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by

Jaime Marquez

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I. Introduction

One characteristic that many developing countries share is the substantial government participation in the economic development process through the setting of targets for output growth and the dates to achieve them (Chenery and Strout 1966, Lewis 1984). As a result, the government plays a key role in determining the speed at which the economy's capital stock adjusts to the level implied by the growth target. Naturally, the setting of these growth targets involves taking into account a number of additional factors such as the distributional effects of growth, the level of education, natural resources, and national priorities. But, the aspect that concerns us here is the interaction between the availability of foreign exchange resources and the speed of adjustment of capital stock.

In particular, if a developing economy is experiencing a lack of foreign exchange, unable to finance the foreign component of its capital stock, then it may choose to stretch out the completion date of projects already under way by lowering the speed of adjustment of capital formation rather that abandoning these projects altogether. On the other hand, if a particular economy has foreign exchange at its disposal, then it could achieve its target growth rate in less time by raising the speed of adjustment of capital formation. Therefore, it is quite conceivable that the speed of adjustment of capital formation in a developing country may be related to the availability of foreign exchange resources.

Although the relationship between the speed of adjustment of capital formation and foreign exchange resources is intuitively obvious, we find that this speed is generally treated in the development literature as one more parameter to be estimated, completely unrelated to the availability of foreign exchange resources. Given that these resources are a key aspect of the design and implementation of investment plans (see World Bank 1982), it is of interest to study investment and import behavior allowing for a non-constant speed of adjustment and, especially, for imperfect substitutability between domestic capital and foreign capital as pointed out by McKinnon (1964) and Taylor (1979).

The intuition behind our approach is developed in section II. In sections III and IV we present a theoretical framework to explain investment and import behavior allowing for an endogenous speed of adjustment and for imperfect substitutability between the domestic and the foreign capital stocks. In section V we implement empirically our theoretical analysis and present empirical results; finally section VI contains our conclusions.

II. Investment, Foreign Exchange, and Growth

Several approaches have been used in modeling the effects of foreign exchange constraints on output growth. One approach relates foreign exchange resources--measured as either total exports, international reserves, or deficit in the balance of payments--to investment activities which are linked to output growth via capital accumulation.[1] A second approach relates output growth directly to foreign exchange resources via an aggregate production function on the basis that foreign exchange is a scarce resource and thus can be treated "as if" it were a factor of production (Tyler 1981, Robinson 1971).

In this paper we study the influence of foreign exchange constraints on growth by focusing on investment and import demand behavior. We begin by assuming that investment demand depends on the price of capital relative to energy, real income, and the available amount of foreign exchange resources (this functional relation is formally derived below in section III):

$$I^d = I\,(Q,\ Y,\ X),$$

where I^d = ex-ante investment demand,

Q = rental price of capital relative to the price of energy,

Y = real income, and

X = available amount of foreign exchange resources, in real terms.

In addition, we model the ex-ante demand for imports of capital goods as a function of the level of investment and of the price of capital goods imports relative to the price of domestic goods (again, this functional relationship is formally derived in section IV):

$$M_m^{\ell} = M\ (\ P,\ I^d\ ),$$

where M_m^{ℓ} = demand for imports of capital goods,

P = price of capital goods imports relative to domestic prices.

The interdependency between investment and imports is depicted in Figures 1a and 1b. Each of these functions is inversely related to their respective relative prices, and thus the downward sloping nature of their schedules. Suppose now that a target level of income Y^* has been set by the government or the planning board. Given relative prices, q, and a given amount of foreign exchange resources, $\bar{X}$, we can determine the ex-ante demand for investment goods as I^d. This level of investment demand determines in turn the ex-ante demand for capital goods assuming a perfectly elastic supply schedule for capital goods imports, and assuming that $\bar{X}$ is large enough to purchase the required capital goods imports. Ex-post, the supply of investment will be equal to a domestic component plus imports of capital goods, $\bar{M}$.

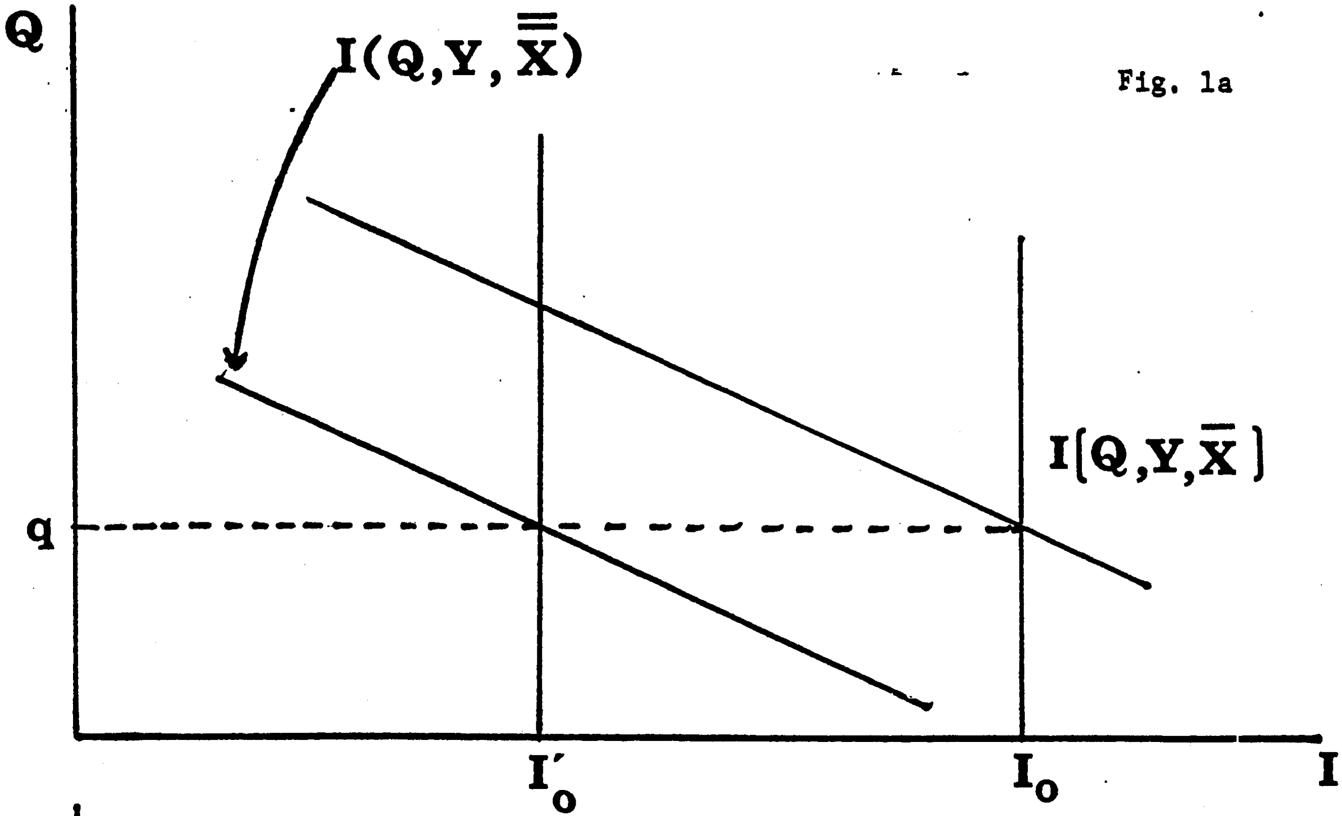

Fig. 1a

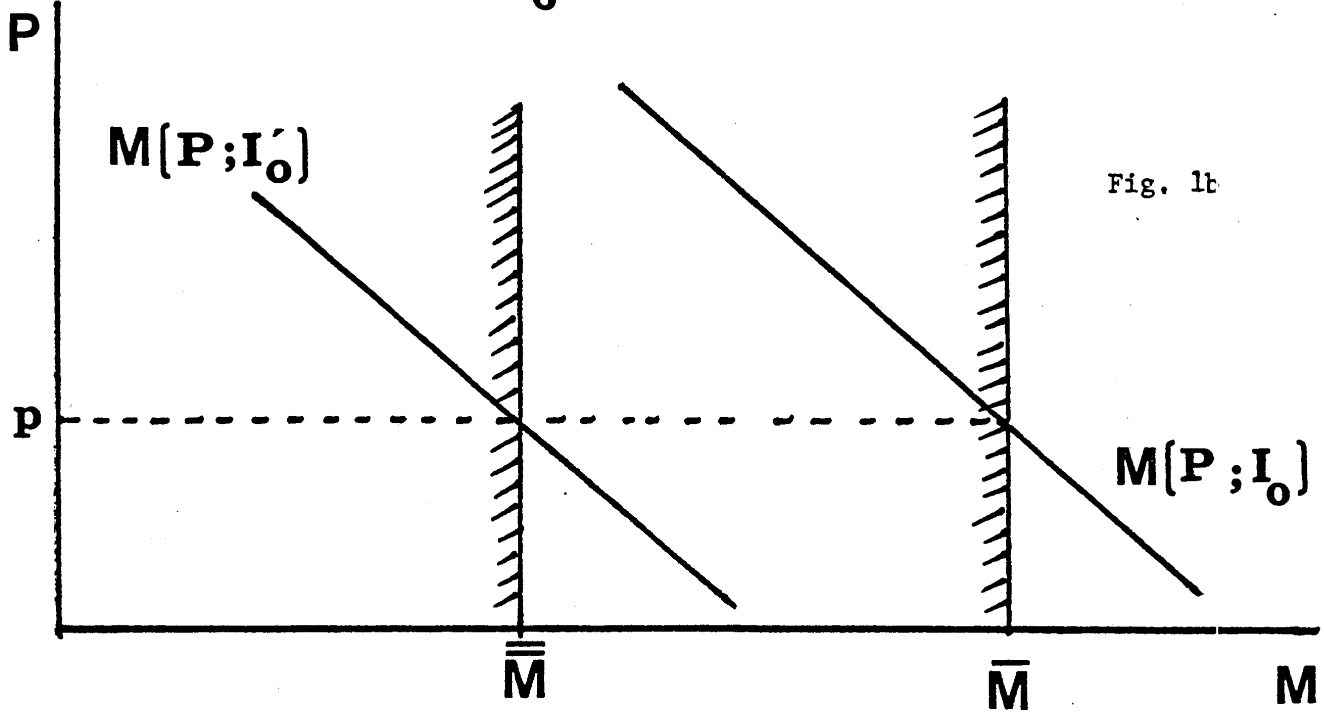

Fig. 1b

The typical LDC, however, does not have enough foreign exchange resources available to finance all the required imports. Suppose then that there exists a lower level of foreign exchange resources, $\bar{\bar{X}}$, implying a maximum level for imports of capital goods equal to $\bar{\bar{M}}$, below $\bar{M}$. In this situation some of the investment projects that would have taken place under $\bar{X}$ will not take place under $\bar{\bar{X}}$, shifting the investment demand schedule to the left, with a corresponding deterioration of growth prospects. This decline in investment demand implies in turn a decline in the demand for capital goods imports (given prices), which shifts the import demand schedule to the left until these imports are consistent with the (lower) amount of foreign exchange resources available, $\bar{\bar{X}}$.

As a result, a constraint on foreign exchange resources adversely affects output growth because it dampens investment possibilities, which in turn causes a decline in the demand for imports. An alternative argument is to consider constraints in foreign exchange as a limit on the availability of capital goods imports, which would reduce the supply of investment goods and therefore the prospects for growth. There are, however, two drawbacks to this second line of reasoning: (1) it cannot be refuted empirically, that is, to the extent that investment is partly made up of capital goods imports, a limit on the latter must impose a limit of the former;[2] (2) it is implictily assumed that an increase in the amount available of foreign exchange resources would lead to an automatic increase in capital goods imports, even if there is no demand for them! For these reasons we model the effect of foreign exchange constraints on output via the constraint put on investment opportunities.

III. Investment Demand and Foreign Exchange

In deriving the demand for investment goods, we make use of the ideas stemming from the two-gap literature, and we incorporate them in a nested production function as developed by Sato (1967). Here we assume that the production function is strongly separable, which in turns allows us to determine optimal input allocations in two stages: in the first stage, optimal allocations are made with respect to broad categories of inputs such as capital, labor, or energy; in the second stage, optimal allocations are made with respect to less aggregated inputs, such as the composition of the capital stock, taking as given the (optimal) decisions about aggregate inputs of the first stage.[3]

Following the nested production function approach, we represent growth opportunities for developing economies by an aggregate production function whose arguments are the stock of domestic capital, the stock of foreign capital, and energy:

$$Y = F(K_{dt}, K_{ft}, E_t), \tag{1}$$

where Y = amount of output produced at time t,

K_{dt} = stock of domestic capital at time t,

K_{ft} = stock of foreign capital at time t, and

E_t = amount of energy used at time t.

In equation (1) we underscore the fact that domestic capital goods and foreign capital goods are not perfect substitutes for each other, as has been pointed out by McKinnon (1964) and Taylor (1979). Following the work of Sato (1967), we might think of K_{dt} as being made up of structures and of K_{ft} as being made up of equipment. We also introduce raw materials--energy in this case--in the production function on the basis that production processes cannot take place unless a minimum level of raw materials is used in production.[4]

Using the strong input separability assumption, we express the production function as:

$$Y = F(f(K_{dt}, K_{ft}), E_t) = G(K_t, E_t), \quad (2)$$

where

$$K_t = f(K_{dt}, K_{ft}) = \text{aggregate capital stock.} \quad (3)$$

Following the approach developed by Coen (1971), the optimal amount of the aggregate capital stock is determined as a function of factor prices and output:

$$K_t^* = J((P_k/P_e)_t, Y_t), \quad (4)$$

where P_{kt} = rental price of the aggregate capital stock at time t,[5]

$= P_{q,t-1}(r_t + \delta(P_{qt}/P_{q,t-1}))$,

P_{et} = price of energy at time t,

K_t^* = optimal aggregate capital stock at time t,

r_t = nominal interest rate at time t,

P_{qt} = price of investment goods at time t, and

δ = depreciation rate.

After algebraic manipulations, we obtain (Coen 1971:148,149) an expression for actual investment:

$$I_t = b(K_t^* - (1-\delta)K_{t-1}^*) + (1-b)I_{t-1}, \quad (5)$$

where b = speed of adjustment.

Actual investment I_t might differ from optimal or planned, investment $(K_t^* - (1-\delta)K_{t-1}^*)$ because of obvious lags in the delivery of capital goods and, more importantly, because of the lack of financial resources to finance investment projects. Suppose now that a developing economy experiences a reduction of foreign exchange (i.e., the foreign exchange constraint is binding). Then, rather than abandoning projects already under way, it may stretch out the completion date of investment projects by lowering the speed of adjustment of capital formation. On the other hand, if a particular economy has foreign exchange at its disposal, then it could achieve its target growth rate for output in less time by raising the speed of adjustment of capital accumulation.

This clearly suggests the existence of a relation between foreign exchange resources and the speed of adjustment of capital formation. We model the speed of adjustment in two different ways, each leading to a different formulation of investment demand behavior. In the first approach we make two intuitively appealing assumptions: (1) if there are "severe" foreign exchange constraints, then the speed of adjustment should be zero; (2) if foreign exchange constraints are not present at all (e.g., Saudi Arabia) then the speed of adjustment should converge to a value B_0 reflecting delivery lags and other constraints such as size and education of the labor force, and appropriate infrastructure, to mention only two factors. One function satisfying these properties is:

$$b_t = B_0\left(1-\exp(-X_t)\right), \tag{6}$$

where X_t represents the purchasing power of foreign exchange resources, measured in several ways as we shall see below. In reality, however, the foreign exchange resources are neither zero nor infinite and for this reason we could very well use an approximation to the function b_t:[6]

$$b_t \simeq B_0 X_t. \tag{7}$$

Using equations (4), (5), and (7) we obtain an expression for investment behavior (Coen 1971:167):

$$I_t = B_o X_t\{\alpha_o + \alpha_y(P^y(L)A(L)Y_t) + \alpha_p(P^p(L)A(L)(P_k/P_e)_t)\} + (1-B_o X_t)I_{t-1}, \quad (8)$$

from which we derive equation (9) as:

$$\Delta I_t = B_o\alpha_o X_t + \alpha_y B_o(X_t P^y(L)A(L)Y_t) + \alpha_p B_o(X_t P^p(L)A(L)(P_k/P_e)_t) - B_o X_t I_{t-1} + u_t \quad (9)$$

where $u_t \sim N(0,\sigma_u^2)$,

$A(L) = L^o - (1-\delta)L^1$,

$P^y(L) = \sum_i \alpha_i L^i$,

$P^p(L) = \sum_j \gamma_j L^j$,

and L is the lag operator, $L^j Z_t \equiv Z_{t-j}$.

We obtain the long run expression for investment[7] by setting $Y_t = Y_{t-1}$, $X_t = X_{t-1}$:

$$I_t = \alpha_o + \alpha_y\ \delta Y_t + \alpha_p\ \delta(P_k/P_e)_t. \quad (10)$$

As we can see, our first approach to modeling the speed of adjustment results in a long run investment demand function unconstrained by the availability of foreign exchange resources. This implies that the LDCs will be able, "somehow", to satisfy their investment needs with domestic production. For this reason we denote this approach as the "Autarkic approach".

The basic premise in our second approach to modeling the speed of adjustment is that foreign exchange resources affect investment demand even in the long run. Implicitly we are assuming that the LDCs will have greater participation in world trade and capital markets as their income increases.

For this reason, we denote this second approach as the "Trade approach". Following Coen (1971), we assume that the speed of adjustment is linearly related to the available amount of foreign exchange, X_t, relative to the needed expansion in capital, $K_t^* - K_{t-1}$:

$$b_t = b_o + b_1((X_{t-1})/(K_t^* - K_{t-1})) , \tag{11}$$

giving an alternative equation to investment equation (8) (Coen 1971:164-165):

$$I_t = b_o(K_t^* - K_{t-1}^*) + (1-b_1)(1-\delta)I_{t-1} + b_1(X_{t-1}-(1-\delta)X_{t-2}). \tag{12}$$

This formulation can be re-expressed in a form suitable for parameter estimation (Coen 1971:167) as:

$$I_t = b_o\delta\ \alpha_o + b_o\alpha_y(P^y(L)A(L)Y_t) + b_o\alpha_p(P^p(L)A(L)(P_k/P_e)_t) + (1-b_o)(1-\delta)I_{t-1} +$$

$$+ b_1(X_{t-1} - (1-\delta)X_{t-2}) . \tag{13}$$

The steady state investment demand function is:

$$I_t = (b_o\delta\alpha_o/\Phi) + (b_o\delta\alpha_y/\Phi)Y_t + (b_o\delta\alpha_p/\Phi)(P_k/P_e)_t + (b_1\delta/\Phi)X_t , \tag{14}$$

with $\Phi \equiv \delta + b_o - \delta b_o$, which clearly depends on the availability of foreign exchange resources.

IV. Imports of Capital Goods and the Optimal Composition of the Aggregate Capital Stock

As we recall from equation (3) above, the capital stock is an aggregate of domestic and foreign capital stocks. If we assume a CES aggregator function for f, and cost minimizing behavior, then the optimal composition of the aggregate capital stock between domestic and foreign capital stock is given by:

$$K_{dt}/K_{ft} = ((1-\psi)/\psi)^{\sigma}(P^{f}_{kt}/P^{d}_{kt})^{\sigma} , \tag{15}$$

where σ = elasticity of substitution between domestic and foreign capital stocks,

P^{f}_{kt} = rental price of foreign capital,

P^{d}_{kt} = rental price of domestic capital, and

ψ = value share of K_{ft} in total aggregate capital stock.

Solving for K_{dt} in (15) and using a CES aggregator function for K^{*}_{t}, we get the optimal demand for foreign capital, K^{*}_{dt} as:

$$K^{*}_{ft} = \{1+((1-\psi)/\psi)^{\sigma}(P^{f}_{kt}/P^{d}_{kt})^{\sigma-1}\}^{(1/\rho)}K^{*}_{t} = g(P^{f}_{kt}/P^{d}_{kt})K^{*}_{t} . \tag{16}$$

where $\rho = (1-\sigma)/\sigma$. Taking time derivatives in equation (16), we get:

$$\dot{K}^{*}_{ft} \equiv dK^{*}_{ft}/dt = \dot{g}_{t}\, K^{*}_{t} + g_{t}\, \dot{K}^{*}_{t} . \tag{17}$$

But $\dot{K}^{*}_{ft}$ can be approximated by optimal imports of capital goods, $M^{\ell*}_{mt}$, and $\dot{K}^{*}_{t}$ is, by definition, aggregate optimal net investment, I^{*}_{nt}. Furthermore, for low values of σ we find that $\dot{g}_{t} \to 0$, which allows us to write the import demand equation as:

$$M^{\ell*}_{mt} = g(P^f_{kt}/P^d_{kt}) I^*_{nt} = M(P^f_{kt}/P^d_{kt},\ I^*_{nt}). \tag{18}$$

We use two different approaches to transform equation (18) into an expression suitable for parameter estimation. In the first approach we assume that the investment elasticity of imports is one. This assumption implies that the optimal share of capital goods imports in total net investment is a function of the real price of foreign capital:

$$\left(M^{\ell}_{mt}/I_{nt}\right)^* = g(P^f_{kt}/P^d_{kt})\ \exp(v_t), \tag{19}$$

with $v_t \sim N(0,\sigma^2_v)$ and $E(v_t v_{t-1}) = (1-\lambda)\sigma^2_u/\left(1+(1-\lambda)^2\right)$.

Changes in relative prices will induce a change in the optimal share of capital goods' imports in total net investment. However, the adjustment to relative price changes is unlikely to be instantaneous, and a powerful reason to have a wedge between optimal and actual values is the presence of a foreign exchange constraint. As a result there will be a difference between the actual and the optimal import-investment share. We postulate the following adjustment process:

$$\left(M^{\ell}_{mt}/I_{nt}\right) = \left(M^{\ell}_{mt}/I_{nt}\right)^{*\lambda'} \left(M^{\ell}_{mt-1}/I_{nt-1}\right)^{1-\lambda'} e^{\left(v_t - (1-\lambda)v_{t-1}\right)}, \tag{20}$$

where λ' is the speed of adjustment of the optimal import share. As in the case of investment demand behavior, we assume that the adjustment rate varies in direct relation to the availability of foreign exchange resources, that is, $\lambda' = B'_0 X_t$. After taking logs in equation (20), we get:

$$\Delta \ln(M^{\ell}_{mt}/I_{nt}) = B_o'X_t \ln(A)+\alpha B_o'(X_t \ln(P^f_{kt}/P^d_{kt}))-B_o'(X_t \ln(M^{\ell}_{mt-1}/I_{nt-1}))+u_t, \quad (21)$$

where[8]:

$$(M^{\ell}_{mt}/I_{nt})^* \cong A(P^f_{kt}/P^d_{kt})^{\alpha}, \ \alpha<0; \quad u_t \sim N(0,\sigma^2_u), \ E(u_t u_{t-1})=0.$$

In the second approach to modeling import demand behavior, we do not assume that the elasticity of capital goods imports with respect to net investment is one, and the influences of foreign exchange constraints on imports and dynamic adjustments are introduced in an ad-hoc way. We approximate equation (18) as:

$$\ln M^{\ell}_{mt} = m_o + D(L)\ln I_{nt} + E(L)\ln X_t + u_t, \quad (22)$$

with $D(L)=\sum_j d_j L^j$, $E(L)=\sum_j e_j L^j$,

where the influence of increases in P^f_{kt}/P^d_{kt} is introduced by reducing the purchasing power of the given level of foreign exchange resources.[9]

To sum up, the main differences between the two approaches (equations (21) and (22)) are in (1) the pattern of adjustment of imports to changes in both prices and availability of foreign exchange resources, and (2) in the value of the elasticity of imports with respect to net investment. For the first approach, equation (21), we assume a smooth pattern for the influence of past prices on investment and that the value of the import elasticity with respect to changes in net investment is equal to one. For the second approach, equation (22), the influence of prices is introduced as a reduction of foreign exchange resources; in addition, the long run elasticity of imports with respect to net investment is freely estimated.

V. Empirical Results

The purpose of this section is to estimate the parameters of the investment demand and capital imports equations derived in sections III and IV using aggregate non-OPEC developing countries data for the period 1960-1977. Obviously, a more disaggregate level would be preferable, although our empirical results are supported by particular country studies such as those reported in Taylor (1979), Salas (1982), Klein (1965), and van Wijnbergen (1982). In any event, the specifications we have developed here are of interest since they can be applied to the estimation of investment and demand equations for particular countries.

Since there is not a unique way of measuring the availability of foreign exchange resources, we study five alternatives:

$$X_{t1} = (P^{\ell}_{mt} X^{\ell}_{mt} + P_{rt} M^{d}_{rt}) / P^{d}_{mt} \ , \tag{23a}$$

$$X_{t2} = (P^{\ell}_{mt} X^{\ell}_{mt} + P_{rt} M^{d}_{rt} - P_{ot} M^{\ell}_{ot}) / P^{d}_{mt} , \tag{23b}$$

$$X_{t3} = E_t(R^{\ell}_t / P^{d}_{mt}) = Z(L)(R^{\ell}_t / P^{d}_{mt}) = \textstyle\sum_j z_j L^{j+1} (R^{\ell}_t / P^{d}_{mt}) , \tag{23c}$$

$$X_{t4} = R^{\ell}_{t-1} / P^{d}_{mt} , \tag{23d}$$

$$X_{t5} = R^{\ell}_{t-1} / P^{d}_{mt-1} , \tag{23e}$$

where

P^{ℓ}_{mt} = export price of manufactures of LDCs,

P_{rt} = export price of raw materials of LDCs,

P_{ot} = price of oil charged by OPEC,

X^{ℓ}_{mt} = exports of manufactures from LDCs to DCs,

M^{d}_{rt} = LDCs' exports of raw materials to DCs,

M^{ℓ}_{ot} = imports of oil of LDCs from OPEC,

CF_t = net capital flows to LDCs from DCs and OPEC.

R^{ℓ}_t = foreign exchange reserves, and

$$R^{\ell}_t = R^{\ell}_{t-1} + P^{\ell}_{mt} X^{\ell}_{mt} + P_{rt} M^{d}_{rt} - P_{ot} M^{\ell}_{ot} - P^{d}_{mt} M^{\ell}_{mt} + CF_t.$$

X_{t1} represents the value of exports of LDCs in terms of the capital goods they import from the DCs; X_{t2} is similar to X_{t1}, but we deduct the value of oil imports from total exports since oil is an intermediate input and it is needed to maintain the current level of output; according to X_{t3} the relevant measure of foreign exchange resources is the expected value of the stock of international reserves (in terms of capital goods imports), and we assume that expectations are formed by a distributed lag of past values of the level of international reserves in real terms. X_{t4} and X_{t5} are special cases of X_{t3}.

Va. Empirical Results for Aggregate Investment Demand

In Table 1 we present the long run parameter estimates for the investment demand equation corresponding to the Autarkic approach (equation (9)), where the maintained hypothesis is that investment behavior, in the long run, is independent of the amount of foreign exchange available. With the exception of X_{t5}, the values for the long run marginal propensity to invest range from 0.11 to 0.15. This relatively low estimated marginal propensity to invest suggests in turn a low domestic marginal propensity to save out of disposable income, which indicates that domestic savings have played a minor role in financing gross capital accumulation in LDCs (see Taylor 1983, Lewis 1984). The values for the long run income elasticity (valued at the mean) range from 0.47 to 0.88. The estimated relative price elasticity (valued at the means) ranges from -0.1 to -0.22. This price inelasticity could be due to (1) the absence of a significant amount of skilled labor, which if available, could have been used as a substitute factor for capital, and (2) excess capacity in the capital stock (Behrman 1971). The inelastic response of investment demand to changes in either real income or prices is robust to the definitions of foreign exchange resources used here.

In the second formulation for investment demand, equation (13), the maintained hypothesis is that foreign exchange resources have a positive effect on investment in both the short and the long run. The parameter estimates for this formulation are presented in Table 2. However, we use the level of foreign exchange resources, instead of its changes since in estimating equation (13) we obtained implausible results such as positive price elasticities. In any event, it is quite reasonable to expect a positive association between the level of investment and the availability of foreign exchange reserves, as implied by the two-gap literature. The results indicate a long run marginal propensity to invest ranging in value from 0.04 to 0.16 while the estimated long run income elasticity ranges from .21 to .69. The estimated long run (relative) price elasticity ranges from -0.027 to -0.023, very close to that of equation (9); the estimated long run foreign exchange elasticity ranges from 1.2 to 4.6, which is indicative of the potential negative impact of oil price increases on capital accumulation and income growth of non-oil

LDCs. As a corollary, it also indicates that higher prices for exports of LDCs, as well as greater access to international capital markets have a significant positive impact on LDCs capital accumulation and output growth.

The available empirical estimates from equations (9) and (13) suggest that the capital accumulation process in non-oil LDCs has (1) a weak response to sustained changes in income; (2) a negative (and inelastic) response to sustained increases in the relative rental price of capital; and (3) a rather strong response to sustained changes in foreign exchange resources.

V.b Empirical Results for Capital Goods Imports

Table 3 contains the results for the share of imports of capital goods imports in total net investment.[10] Because data on P^d_{kt} are very difficult to obtain,[11] we have assumed that $dq_t/dt \simeq dP^f_{kt}/dt$, where $q_t \equiv P^f_{kt}/P^d_{kt}$. In contrast to the results for investment, the parameter estimates for imports of capital goods are sensitive to the definition of foreign exchange resources; in particular using X_1, X_2, and X_3 we get implausible results such as positive price elasticities. For this reason we only present results for definitions X_4 and X_5. We find that the estimated long run price elasticity for equation (21) is -0.6, implying an inelastic response of the share of capital goods imports in net investment to sustained price changes.

The results for equation (22) are presented in Table 4.[12] But again, the parameter estimates are sensitive to the definition of foreign exchange resources, and therefore we only present the results for X_3, X_4, and X_5. We find that a sustained 1% increase in net investment increases imports of capital goods by a magnitude varying from .28% to .57% depending on the import category used (SITC 5-9 or SITC 7) and on the measure of foreign exchange reserves. This inelastic response of capital goods imports to net investment indicates that the assumption of unitary elasticity is not appropriate for the non-OPEC LDCs considered as an aggregate.[13]

Given a level of investment, a one percent increase in foreign exchange reserves has a positive and direct, but relatively small effect on imports of capital goods with a magnitude that ranges from .21% to .38%[14]. However, changes in the available amount of foreign resources affect the demand for investment which in turn affects imports. Thus, an increase in foreign exchange has a positive, and indirect, effect on imports operating through increases in investment. Taking into account direct and indirect effects, we derive the "total" elasticity of imports of capital goods with respect to an increase in foreign exchange reserves as:

$$\eta_i \equiv (X_{ti}/M^{\ell}_{mt})(dM^{\ell}_{mt}/dX_{ti}) = ((I_{nt}/M^{\ell}_{mt})(\partial M^{\ell}_{mt}/\partial I_{nt}))((X_{ti}/I_{nt})(\partial I_{nt}/\partial X_{ti})) +$$

$$+((X_{ti}/M^{\ell}_{mt})(\partial M^{\ell}_{mt}/\partial X_{ti})) \text{ for } i=1,2,3,4,5.$$

Using X_3 as the measure of foreign exchange reserves, we find (using the information from tables 2 and 4)[15] that η_3 equals 1.004 for SITC 5-9, and 1.3366 for SITC 7. These results clearly indicate that changes in the availability of foreign exchange resources have a significant impact on capital good imports as soon as we recognize the influence that these resources have on investment.

In summary, our empirical results point to an inelastic response of capital goods imports to changes in the rental price of foreign capital, probably due to substantial excess in productive capacity (Behrman 1971).

We also notice that capital goods imports have an inelastic response to sustained changes in net investment although this response is by no means insignificant. This inelasticity implies that the share of imports of capital goods in total net investment will decline as net investment increases. This might be an encouraging result since the alternative possibilities imply either a long run fixed relation between the domestic and the foreign capital stock (for an elasticity of one) or an ever increasing share of capital goods imports in total net investment (for an elasticity greater than one.) Finally, a sustained increase in the available amount of foreign exchange resources has two effects on imports: (1) a small direct effect, and (2) a large indirect effect operating through the effect of variations in the foreign exchange on investment.

VI. Summary and Conclusions

The main purpose of this paper has been to characterize some of the most important determinants of long run growth in the non-oil LDCs: capital accumulation and foreign exchange constraints. There are other important factors such as labor and education, but the analysis of their influence has been postponed.

We develop an explanation of investment and import demand behavior that allows for imperfect substitutability of domestic capital goods for foreign capital goods and for a non-constant speed of adjustment of capital formation. In particular, we model the speed of adjustment as a function of the availability of foreign exchange resources. Our approach is implemented empirically; the results indicate that aggregate capital accumulation can be characterized as having a direct, but weak response to long run growth in income, an inverse and inelastic response to changes in relative prices, and a rather strong response to the availability of foreign exchange resources. We find that imports of capital goods have a positive and inelastic relation to investment, an inverse and inelastic relation to the rental price of foreign capital stock, and an elastic association with respect to changes in the available amount of foreign exchange reserves. In summary, we find that foreign exchange constraints adversely affect growth possibilities for LDCs because of the resulting reduction in the speed of adjustment of capital formation consistent with targeted growth rates.

Footnotes

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[1] See Salas (1982), and Klein(1983).

[2] This argument implies that domestic capital goods are imperfect substitutes for capital goods imports, which seems an accurate description for LDCs (see McKinnon 1964 and Taylor 1981).

[3] As a result of this multistage decision process, it is possible to have different elasticities of substitution for different pairs of factors, which is a relevant consideration in modeling the agricultural sector (Kaneda 1982) and the price determination process (van Wijnbergen 1982, Taylor 1979).

[4] In addition, we use energy as this essential raw material because it introduces one more channel of influence to study the effects of oil price changes on growth performance of LDCS and their financing requirements (see Marquez 1983).

[5] Notice that we are assuming zero growth in expected capital gains.

[6] If $e^{-x(t)} = \sum_{i=0}^{\infty} (-x(t))^i / i! \simeq 1 - x(t)$ is substituted in equation (6), then we obtain equation (7).

[7] The steady state we have assumed is characterized by having zero growth rates.

[8] The approximation of $(M^{\ell}_{mt}/I_{nt})^*$ as $A(P^f_{kt}/P^d_{kt})$ can be derived by expanding equation (16) around σ=1; Kmenta (1971) provides an example for the CES production function. The parameter α is negative provided σ <1, which seems reasonable for LDCs (see Taylor 1981). In addition, the serial independence of u_t follows from the statistical properties of v_t.

[9] Regression results using both relative prices and foreign exchange resources in real terms yield non-significant parameter estimates for relative prices. This empirical evidence suggests that the influence of higher prices can be captured by using available foreign exchange deflated by the price of imports.

[10] We use SITC 7 as a proxy for imports since otherwise it would be possible to have a share of imports greater than one.

[11] This is because a good deal of the domestic capital stock takes the form of infrastructure built by the government. The difficulty in gathering the data arises because the government may use a social criterion, and not market prices, in evaluating the desirability of a particular project.

[12] We now use SITC 7 and SITC 5-9 as proxies for imports.

[13] Similar results have been obtained by Salas (1982) for Mexico; van Wijnbergen (1982) obtains a unitary investment elasticity for South Korea, although no tests are shown for possible misspecifications.

[14] Similar results have been obtained by Salas (1982).

[15] For SITC 5-9, η_3= 0.277x2.38+0.3448=1.004; for SITC 7, η_3=0.47562x0.238+0.20464=1.3366. Notice that we are assuming that the elasticity of gross investment with respect to foreign exchange is a good approximation to the same elasticity but for net investment.

Table 1

Parameter Estimates for the Long Run Investment Demand Function Under the Autarkic Approach*

	X_1	X_2	X_3	X_4	X_5
α_o	47.4995	51.7502	61.2419	48.6433	128.1963
$\alpha_y\delta$	0.1092	0.1398	0.1238	0.1547	0.2040
$\alpha_p\delta$	-10.4681	-17.4167	-15.0396	-14.4759	-22.5135
B_o	0.0020	0.0017	0.0030	0.0031	0.0014
$\frac{Y}{I}(\frac{\partial I}{\partial Y})$	0.4755	0.6088	0.5391	0.6737	0.8883
$\frac{P}{I}(\frac{\partial I}{\partial P})$	-0.1018	-0.1694	-0.1463	-0.1408	-0.2190
$\bar{R}^2$	0.9126	0.8982	0.8994	0.9159	0.9207
D.W.	2.318	2.117	2.078	2.233	2.22
SSE	7.0658	8.2308	8.133	6.799	6.408

* Parameter estimates correspond to equation (10), derived from parameter estimates from equation (9). $\bar{R}^2$, D.W. and SSE come from equation (9).

$P^y(L) = 0.85L^o + 0.10L^1 + 0.05L^2$. $P^p(L) = 0.2L^o + 0.5L^1 + 0.3L^2$.

$A(L) = L^o - 0.967L^1$. $P = P_k/P_e$. Reserve expectations are estimated using a 3 order autoregressive scheme:

$Z(L) = (1.055L^1 - 0.89L^2 + 0.83L^3)$

The mean values of the x's are: X_1=30.7, X_2=36, X_3=18, X_4=14, and X_5=16.

Table 2

Parameter Estimates for the Long Run Investment Demand Function Under the (Modified) Trade Approach*

	X_1	X_2	X_3
$\frac{b_o\ \alpha_y\ \delta}{\Phi}$	0.0483	0.0624	0.1597
$\frac{b_o\ \alpha_p\ \delta}{\Phi}$	-2.8081	-8.8842	-24.2046
$\frac{b_1}{\Phi}$	2.25667	10.3667	9.3455
$\frac{Y}{I}(\frac{\partial I}{\partial Y})$	0.2103	0.2717	0.6954
$\frac{P}{I}(\frac{\partial I}{\partial P})$	-0.0273	-0.0864	-0.2354
$\frac{X}{I}(\frac{\partial I}{\partial X})$	1.2333	4.0433	2.38
$\bar{R}^2$	0.9927	0.9918	0.9897
D.W.	2.635	2.397	2.100
SSE	7.07	7.904	9.95

* Parameter estimates come from equation (14), derived from equation (13). $\bar{R}^2$, D.W. and SSE come from equation (13).

P, $P^y(L)$, $P^p(L)$, and A(L) are defined in Table 1.

Table 3

Estimated Elasticities for Share of

Imports of Capital Goods in Investment

	X_5	X_4
B_o'	0.022967	0.023188
$\frac{P}{MI}\left(\frac{\partial MI}{\partial P}\right)$	-0.6040	-0.6201
A	6.0328	6.7615
$\bar{R}^2$	0.5902	0.5764
D.W.	2.419	2.421
SSE	0.004367	0.004514

where $MI = M_m^{\ell} / I_n$; parameter estimates for equation (21).

$P = P_{kt}^{f} / P_{kt}^{d}$.

Table 4

Long Run Elasticities for Imports of Capital Goods
(Numbers in parentheses are t-statistics)

	X_5	X_3	X_4
SITC #5-9			
$\left(\frac{X_i}{M_m^\ell}\frac{\partial M_m^\ell}{\partial X_i}\right)$	0.3754 (5.28)	0.3448 (4.432)	0.2261 (4.59)
$\left(\frac{I_n}{M_m^\ell}\frac{\partial M_m^\ell}{\partial I_n}\right)$	0.29057 (7.522)	0.277 (1.802)	0.5674 (5.317)
$\bar{R}^2$	0.9878	0.966	0.9879
D.W.	2.279	1.575	2.364
SSE	0.0010	0.0023	0.0011
SITC #7			
$\left(\frac{X_i}{M_m^\ell}\frac{\partial M_m^\ell}{\partial X_i}\right)$	0.2424 (3.118)	0.2046 (1.633)	0.3828 (3.412)
$\left(\frac{I_n}{M_m^\ell}\frac{\partial M_m^\ell}{\partial I_n}\right)$	0.4529 (10.767)	0.4756 (7.501)	0.4041 (7.749)
$\bar{R}^2$	0.9897	0.9843	0.99
D.W.	1.849	1.408	1.96
SSE	0.0013	0.0020	0.0012

* Parameter estimates for equation (22).

$D(L) = 0.1L^o + 0.7L^1 + 0.2L^2$. $E(L) = L^o$.

$Z(L) = 1.06L^1 - 0.89L^2 + 0.83L^3$.

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Appendix A

Data problems are frequently encountered in empirical anlayses of LDC's, especially at the level of aggregation used here. We first deal with the consequences for parameter estimation of using constant exchange rates to convert individual country's GDP, expressed in domestic currencies into an aggregate income measure, expressed in US$. We then present the data sources.

The nature of the problem of exchange rate conversion is two fold: (1) exchange rate fluctuations result in income fluctations unrelated to input changes; (2) even if exchange rates do not fluctuate, their use may not be meaningful when a sizeable fraction of the domestic output is not internationally traded. In our data set we use constant exchange rates to avoid the first problem. In order to solve the second problem, we could have used Purchasing Power Parities to obtain an aggregate measure of income taking into account the internal structure of prices (of traded and non-traded goods) for each of the countries. This measure of income can be obtained from Summers, Kravis, and Heston (1980). Consumption, investment, and government expenditures can be similarly obtained. However, Summers, Kravis, and Heston do not have data on international trade variables such as imports of manufactures. For this reason, and in order to have a consistent accounting system, we have used constant exchange rates to convert variables from domestic currencies into US$.

Notice that using constant exchange rate conversions, instead of

Purchasing Power Parity, need not bias our parameter estimates for marginal propensities and elasticities if there is a fixed relation between the variables measured under both methods. To determine whether such a fixed relation exists, we divide our measure of real output for non-oil LDC's, Y, by the measure of real output for non-oil LDC's obtained by Summers, Kravis, and Heston, Y*, for the period 1960-1977. The ratio of Y to Y* has a mean of 0.2232 with a standard deviation of 0.0032, which clearly indicates a fixed relation between Y and Y*. We also compare the share of investment in real income for the cases of constant exchange rate conversion and Purchasing Power Parity conversion. In both instances, this share equals 20%, which implies that the ratio of investment measured by constant exchange rate to investment measured by Purchasing Power Parity, is the same as Y/Y*. Again, this implies a fixed relation between investment obtained using constant exchange rates and investment obtained using Purchasing Power Parities. In conclusion, our estimated elasticities and marginal propensities are not affected by the use of constant exchange rates to convert individual countries' GDP expressed in their domestic currency, into an aggregate measure of real income in US$. We want to emphasize that this happens to be an empirical property of our data set, and we do not mean to generalize these results to other data sets.

Data Sources

Real income is measured in billions of US$ in 1970 prices and 1970 exchange rates. The source is Bijou Yeh (1980), "A Global Economic Model of a Three Region World," Ph.D. Dissertation, University of Pennsylvania. (Main sources: World Bank, U.N., and I.M.F.)

The capital stock is measured in billions of US$ in 1970 prices and 1970 exchange rates. We use a capital output ratio of 3.38, which is very close to the median capital output ratio for developing economies (Chenery and Strout, 1966), and a depreciation rate of 3%.

Import data are measured in billions of US$ of 1970 prices and are obtained from U.N. Trade Statistics, various issues.

Data on international reserves are in billions of US$ and are obtained from I.M.F., Yearbook, 1980.

Data for prices are measured in indexes with 1970 as the base year. They are obtained as follows:

P_o: The price of oil is a chained price index of three oil prices, Ras Tanura (Saudi Arabia), Es Sidra (Libya), and Tia Juana (Venezuela): I.M.F. Yearbook, 1980.

P_m^{ℓ} : Export price index of manufactures of non-oil LDC's: U.N. Trade Statistics.

P_r : Import price index of raw materials is a weighted average of the import price of SITC#0-1 and #2 plus #4. The weights are the trade value shares: U.N. Trade Statistics.

P_m^d : Export price index of manufactures of developed economies: U.N. Trade Statistics. We also use this index as a proxy for P_{qt}, which is then used to construct P_{kt}^f/P_{kt}^d using the definition of rental price of capital (see equation 1).