14 — Q Test (39): 27.3

$$INV_t = \sum_{i=1}^{2} \alpha_i GRT_{t-i} + \sum_{i=1}^{2} \beta_i INV_{t-i} + \sum_{i=0}^{1} \delta_i PUB_{t-i} + \sum_{i=0}^{1} \tau_i DEB_{t-i} + \sum_{i=0}^{1} \Phi_i RER_{t-i} + \phi INF_t + \Theta TIR_t$$

	Estimated Coefficient	T-Statistic	Block F-Statistic
Endogenous Variables			
Lags of Private Investment			2.28
Lags of GDP Growth			5.57**
Stochastically Independent Variables			
Contemp. Public Investment	1.23	0.42	
Lagged Public Investment	–5.42	–3.02**	0.41
External Debt	–5.17	–1.38	
Lagged External Debt	–7.08	–2.54*	4.57**
Real Exchange Rate	2.41	0.92	
Lagged Real Exchange Rate	1.60	0.70	1.82
Inflation	0.047	0.96	
Real Interest Rate	0.26	1.37	

Adjusted R : 0.21 — Degrees of Freedom: 177

Durbin-Watson Stat: 2.01 — Q-Test (39): 17.92

Note: Both equations estimated by 3SLS, all variables in first differences of the logs, except growth and volatility index. * and ** mean significant 95% and 99%, respectively.

Notes:

1 The new theory of endogenous growth, however, is not free of criticism. See de Long and Summers (1991) which present evidence that cross-country growth depends heavily on equipment investment.

2 This assumes public investment and real exchange rate are stochastically independent from growth and investment; a statistical test is performed in section IV to asses the validity of this statement.

3 For a survey on this topic see Serven and Solimano (1991a).

4 See Kiguel and Liviatan (1991) and Cardoso (1991).

5 All numbers in table 1 and figures 1 to 6 are unweighted averages. Data sources and definitions in appendix I.

6 Highly indebted countries are defined in this paper as those whose debt stock exceeded, on average, 50% of GDP during 1975-1989. Those countries are Argentina, Bolivia, Brazil, Chile, Costa Rica, Ecuador, Kenya, Mexico, Peru, Philippines, and Uruguay. Less indebted countries are Colombia, Guatemala, India, Korea, Pakistan, Singapore, Sri Lanka, Thailand, Turkey, and Zimbabwe.

7 Figures are real investment to real GDP ratios.

8 On a discussion of the causality between capital flows and real exchange rate misalignments see Morandé and Schmidt-Hebbel (1988) and Edwards (1988).

9 See the surveys on empirical results by Jorgenson (1971) and Clark (1979).

10 Some investment functions for individual countries, such as Schmidt-Hebbel (1988), are based on dynamic optimizing behavior with explicit adjustment costs.

11 For a description of these methods and their limitations see Anderson and Hsiao (1982) and Bhargava and Sargan (1983).

12 A description of the failures of this model is provided in Romer (1989).

13 Blanchard and Quah (1989), Sims (1986) and Soto (1990) are examples of this "structural VAR modelling".

14 See model specification below.

15 It should be noted that Granger non-causality is appropriate in this context since the purpose is to forecast (and not make inferences) growth and private investment conditional on debt, the RER, and public investment. See Granger (1969) and Engle, Hendry and Richard (1983) for detailed proofs.

16 All variables in logs except the growth rate and volatility index.

17 Chamberlain (1984) avoids this problem by assuming that the first observation in the panel coincides with the "birth" of the unit. An assumption which is untenable in most applications.

18 For detailed references on Akaike's and other lag length criteria see Judge et al (1985).

19 The results are reported in appendix II.

20 See Serven and Solimano (1991b) for a similar procedure.

21 A general warning about this and other results of this paper is that they may present "small sample" problems since only 21 countries are included in the estimation. The methodology obtains estimators that are consistent when the number of countries, and not the number of observations, tends to infinity.

22 All shocks are once-and-for-all shocks in period zero, orthogonalized and with size equal to one standard deviation of the residuals.

23 Preliminary findings of an independent research project that uses a similar technique also found this oscillatory responses of growth and investment to shocks (see Lavy, Newey and Pedroni, 1991).

24 The persistence of growth shocks has been discussed extensively in the unit roots literature. See Perron and Campbell (1991) for a survey.

25 Its low significance may be due to the fact that its construction entails the use of moving averages of the mean and the standard deviation of the series of inflation, probably smoothing in excess its effect on growth.

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DISEÑO DEL CONTRATO OPTIMO DE CREDITOS Y SUS CONTINGENCIAS IMPLICITAS EN EL CASO DE PAISES EN DESARROLLO*

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Abstract:

This paper argues that LDC loans contain implicit contingent features that provide insurance to the borrowing country against unfavorable economic circumstances. The motivation for, and optimality of, the implicit features of LDC loans are analyzed. Two policy implications to reduce the cost of default in LDC contracts are derived. First, if parties can make some of the implicit contingencies explicit, or countries can be insured against commodity price fluctuations, some sources of default would be eliminated and costs avoided. Since agents may be unable to include all contingent provisions explicitly, the second implication, therefore, is that default and rescheduling costs may be reduced if the parties submit to arbitration.

1. Introducción

La historia de los préstamos internacionales muestra una correlación significativa entre las malas condiciones económicas mundiales y los episodios de incumplimiento. También deja en claro que, si bien los deudores efectúan devoluciones sustanciales, ellos suelen no cancelar la deuda en las condiciones contractuales originales. Además, la "capacidad de pago", vale decir, la capacidad del país para gravar y luego transformar recursos internos en divisas, ha cumplido un papel importante en la negociación de acuerdos entre acreedores y deudores en los casos de incumplimiento. Por último, los países morosos raramente han sido sancionados por su incumplimiento, ya sea mediante sanciones

* Esta investigación fue realizada cuando el autor era profesor de St. John's University, por lo tanto las ideas aquí expresadas son sólo del autor y en ninguna forma deben atribuirse al Banco Central de Chile.

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