Energy Prices, Substitution, and Optimal Borrowing in the Short Run

An Analysis of Adjustment in Oil-Importing Developing Countries

SWP466

World Bank Staff Working Paper No. 466

July 1981

Prepared by: Ricardo Martin and Marcelo Selowsky
Development Economics Department

The views and interpretations in this document are those of the authors and should not be attributed to the World Bank, to its affiliated organizations, or to any individual acting in their behalf.

WORLD BANK

Staff Working Paper No. 466

July 1981

ENERGY PRICES, SUBSTITUTION, AND OPTIMAL BORROWING IN THE SHORT RUN AN ANALYSIS OF ADJUSTMENT IN OIL-IMPORTING DEVELOPING COUNTRIES

The response of oil importing developing countries to the 1973-74 and 1979-80 oil price shocks was to strongly increase their external borrowing, particularly from private sources. Such borrowing increased from 1.7 percent of their GDP in 1970-73 to 5.1 percent in 1975. It then increased again from 2.3 percent in 1976-78 to 3.9 percent in 1980. This heavy extra borrowing from private sources has become a source of concern because it will imply a historical peak of debt service ratios for middle income countries of 29 percent by 1985 (World Development Report, 1980). The Bank and IMF have reacted by opening new lending facilities to respond to these oil induced demands for borrowing, structural adjustment lending in the case of the Bank.

This paper builds a normative framework to evaluate three questions:

- To what extent the increases in indebtedness of developing countries was "excessive" or simply the result of a perfectly rational strategy?

- What borrowing strategies can be expected in the future as the developing countries revise their expectations about the length of time between shocks? (i.e., was the 1973-74 shock perceived as a one time phenomenon?)

- What is the derived demand (or oil price induced borrowing) to be faced by multilateral institutions providing some amount of concessionary credit, i.e., the interest elasticity of that demand.

The framework used here consists of a short-term model (no factor mobility except for intermediate inputs) of two sectors (traded and nontraded goods). Prices are flexible, and the exchange rate is allowed to float. An optimal borrowing rule is derived by maximizing a welfare function over the planning period. That period, defined by the expected number of years of oil price stability after the shock, is short.

It is assumed that in the short run, immediately after the shock, the economy is rather inflexible, in the sense that substitution possibilities in production (between energy and other inputs) and consumption (between traded and nontraded) are low. As substitution possibilities increase, the required change in relative prices (with respect to the preshock situation) is less than in the first period. This becomes the rationale to borrow in the first period against subsequent periods, i.e., to bring foreign exchange toward the period where it is more scarce.

The figures on optimal borrowing are sensitive to the share of oil in imported inputs, the share of imported oil in GNP and the expected number of years without additional shocks (that is the planning period, T). Large countries like India and Brazil have a high share of energy among their imported inputs but a small share of trade in GNP. The Philippines and Korea have the reverse case. For Jamaica both shares are high. If T = 3, the model predicts the following extra borrowing as a percent of GDP (during the first year after the shock) for each of the two shocks that took place in the 1970s: 0.8 percent for Brazil and India, 1.7 percent for the Philippines, 2.0 percent for Korea and 3.4 percent for Jamaica. If T had been expected to be five years the borrowing would increase by a third, some of it taking place the second year after the shock.

These figures are lower bounds for two reasons. First, the mobility of factors as a function of time adds a source of flexibility and becomes, in addition to differential substitution, another reason for borrowing; this is explored in Section V. Second, countries may indeed have expected the shock to have been a one-time phenomenon and may therefore have acted as if T were very large.

The estimated magnitudes of optimal borrowing are quite insensitive to the cost of borrowing, i.e., the demand is very interest inelastic. If interest rates were to be zero instead of 10 percent, the estimated optimal borrowing would only be 6 percent larger. That means that the demand to be faced by multilateral institutions--if providing credit at terms below private sources--will depend more on the displaced private credit than on any net additional borrowing to be generated by these lower terms.

Prepared by: Ricardo Martin and Marcelo Selowsky
Development Economics Department
Development Policy Staff

TABLE OF CONTENTS

List of Tables

I. Introduction

1. The increase in the world price of energy during the 1970s consisted basically of two large shocks: the increase experienced between 1973 and 1974 when energy prices almost tripled, and that between 1978 and 1980 when prices almost doubled (Table 1). Oil importing developing countries adjusted to these shocks by quickly increasing their external borrowing, particularly from private sources. The additional borrowing between 1970-73 and 1975 amounted to 3.4 percent of GNP. Between 1978 and 1980 it amounted to 1.6 percent of GNP. This sharp increase in short-term borrowing has become a source of concern because it implies substantially higher debt service ratios in the near future; for middle-income countries this ratio will peak at around 29 percent of exports by 1985.1/

Table 1: BORROWING OF OIL-IMPORTING DEVELOPING COUNTRIES AND OIL PRICES

	1970-73	1975	1978	1980
		Percentage of GDP		
Low income	1.9	3.8	2.7	3.6
Middle income	1.7	5.3	2.2	4.0
Total	1.7	5.1	2.3	3.9
OPEC petroleum prices 1977 dollars (per barrel):	4.7	12.0	11.1	19.3

Source: World Development Report 1980 and Price Prospects for Major Primary Commodities (World Bank, January 1980).

The first question is whether these high levels of borrowing--to adjust to the oil shocks--should indeed represent a source of concern. To answer this, we require a normative framework to evaluate the extent to which such policy responses deviated from an optimal policy, i.e., from an optimal borrowing strategy.

Most of the additional borrowing in these periods came from private sources at commercial terms. International lending institutions like the IMF and the World Bank have opened new lines of program loans (structural adjustment loans in the case of the Bank) to finance future demands that might arise from further increases in the price of energy. If, as was the case in the past, the increases consist of unexpected short-run price shocks (more than evenly distributed trend) one might expect important differences in the cost of borrowing from commercial sources and from the Bank and the Fund. This becomes particularly true if we think of the supply of credit from commercial sources to be upward sloping in the short-run. Hence, the question becomes what is the probable demand for additional borrowing--induced by these shocks--to be faced by these institutions to the extent they provide cheaper sources of credit? In other words, what is the price or cost elasticity of the demand for borrowing induced by short-term increases in the price of oil?

To address these questions, we need a framework in which the demand for borrowing results from welfare or utility maximizing behavior. The objective of this paper is to set forth such a framework, then derive the demand for borrowing induced by the increase in the price of energy and to explore the sensitivity of the results to parameter values characterizing different types of oil-importing developing countries.

2. Higher prices of imported energy affect real income and the exchange rate or the relative price of traded and nontraded goods (exportables and importables). The magnitude of the effects depends on the possibilities for substituting energy and imported inputs by domestic factors (substitution in

production) and for replacing in consumption traded by nontraded goods (substitution in consumption). They also depend on the factor mobility between both sectors: the higher the degree of factor mobility the smaller the effects on income and relative prices.

Presumably, both the possibilities of substitution in production and consumption and the degree of factor mobility, depend on time. It takes time for production processes to be restructured, consumption habits to be changed and factors to move. Consequently, one might expect the induced decline in real income and increase in the exchange rate to be larger in the first period following the shock than in successive periods. These differential effects provide a rationale for borrowing abroad in the short-run: such borrowing transfers income to the period where real income has experienced the strongest decline and increases the supply of foreign exchange in the period where it is most scarce.

3. In this paper the difference between the first year after a shock and subsequent years rests on the different possibilities of substitution in production and consumption. We assume, first, that the period of analysis (the horizon within which the borrowing decision is optimized) is short enough to exclude sectoral mobility of domestic primary factors. In Parts II to IV only imported inputs are mobile across sectors during this planning period; Part V considers the effect of gradual labor mobility.

Two techniques will be used in modeling the structure of the economy. The first is a log-linear model, which allows for an easier interpretation of the main economic forces behind the results. The second is an exact model (presented in the appendix), which revaluates all parameters separately in each period; its advantage rests in capturing changes that appear as second order effects in the log linear approximation. The most important difference between the two models is in the change in real income following the energy shock. In the log-linear model the decline in real income is independent of the substitution possibilities in production: in all periods after a shock the decline is the same as that in the initial period; and equal to the increase in the price of energy multiplied by the initial share of energy in GNP. The exact model captures the fact that in the first period that share is higher than in subsequent periods (because of fewer substitution possibilities). That higher share means that income declines more in the first period. Thus the exact model captures the borrowing induced by differences in real income; the log-linear model does not.

II. A Short Run Adjustment Model

The basic features of the economy we are considering are these:

(i) The economy has two productive sectors: nontraded goods and exported goods. It imports intermediate inputs and final goods. The internal prices of traded goods--exports, intermediate inputs and imported final goods--are always equal to the exchange rate multiplied by world (dollar) prices. The exchange rate always equilibrates the balance of payments.

(ii) Imported intermediate inputs are used in both productive sectors and are the only mobile and variable factors in the short run. Domestic primary factors, capital and labor, are presumed immobile in the short run.

(iii) Prices and wages are flexible so that full employment is maintained. Alternatively it might be assumed that (under some price inflexibility) there is always a compensatory macroeconomic policy able to restore relative prices consistent with full employment.[2/]

(iv) Although some initial borrowing can take place, it is assumed that there are no endogenous international flows of capital.

The subindexes N,X,E and F will indicate nontraded goods, exports, imported inputs and imported final goods. Quantities produced and demanded will be Q_i and D_i. E_i will denote the quantity of the imported input in the i industry (i = N,X). P_i denotes domestic prices, and R denotes the exchange rate in domestic currency. Π is the world (dollar) price of imported inputs and $P = \Pi R$ is its domestic price. The world price of the other traded goods (exports and imported final goods) remain constant throughout the analysis; we define quantities so that initial prices are equal to one.[3/]

The model is log-linear. The log differential of the above variables will be denoted by lower case notations: q_i, d_i, e_i, p_i, r and π .

Let a_i (i = X,N) be the initial share of imported inputs in the gross value of production of exports and nontraded goods. From the production function we can derive:

$$(1) \quad q_i = a_i e_i$$

$$(2) \quad q_i = \frac{a_i \sigma_i}{1-a_i} (p_i - p) = \varepsilon_i (p_i - p),$$

where σ_i is the elasticity of substitution between imported inputs and domestic factors and ε_i is the resulting supply elasticity. The price of imported inputs is equal to $p = \pi + r$ so that the supply of good i can be written as:

$$(3) \quad q_i = \varepsilon_i (p_i - \pi - r)$$

Aggregate income in terms of nontraded commodities (they become the numeraire, i.e., $P_N = 1$ and $p_N = 0$) is equal to the value added in both sectors plus transfers from abroad, T, that is, $Y = Q_N + RQ_X - RE\Pi + RT$. By total differentiation of Y and by recalling that the economy is always at his transformation frontier, we can write:4/

$$(4) \quad y = c_F r - a\pi + B,$$

where c_F and a are the values of imports of final commodities and of imported inputs as fractions of income. B is the additional borrowing abroad, also as a fraction of aggregate income, i.e., $B = (dT/Y)$.

The demand for nontraded goods depends on the relative price of traded and nontraded goods and on total expenditure. If aggregate expenditure equals aggregate income, we can write:

$$(5) \quad d_N = (\eta^* - c_F \eta_N) r + \eta_N y,$$

where $(\eta^* - c_F \eta_N)$ is the uncompensated price elasticity of nontraded goods with respect to the relative price of traded goods. η^* is the compensated (pure substitution) own-price elasticity (defined positive), and η_N the income elasticity of nontraded commodities, respectively. Substituting (4) in (5) gives:

$$(6) \quad d_N = \eta^* r + \eta_N (B - a\pi).$$

Equilibrium requires that d_N be equal to q_N.[5/] That determines all variables as functions of the change in the world price of imported inputs and additional borrowing:

$$(7) \qquad r = \frac{(a\eta_N - \varepsilon_N)\pi - \eta_N B}{\varepsilon_N + \eta^*} ,$$

$$(8) \qquad q_N = -\varepsilon_N(\pi + r) ,$$

$$(9) \qquad q_x = -\varepsilon_x \pi \qquad\qquad \text{(since } p_x = r\text{)}$$

$$(10) \qquad e = \frac{q_N}{a_N}\frac{E_N}{E} + \frac{q_x}{a_x}\frac{E_x}{E} , \quad \text{and}$$

$$(11) \qquad d_F = -\left(\frac{1-c_F}{c_F}\right)\eta^* r + \eta_F(B - a\pi) ,$$

where η_F is the income elasticity of imported final goods.[6/] In the absence of additional borrowing ($B = 0$) the sign of r depends only on $a\eta_N \gtrless \varepsilon_N$, the relative effect of π through the demand and supply of nontraded goods. An increase in the world price of imported inputs tends to reduce demand by its income effect and reduce supply by its effect on costs. The higher the share of imported inputs in GNP and the smaller the substitution possibilities in production (smaller σ_N and therefore smaller ε_N), the more likely a devaluation will take place ($r > o$). [7/] The degree of substitutability in consumption between domestic and imported final goods, η^*, determines only the magnitude of the change in r, not its sign.

If the higher world prices of imported goods increases the exchange rate ($r > o$), the effects can unambiguously be followed in equations (8) and (11). Production of nontraded goods and exports goes down as do imports of inputs and imported final commodities.

Substitution in production and consumption affects r as follows: the smaller σ_n, the higher the probability of a devaluation. If there is a devaluation, its magnitude will depend on σ_N and η^*. Smaller substitution elasticities may imply a larger devaluation. Notice that σ_X--the elasticity of substitution in the export sector--does not enter expression (7). The reason is that the relative price of imported inputs in this sector (in relation to the price of the output) increases by T; it increases by $\pi + r$ in the nontraded sector. The log-linear approximation σ_X is of second order; the effect of π on the supply of exports is captured by a_X, the share of imported inputs in that sector.

Figure 1 presents the effects of the increase in Π in the market for nontraded goods. The demand function is defined for a given level of <u>real income</u> (that is, it is the compensated demand), so that it falls when the price of the imported inputs increases. The proportional change in real income is:

$$(12) \quad y^* = y - c_F r = B - a\pi ,$$

so that the horizontal shift in the demand function is $a\eta_N\pi$. Note that the change in real income does not depend directly on substitution conditions in production or consumption. But as sustitutability increases, a is reduced so that for noninfinitesimal changes in Π the reduction in real income is smaller.

The supply function depends only on P_N/P, because the imported input is the only variable factor. Therefore, as Π increases the supply shifts vertically by the same proportion. Increased substitution results in a more elastic supply function and thus on a higher P_N/R in equilibrium (that is, a

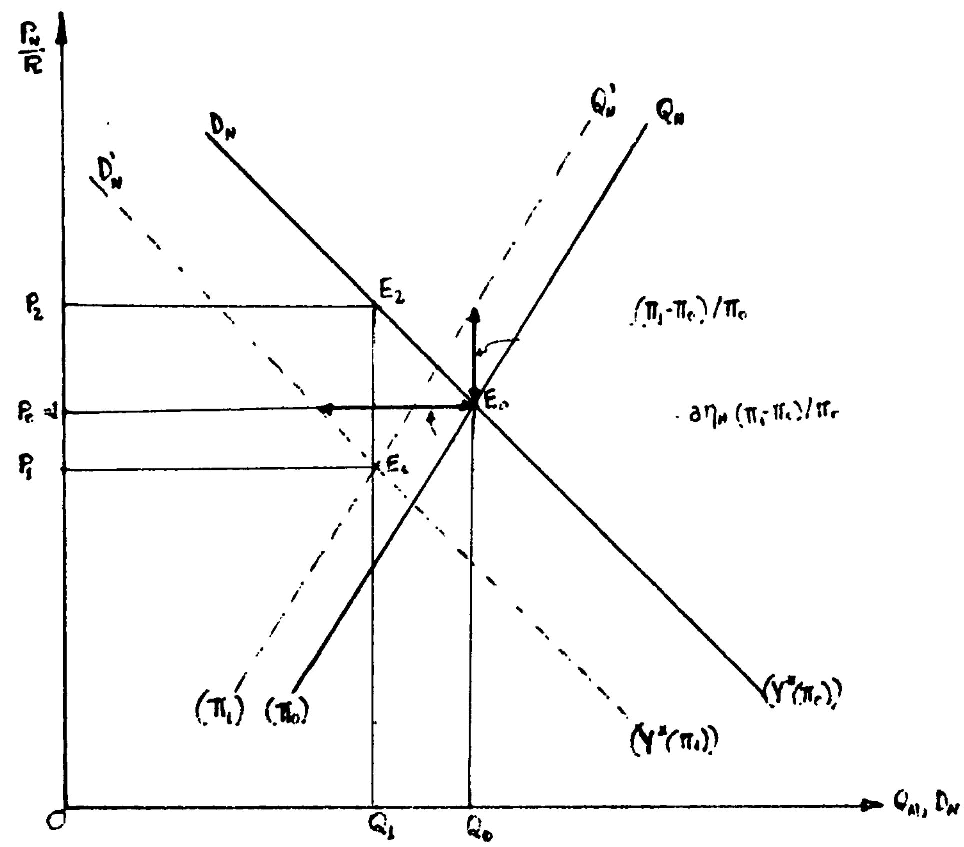

Figure 1: EFFECT OF AN INCREASE IN Π

smaller devaluation). More substitution in demand--that is, a flatter demand schedule--has the same effect.

III. Optimal Borrowing

An exogenous increase in the international price of the imported inputs affects real income and the relative price of nontraded and traded goods, as was shown in the previous section.

The magnitude of the effects depends on the cost of substituting imported inputs for domestic factors and the difficulty of replacing in consumption traded by nontraded goods. Both the costs and the difficulty of substitution presumably became smaller as time is allowed for adjustment: with time, habits change, production processes are restructured, and the product mix (within each of our aggregated "goods") is altered, resulting in better adaptation to the higher price of international goods. That suggests that we can expect that in the period immediately following the shock the reduction in real income and the increase in the exchange rate will be higher than in successive periods. This provides a reason for borrowing for 'structural adjustment' to the shock, as a way of both transferring income to the period when it is relatively lower and increasing the supply of foreign exchange when it is more scarce. If we assume as welfare criterion the discounted sum of utility in all periods, the extent to which we should reduce the spreads in real income and in exchange rate depends on how rapidly the marginal utility of income increases as real income falls (in other words, on the degree of risk aversion of society).

In effect, with constant marginal utility there is no argument for borrowing to equalize income across time--or against increasing income differences--if that advances other objectives. Under these conditions, for as long as one expects exchange rate differences across time, there is a gain in eliminating them by borrowing. The gain to be obtained is of the same type as that from trade between regions with different relative prices.[8/] On the other hand, with strong risk aversion the equalization of real income becomes the overriding consideration in determining the level of borrowing.

Without a social discount of the future and with a zero interest rate on borrowing, it is clear that the condition for optimal borrowing is having the marginal utility of traded goods be equal for all periods:

$$R_t \lambda_t = \text{constant for all } t,$$

where λ_t is the marginal utility of income (measured as before in terms of nontraded goods). If income in the present and the future is not equally valuable from the social point of view, we would like to equalize the discounted marginal utilities. On the other hand, a positive rate of interest on borrowing makes additions to present income more costly in terms of future income. Thus, if $(\rho-1)$ is the cost of borrowing and if $(\delta-1)$ is the social rate of discount the optimal borrowing condition is:[9/]

$$(13) \qquad \left(\frac{\rho}{\delta}\right)^t R_t \lambda_t = \lambda_o \qquad \text{for all } t.$$

We assume that the country was on an optimum borrowing path before the shock. The path could have involved no borrowing, if $\rho=\delta$ and there was no expectation of change in the exchange rate or in real income (so that λ_t and R_t are constant). More likely, the path involved some positive borrowing, justified by expected increases in income and/or appreciations of the domestic currency. We will not choose between these alternatives, but will work with the <u>changes</u> on the preshock paths (whatever their shape) brought about by the price shock. In any case, to remain on an optimal borrowing path after the shock, and on the assumption that the cost of capital is not altered, any expected asymmetric change in the exchange rate has to be compensated by a corresponding variation in λ_t.

The marginal utility of income, λ_t, depends on income (in terms of nontraded goods) Y, and the relative price of traded goods, R. Let ϕ be (minus) the elasticity of λ with respect to income, i.e., the risk aversion coefficient. Then we have:[10/]

$$(14) \quad d \log \lambda = - \phi y^{*} - c_F \eta_F r \quad ,$$

where y^{*} is the proportional change in real income defined in equation 12.

Optimal borrowing after the increase in the international price of the input requires that (13) still be satisfied. That implies, by (14), the following condition:

$$(15) \quad \bar{\lambda}_o \equiv d \log \lambda_o = - \phi y^{*}_t + c_N \eta_N r_t \qquad \text{for all } t.$$

The model is closed by the repayment condition relating future payments to the amount borrowed and the rate of interest. As B_t is expressed as a fraction of GDP, the budget constraint is $\Sigma B_t Y_t \rho^{-t} = 0$. If we assume that real income grows at a rate (g-1) per period, we have:

$$(16) \quad \sum_{t=1}^{T} (B_t g^t) \rho^{-t} = 0.$$

Equations (15) and (16)--together with (7) and (12) generalized for t=1,..,T--determine borrowing, real income, and the exchange rate, given the evolution of the substitution parameters in production and consumption. The model is summarized in Table 2. Note that the resulting system is independent of ρ/δ, because all variables are measured as deviations from the reference path (which does depend on ρ/δ, as we assume that path to be the result of an optimum borrowing strategy). The value of ρ, however, enters the system through its effect on the budget constraint (equation 16).

The model discussed so far is based on log-linear approximations to the equilibrium conditions. It gives a good qualitative picture of the main forces, but has some limitations. In particular it ignores two second-order effects: substitution in the export sector; and the effect of the degree of substitution on the change in real income arising from the external shock. Because the second effect is ignored, the model predicts that as the risk aversion coefficient, ϕ, increases the amount borrowed should shrink to zero. That is not valid in an exact model, though the level of borrowing still becomes very small for large values of ϕ (see Appendix B).

Table 2: OPTIMAL BORROWING. LOG-LINEAR APPROXIMATION

	Equation	Number of Equations
(7)	$r^*_t = \dfrac{a\eta_N - \varepsilon_t}{\varepsilon_t + \eta^*_t}\pi - \dfrac{\eta_N B_t}{\varepsilon_t + \eta^*_t}$	T
(12)	$y^*_t = B_t - \alpha\pi$	T
(15)	$\lambda_o = -\phi y^*_t + c_N \eta_N r_t$	T
(16)	$\sum_{t=1}^{T} B_t (\rho/g)^{-t} = 0$	1

Endogenous variables: r_t = change in the exchange rate in period t; y_t^* = change in real income in period t; and B_t = net additional borrowing in period t; expressed as a fraction of GDP; λ = change in the shadow price of foreign exchange.

Exogenous variables: π = change in the international price of imported inputs; a = initial value of imported inputs as a fraction of GDP; η_N = income elasticity of demand for nontraded goods; c_N = share of nontraded goods in total expenditures; ρ = 1 + interest cost of borrowing; g = 1 + rate of growth of real income; ϕ = risk aversion coefficient ($\geq$ 0); η_t^* = compensated price elasticity of demand for nontraded goods ($\geq$ 0) in period t.; ε_t = elasticity of supply for nontraded goods in period t, where $\varepsilon_t = \sigma_N a_N/(1-a_N)$; and T = planning period (loan must be repaid at t = T+1).

The model can be easily solved for B_t, r_t, y_t^* and λ_o. If we denote by r_t^0 the change in the exchange rate (with respect to the preshock path) in the absence of any extra borrowing as:

$$(17) \quad r_t^0 = (a\eta_N - \varepsilon_t)\pi/(\varepsilon_t + \eta_t^*)$$

we can show that the optimal change in borrowing in period t is:

$$(18) \quad B_t = \frac{r_t^0 - \bar{r}^0}{\left(\frac{\phi}{C_N\eta_N} + \frac{\eta_N}{\varepsilon_t + \eta_t^*}\right)} \qquad (t = 1,..,T)$$

where $\bar{r}^0$ is a weighted average of the r_t^0 during the T years:

$$(19) \quad \bar{r}^0 = \sum_{t=1}^{T} w_t r_t^0, \quad ,$$

$$(20) \qquad w_t = w_o\ (\rho/g)^{-t} / \left(\frac{\phi}{c_N \eta_N} + \frac{\eta_N}{\varepsilon_t + \eta_t^*}\right) ,$$

where w_o is defined by $\sum_{t=1}^{T} w_t = 1$

The change in the exchange rate incorporating the optimal extra borrowing becomes:

$$(21) \qquad r_t = \frac{\frac{\phi}{c_N \eta_N} r_t^o + \frac{\eta_N \bar{r}}{\varepsilon_t + \eta_t^*}}{\left(\frac{\phi}{c_N \eta_N} + \frac{\eta_N}{\varepsilon_t + \eta_t^*}\right)}$$

Because substitutability is assumed to increase with time, r_t^0 is a decreasing function of time. Equation (18) shows that we will borrow in periods where, in the absence of borrowing, the exchange rate would have been higher than average--and will repay when the foreign currency is relatively cheap.

The actual devaluation, r_t, is by (21) a weighted average of the devaluation without borrowing, r_t^0, and the 'average' devaluation $\bar{r}^0$. As more importance is given to the equalization of real income (that is as the risk aversion coefficients ϕ increases) the closer r_t is to r_t^0 (and B_t to zero). Of course, for $\phi = 0$ the exchange rate is equalized in all periods, that is, $r_t = \bar{r}^0$.

The weights assigned to each period, w_t, decrease with t, the more strongly so the higher the interest rate. Note however that as long as r_t^0 decreases with time (and $\phi < \infty$) we have a positive initial borrowing for all values of ρ (though B_1 does go to zero as ρ increases).

The duration of the planning period T has so far been assumed to be exogenous. As T increases to T+1, the average $\bar{r}^0$ declines if r_{T+1} is lower than the average, implying higher initial borrowing. If we expect additional shocks, however, r^0_{T+1} could be very high, so that the optimal policy would call for a new cycle of borrowing and repayment starting there. That means T should be something like the expected length of the period between two successive external shocks, a period in which a short-term borrowing strategy is articulated.

If we take a two-period horizon, we can provide a graphical analysis of the forces determining the induced borrowing. This is shown in Figure 2.

Panels A and C show the time paths of the exchange rate and real income. Defining the preshock time trend of both variables as the base (=100), the values R_t and Y_t became indexes (or percentage deviations) of the postshock values with respect to the preshock trend. The solid line path shows that postshock values of R_t and Y^*_t under a no-borrowing policy. Due to higher elasticities of substitution in T_2 than in T_1, the increase in R_t and and the decline in Y^*_t are stronger in the first period.11/ This provides an incentive to transfer resources from the second period to the first: foreign exchange because it is more scarce, and income because it has declined more.

Panel B shows the effect of borrowing and repayment at an interest rate (ρ^*-1). If $\phi = 0$ (constant marginal utility of income) the reduction of spreads in income does not add to the welfare function. The welfare criterion is to equalize R_t (or the percentage deviations with respect to the trend) in both periods. The optimal borrowing is B^R_1, and the resulting time paths of R_t and Y^*_t are shown by dotted lines (for $\phi = 0$). In this case the path of Y^*_t has been reversed: real income in the first period becomes larger than in the second.

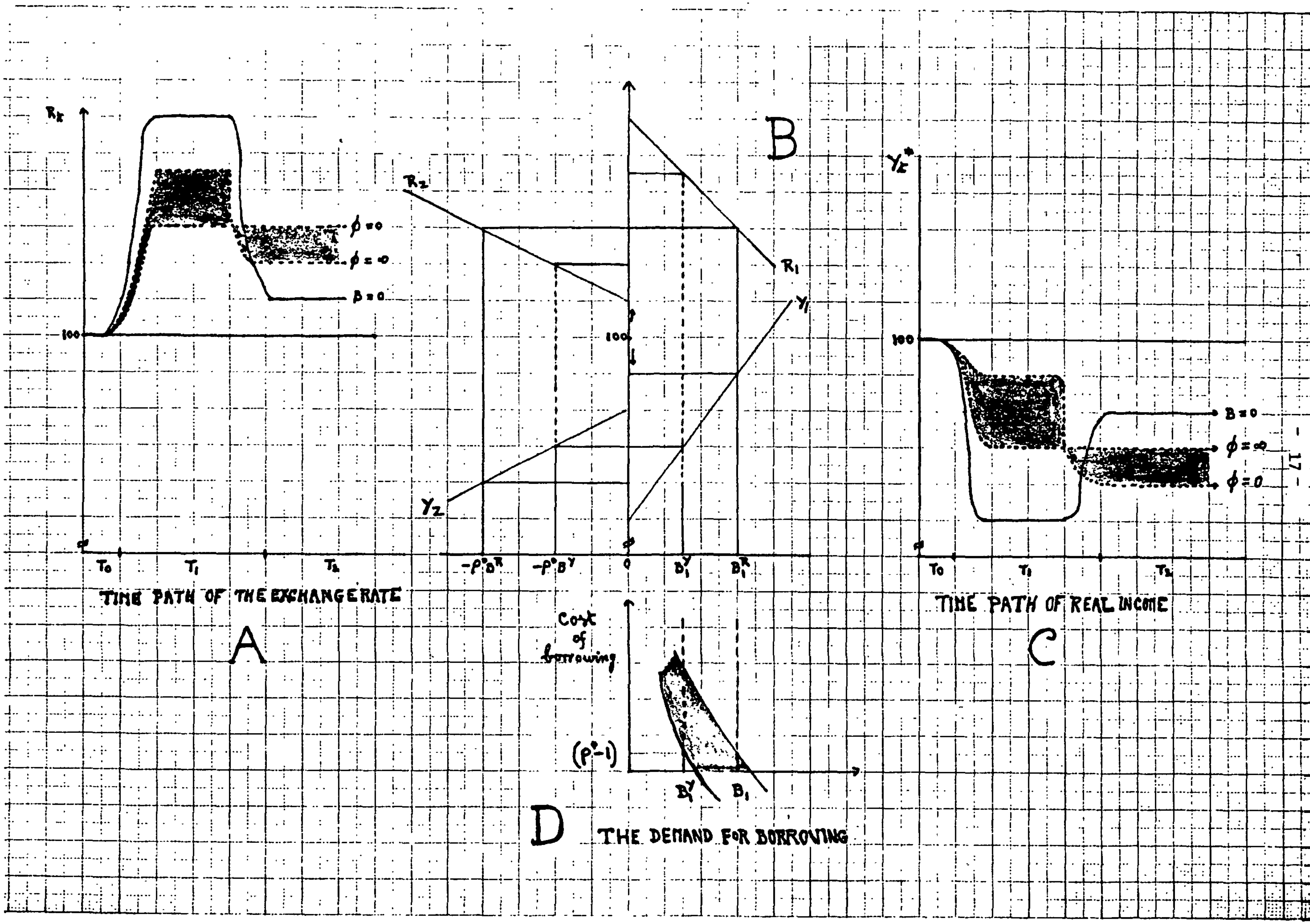

Figure 2: OPTIMAL BORROWING PATHS

Under the alternative extreme assumption that $\phi = \infty$, the overriding welfare criterion is to equalize real value in both periods, no matter what is the effect on the exchange rate. The optimal borrowing in T_1 becomes B_1^Y and the resulting time paths of R_t and Y_t^* are shown by dotted lines for $\phi = \infty$. Under this case R_1 still remains above R_2, though the difference has been smoothed because of borrowing during the first period.

Panel D shows the derived demand for borrowing under the extreme cases $\phi = 0$ and $\phi = \infty$. In the first case the derived demand results from equalizing the exchange rate; in the second case from equalizing real income.

In the more general case ($0 < \phi < \infty$)--that is, when the equalization of income adds to the welfare criterion but is not the overriding consideration of planners--the optimal borrowing at a cost (ρ^*-1) will be between B^R and B^Y. The equilibrium path of R_t and Y_t will lie in the shaded area, between the $\phi = 0$ and $\phi = \infty$ cases.

In the general case, borrowing stops short of B^R. The movement toward equalization of exchange rates is neutralized because it induces an "excessive" transfer of income to the present according to the second welfare criterion: too much income is being transferred when there is a declining marginal utility of income. But borrowing will be larger than B^Y when the elimination of income differences between the two periods does not have an infinite value. In that case the tendency toward some equalization of exchange rates also adds to welfare and justifies a level of borrowing larger than B^Y. For any positive value of ϕ the derived demand for borrowing will lie in the shaded region of panel D.

IV. Empirical Evaluation

In this section we calculate the borrowing implied by our model as a response to an exogenous increase in the world price of imported inputs. We first discuss a base case defined by values of the parameter representative of the average oil-importing developing country. We then explore sensitivity to changes in parameters.

(a) Base case

The Appendix to this section provides a 'snapshot' of the composition of aggregate demand and supply and the structure of imports for several oil-importing developing countries in the 1970s. That snapshot suggests the values for the shares shown in Table 3.

We need also the share of nontraded goods in total expenditures, c_N. If exports are not consumed domestically and there is no production of the imported final goods, the share of nontraded goods is simply one minus the share of imports of final goods in GNP (i.e., $c_N = 1 - c_X - c_B + a$). But these assumptions are very extreme. Moreover, they are not required by our model: for as long as the relative price of imported final goods and exports remains constant, both can be considered as the same good and we can interpret Q_X and D_F as total production and consumption of internationally traded goods (exportables and importables). If k_M is a coefficient giving the ratio of the value of consumption of tradables to import of final goods, we have:[12/]

$$(22) \quad c_N = 1 - k_M(c_X + c_B - a).$$

As k_M increases, so too do total production and consumption of traded goods, Q_X and D_F. The model does not differentiate between increases in production of exports or import substitutes, though the difference may be important to determine the correct input intensity. The ratio of production of tradables to exports is given by $k_M + (1 - k_M)(a - c_B)/c_X$.

Table 3: SUMMARY OF PARAMETER VALUES

Symbol	Parameter	Base value
c_X	Exports as a proportion of GDP	0.23
a	Import of inputs as a proportion of GDP	0.12
a_E	Energy imports as a proportion of total imported inputs	—
c_B	Initial deficit in the current account of balance of payments	0.04
k_M	Ratio of consumption of tradables to imports	1.0
k_X	Ratio of input use in tradables and nontraded goods	1.0
k_A	Ratio of domestic production of inputs to imports of inputs.	0
η_N	Income elasticity for nontraded goods	1.1
T	Planning horizon	3
ρ	Cost of borrowing	1.1
ϕ	Coefficient of risk aversion	0
g	Growth of income	1.
σ_S^N	Short Run } Elasticity of substitution in nontraded goods	0.2
σ_L^N	Long Run } Elasticity of substitution in nontraded goods	0.4
μ_N	Speed of adjustment of σ^N	0.5
$\sigma_S^D = c_n \cdot \eta_S^*$	Short Run } Substitution in consumption	0.05
$\sigma_L^D = c_N \cdot \eta_L^*$	Long Run } Substitution in consumption	0.1
μ_D	Speed of adjustment of σ^D	0.5

(Table 3, con't)

(Table 3, con/t)

Notes: The other parameters of the model are obtained from those defined above:

(1) Share of nontraded goods in GDP: $c_N = 1-k_M(c_X+c_B-a)$

(2) Production of tradables as fraction of GDP:

$$Q_X/Y = a+c_F-c_B,\ c_F = 1-c_N$$

(3) Supply elasticity in period t:

$$\varepsilon_t = \frac{a_N\sigma_t^N}{1-a_N} \text{ with } \sigma_t^N = \sigma_L^L - (\sigma_L^N - \sigma_S^N)(1 - \mu_{ND})^{t-1}$$

(4) Compensated elasticity of demand:

$$\eta_t^* = \sigma_t^D/c_N,\ \ \sigma_t^D = \sigma_L^D - (\sigma_L^D - \sigma_s^D)(1 - \mu_D)^{t-1}$$

(5) Domestic production of inputs as a fraction of GDP: $Q_E/Y = k_A a$

(6) Input use in nontraded goods: $a_X = (a+Q_E)/(c_N+k_Xc_X)$

In a similar way, we can easily accommodate some domestic production of inputs (Q_E) in our model: we need only make total factor use $c_Na_N + c_Xa_X$ bigger than input imports, a. The parameter k_A, defined as the ratio of domestic production to imports of inputs allows us to explore the sensitivity of the model to this factor.

Finally, k_X is defined as a_X/a_N--that is, as the relative input intensity of exports and nontraded goods--and we take equal intensity as our base case ($k_X = 1$). The income elasticity of nontraded goods, η_N, is fixed at 1.1 for the base case. We will discuss the other parameters below.

All the discussion in Parts II and III is based on the price of imported inputs. What we actually have in mind is the price of oil. We assume that the increase in the price of inputs, π, is just the increase in the price of energy, π_E , multiplied by the share of oil imports in intermediate imports, a_E. 13/ Table 4 classifies countries by typical values of a_E before and after the 1973 increase in the price of energy. The table also shows values of π resulting from a range of short-run oil price increases, the upper-bound values characterizing the 1973 and 1978-79 experiences.

Table 4: INCREASES IN THE PRICE OF IMPORTED INPUTS ASSOCIATED WITH A π_E PERCENT INCREASE IN THE PRICE OF ENERGY

Country	Imported energy as a fraction of imported inputs	Increase in the price of imported inputs, π (percent)			
	a_E	π_E=200	π_E=100	π_E=75	π_E=50
GROUP A Brazil, Panama Sri Lanka,	Circa 1973: a_E = 0.30	60			
	Circa 1977: a_E = 0.50		50	37.5	25
GROUP B Philippines, Jamaica, India	Circa 1973: a_E = 0.25	50			
	Circa 1977: a_E = 0.40		40	30	20
GROUP C Kenya, Madagascar, Honduras, Thailand,	Circa 1973: a_E = 0.20	40			
Turkey, Ethiopia, Malawi, Rwanda, Senegal	Circa 1977: a_E = 0.35		35	26.25	17.5
GROUP D Gambia, Pakistan, Sierra Leone,	Circa 1973: a_E = 0.15	30			
Malaysia, Nicaragua, Morocco, Korea, Costa Rica, Guatemala	Circa 1977: a_E = 0.28			28	2114

Table 5 summarizes the main results we are interested in for a typical economy characterized by the base parameter values of Table 3. It shows the effects on the exchange rate, real income, and optimal borrowing of a sudden increase of 1 percent in the world price of imported inputs.

Table 5: BASE CASE: EFFECT OF A 1 PERCENT INCREASE IN THE PRICE OF IMPORTED INPUTS (Π)
(percentage changes with respect to preshock path)

	Exchange Rate			Real income			Borrowing as a percentage of GNP	
	Without	With borrowing		Without	With borrowing			
Period	borrowing	$\phi = 0$	$\phi = 2$	borrowing	$\phi = 0$	$\phi = 2$	$\phi = 0$	$\phi = 2$
1	0.28	0.83	.94	-0.12	-0.09	-0.09	0.034	0.028
2	0.75	0.83	0.86	-0.12	-0.13	-0.13	0.009	-0.008
3	0.60	0.83	0.82	-0.12	-0.15	-0.15	-0.031	-0.025

Note: See Table 3 for the value of the parameters for the Base Case. ϕ is the absolute risk-aversion coefficient.

For a three-year planning horizon, the model predicts for 1 percent increase in the world price of the imported inputs, that the exchange rate would rise by 1.28 pecent in the first period and 0.75 and 0.60 percent in the two successive periods, as substitutability in production and consumption increases (in the long run, the expected devaluation is 0.49 percent for each 1 percent of increase in Π). The percentage decline in real income is just the share of imported inputs, 0.12, multiplied by the increase in the world price of these inputs.

Optimal borrowing without risk aversion completely eliminates the exchange rate differentials in the planning period. It also transfers income from the future to the present, so that the fall in real income initially is only 0.09 percent, (but it goes to 0.15 percent in the third period). Increased risk aversion reduces borrowing and increases income equality, as it allows some differentials in the exchange rate to remain.

What is a reasonable value for the risk aversion coefficient? If we consider society's attitudes toward savings and growth, it is difficult to argue for values of ϕ bigger than say 1.5 or 2.0. Given the present trends in capital accumulation and technical progress per capita income will be higher in the future, so that large values of ϕ would imply that income should be transferred to the poorest generation, that is, to the present generation. In other words savings ought to be zero or very low. This contrasts with the present preoccupations about saving rates being too low.[14/]

During 1973 the real price of oil tripled. That implies an increase of between 30 and 60 percent in the price of imported inputs depending on the energy intensity of imports (Table 4). The amount of additional borrowing that could be so justified is between 1 and 2 percent of GNP (0.034 x 30 and 0.034 x 60). These figures are lower than the actual additional borrowing during that period (see Table 1). In fact, our model ought to produce a lower bound for the derived borrowing as it excludes, among other things, (i) the effect of the world 1974-75 recession on the demand for exports; (ii) the increase in factor mobility with time; and (iii) longer pay-off periods for the loans.

Table 4 also shows, however, that the share of energy in total intermediate imports has increased significantly, so that the effect of a doubling of Π_E is not much smaller now than was the threefold increase in 1973.

(b) Sensitivity to share parameters

The fraction of imported inputs in GDP, a, is the most important parameter influencing the results of the model. The optimal level of borrowing increases proportionally with that share, as do the changes in real income. The exchange rate also is quite sensitive to its value.

The variability of this share across countries is high, mainly because of large differences in the value of imports as proportion of GDP, 15/ which itself depends on the size of the country and its trade policies (as discussed, e.g., by Chenery and Syrquin, 1975, Chapter 4). Table 6 classifies countries in six groups according to the value of the share of imported inputs in GDP. Groups I and II include the relatively large countries, with shares of imported inputs in GDP of less than 10 percent. Group V includes small, highly open economies where this share becomes 24 percent of GNP. This group, thus, is very sensitive to changes in the world price of inputs.

Table 7 presents the effect of the external shock on each of these groups of countries. Note that some of the countries in the lower groups of Table 6 are also on the lower groups of Table 4, i.e., countries can have a large share of oil in total imported inputs but a small share of imported inputs in GDP, so that both forces partly offset each other. In that way, Brazil (Groups A and I) could expect that a doubling of the oil price would increase the cost of the 'average' imported input by 50 percent, with an impact on the exchange rate of 30 percent without borrowing. The predicted optimal additional borrowing is 0.6 percent of GDP, which reduces the devaluation to 20 percent during the three periods of the loan. Korea (Groups D and V), on the other hand, can partly compensate for its very high dependency on imported input (almost five times more than Brazil) by the lower energy content of these inputs. A doubling of π_E will (without borrowing),

Table 6: CLASSIFICATION OF COUNTRIES ACCORDING TO THE SHARE OF IMPORTED INPUTS IN GDP

GROUP I: a ≈ 5%	GROUP IV: a ≈ 18%
Brazil	Senegal
Turkey	Malawi
India	Costa Rica
	Malaysia
	Morocco
	Thailand
GROUP II: a ≈ 9%	
Bangladesh	
Ethiopia	
Pakistan	
	GROUP V: a ≈ 24%
	Gambia
	Kenya
GROUP III: a ≈ 12%	El Salvador
	Guatemala
Sri Lanka	Honduras
Sierra Leone	Jamaica
Madagascar	Korea
Uruguay	Nicaragua
Philippines	Panama

Source: Table A.2, in Appendix A.

increase its exchange rate 56 percent (28 x 2.11) during the first period. The optimal borrowing is calculated to be about 2 percent of GDP, in which case the necessary devaluation becomes only 38 percent.[16/]

The reason for the sensitivity to the share of imported inputs, a, is clear: the bigger the share the stronger the real income loss when the price of energy increases. The effect of the openness of the economy, as measured by the share of nontraded goods, c_N, is slightly more subtle (Table 8). That share enters the model in two ways. First, it is used to define the compensated elasticity of demand, η^*, from its symmetrical part σ^D.[17/] This has no effect on borrowing, but results in lower increases in the exchange

Table 7: SENSITIVITY TO THE IMPORTED INPUT SHARE; EFFECT OF A 1 PERCENT INCREASE IN THE PRICE OF IMPORTED INPUTS
(Percentage changes with respect to the preshock path).

Country Group	Period	Exchange rate			Real income			Borrowing	
		Without borrowing	With borrowing $\phi = 0$	With borrowing $\phi = 2$	Without borrowing	With borrowing $\phi = 0$	With borrowing $\phi = 2$	(percentage of GNP) $\phi = 0$	(percentage of GNP) $\phi = 2$
Group I	1	0.60	0.39	0.44	-0.05	-0.036	-0.038	0.014	0.012
a ≈ 5%	2	0.35	0.39	0.40	-0.05	-0.054	-0.054	-0.004	-0.004
	3	0.28	0.39	0.38	-0.05	-0.063	-0.061	-0.013	-0.011
Group II	1	1.01	0.66	0.74	-0.09	-0.005	-0.069	0.025	0.021
a ≈ 9%	2	0.59	0.66	0.68	-0.09	-0.097	-0.096	-0.007	-0.006
	3	0.47	0.66	0.64	-0.09	-0.113	-0.109	-0.023	-0.019
Group III	1	1.28	0.83	0.94	-0.12	-0.086	-0.092	0.034	0.028
a ≈ 12%	2	0.75	0.83	0.86	-0.12	-0.129	-0.128	-0.009	-0.008
	3	0.60	0.83	0.82	-0.12	-0.151	-0.145	-0.031	-0.025
Group IV	1	1.74	1.13	1.28	-0.18	-0.129	-0.138	0.051	0.042
a ≈ 18%	2	1.02	1.13	1.17	-0.18	-0.194	-0.193	-0.014	-0.013
	3	0.82	1.13	1.11	-0.18	-0.226	-0.217	-0.046	-0.037
Group V	1	2.11	1.37	1.56	-0.24	-0.172	-0.184	0.068	0.056
a ≈ 24%	2	1.24	1.37	1.42	-0.24	-0.259	-0.257	-0.019	-0.017
	3	0.99	1.37	1.35	-0.24	-0.302	-0.290	-0.062	-0.050

Note: See Table 6 for countries representative of each group.

Table 8: SENSITIVITY TO THE OPENNESS OF THE ECONOMY: BORROWING AND EXCHANGE RATES DURING THE FIRST PERIOD OF A THREE-PERIODS HORIZON AS A RESULT OF A 1 PERCENT INCREASE IN THE PRICE OF IMPORTED INPUTS

Share of nontraded goods in GDP	Exchange Rate			Borrowing (percentage of GDP)		Consumption of tradables	Production of tradables
	Without borrowing	With borrowing					
(c_N)	$\phi = \infty$	$\phi = 0$	$\phi = 2$	$\phi = 0$	$\phi = 2$	(c_T)	(q_T)
0.25	0.25	0.11	0.23	0.0338	0.0110	0.75	0.83
0.40	0.49	0.4	0.42	0.0338	0.0184	0.60	0.68
0.50	0.66	0.54	0.54	0.0338	0.0219	0.50	0.58
0.60	0.84	0.52	0.65	0.0338	0.0245	0.40	0.48
0.80	1.19	0.77	0.88	0.0338	0.0278	0.20	0.28
0.85 (Base case)	1.28	0.83	0.94	0.0348	0.0284	0.15	0.23

Note: See Table 3 for the values for the other parameters. Imports of final goods and exports are constant at 0.15 and 0.23 respectively.

rate as c_N decreases. In a very open economy, (one in which a large part of GNP has prices linked to world prices), the exchange rate is a powerful variable: small changes in it are enough to obtain trade equilibrium after the shock. But that alone does not create differences between the devaluation in the first and subsequent periods, which is what provides the reason for borrowing. Second, c_N is used in determining how the marginal utility of income, λ, changes as a result of variations in the exchange rate (equation 15, Table 2). What really matters is the ratio ϕ/c_N. A large value for c_N makes the marginal utility of income, λ, less sensitive to increases in the exchange rate (equation 14) so that in the optimal borrowing condition (equations 13 and 15) the weight of the exchange-rate-equalization objective becomes higher. This is relevant only when the other objective (real income equalization) has also some weight (that is, $\phi \neq 0$), and acts to reduce the amount of borrowing.

The figures in Table 8 confirm these considerations. The smoothing effect of a lower c_N on the exchange rate is shown in the "without borrowing" column: the magnitude of the required devaluation declines by half as c_N goes to 0.50 from the base value of 0.85. The effect on borrowing is present only for $\phi > 0$.

When we explored the effect of the degree of dependence on imported inputs (Tables 7 and A.4) we assumed a constant level of domestic production of the input: $Q_E = 0$. Table 9 shows that the crucial variable for determining the optimal amount of borrowing, is imports, and not total factor use. That is, the amount of domestic production is not important. The predicted devaluation does, however, become smaller as total factor use increases (with constant imports). The reason is that as the factor becomes more important in production, the implied elasticity of supply increases or,

Table 9: SENSITIVITY TO DOMESTIC PRODUCTION OF THE IMPORTED INPUT: BORROWING AND EXCHANGE RATES DURING THE FIRST PERIOD OF A THREE-PERIODS HORIZON AS A RESULT OF A 1 PERCENT INCREASE IN THE WORLD PRICE OF INPUTS

Domestic Production (Q_E)	Imports (a)	Total use ($a+Q_E$)	Exchange rate $\phi = 0$	Exchange rate $\phi = 2$	Exchange rate $\phi = \infty$ No borrowing	Borrowing $\phi = 0$	Borrowing $\phi = 2$
.08	.04	.12	0.05	0.11	0.18	0.011	0.010
.06	.06	.12	0.23	0.32	0.44	0.017	0.014
.051	.069	.12	0.31	0.41	0.55	0.019	0.016
.04	.08	.12	0.42	0.53	0.71	0.023	0.019
0	.12	.12	0.83	0.94	1.28	0.034	0.028
.06	.12	.18	0.55	0.66	0.93	0.034	0.028
.09	.12	.21	0.43	0.53	0.78	0.034	0.027
.12	.12	.24	0.32	0.42	0.65	0.034	0.027
.24	.12	.36	-0.03	0.04	0.20	0.034	0.025

Note: See table 3 for the value of the other parameters of the model.

equivalently, the production-possibility set becomes flatter so that smaller changes in relative prices are required to maintain market clearing.[18/]

(c) Sensitivity of the cost of borrowing and the planning horizon

The predicted levels of borrowing and the change in the exchange rate are quite insensitive to the cost of borrowing (Table 10). If the loans were to have an interest rate of zero rather than 10 percent, the estimated borrowing would be only 6 percent higher (there is also a small shift toward later repayment as the cost declines).

A very low price elasticity of the demand for "adjustment borrowing" on the part of oil-importing countries has some implications for the demand that multilateral institutions might face as result of any future oil shock. The demand they will face--if providing credit at cheaper terms than private sources of credit--will depend more on the private credit displaced than on any net additional borrowing to be generated by these lower terms. Hence, if this excess demand (equal to the total demand minus the supply of credit from other sources) is to have some important price elasticity, it would have to come from the supply elasticity of private credit.

The model assumes that no further price shocks are expected by a country during the repayment period. Hence T can be defined as the period within which countries expect no further shocks: that is, countries implicitly choose the value of T. According to this definition, large values of T are probably not very realistic.

Table 11 shows the sensitivity of borrowing to the planning period. If T = 3 the country would borrow in the first year and repay in two consecutive years. The additional borrowing in the first year is equal to 0.034 percent of GDP. If T = 5 the additional borrowing in the first year of the period becomes 0.044 percent of GDP, around 30 percent larger. If the

Table 10: SENSITIVITY TO THE COST OF BORROWING: EFFECTS OF A PERCENT INCREASE IN THE PRICE OF IMPORTED INPUTS

Cost of Borrowing (percent)	Period	Borrowing (percentage of GDP)		Exchange Rate	
		$\phi = 0$	$\phi = 2$	$\phi = 0$	$\phi = 2$
	1	0.037	0.031	0.79	0.91
-10	2	-0.005	-0.005	0.79	0.82
	3	0.026	-0.021	0.79	0.79
	1	0.035	0.030	0.81	0.92
0	2	-0.007	-0.007	0.81	0.84
	3	-0.028	-0.023	0.81	0.80
	1	0.035	0.029	0.82	0.93
5	2	-0.008	-0.008	0.82	0.85
	3	-0.030	-0.024	0.82	0.81
	1	0.034	0.028	0.83	0.94
10	2	-0.009	-0.008	0.83	0.86
	3	-0.031	-0.025	0.83	0.82
	1	0.032	0.027	0.85	0.96
20	2	-0.011	-0.010	0.85	0.87
	3	-0.033	-0.027	0.85	0.83

Note: See Table 3 for the values of other parameters.

Table 11: SENSITIVITY TO THE LENGTH OF THE PLANNING PERIOD

Planning period (T)	Borrowing (percentage of GDP) First period	Total	Exchange Rate
2	.023	.023	0.97
3	.034	.034	0.83
4	.040	.040	0.75
5	.044	.049	0.71
6	.046	.054	0.67
7	.048	.058	0.65
10	.051	.067	0.61
15	.053	.074	0.59

Note: See Table 3 for the value of other parameters. The risk aversion coefficient, ϕ, is set equal to zero so that the exchange rate is constant during the planning period.

1973 oil shock (which tripled Π_E) is evaluated for a country with $a_E = 0.25$, the increase in the price of imported inputs becomes 50 percent. If T was expected to be five years the country would have borrowed 2.2 percent of its GDP. The fact that many countries borrowed between 3 and 4 percent could be consistent with expectations that the price increase was a one-time event leading countries to borrow against much longer periods.

(d) Sensitivity to the degree of substitution in production and consumption

Up to now the central element in our explanation of borrowing for structural adjustment is the increase in substitutability with the passage of time. Figure 3 provides a simplified interpretation. Initially the economy is using processes adapted to a cost of imported inputs as shown by the line through point E_o. When the price changes, to produce the same quantity, y_o, the economy will use factors as shown in point E_1 in the short run: time is needed to discover such points as E_2, and E_3, to change habits and processes associated to a lower cost of energy, to build new machines and change the specifications of goods.

In our numerical estimations, we summarize both the short-run and long-run isoquants by a constant elasticity of substitution, σ^N. It is assumed that it adjusts geometrically from its short-run value, σ_S^N, to the higher long-run value, σ_L^N, with speed of adjustment μ_N. That is:

$$\sigma_t^N = \mu_N \sigma_L^N + (1-\mu_N)\ \sigma_{t-1}^N \qquad \text{(for } t = 2,\ldots,T)$$

$$\sigma_1^N = \sigma_S^N.$$

If $\mu_N = 0$ substitutability never increases; if $\mu_N = 1$ it reaches its long-run value in the second period. For μ_N between 0 and 1, σ_L^N is reached only asymptotically.

The values of σ_S^N, σ_L^N, and μ_N used in the base case respectively are 0.2, 0.4, and 0.5 (so that $\sigma_1^N = 0.2$, $\sigma_2^N = 0.35$). It is quite difficult to get a good empirical handle on what values of σ_N are reasonable, but what evidence there is suggests that the long-run elasticity of demand for energy ($\sigma_L^N/(1-a_N)$) should not be higher than 0.5 or 0.6.[19/]

The increase in substitution in final demand for nontraded goods is modeled in the same way, with the compensated price elasticity of demand, η^*, playing the role of σ^N in equation (23)[20/]. The base case assumes a doubling

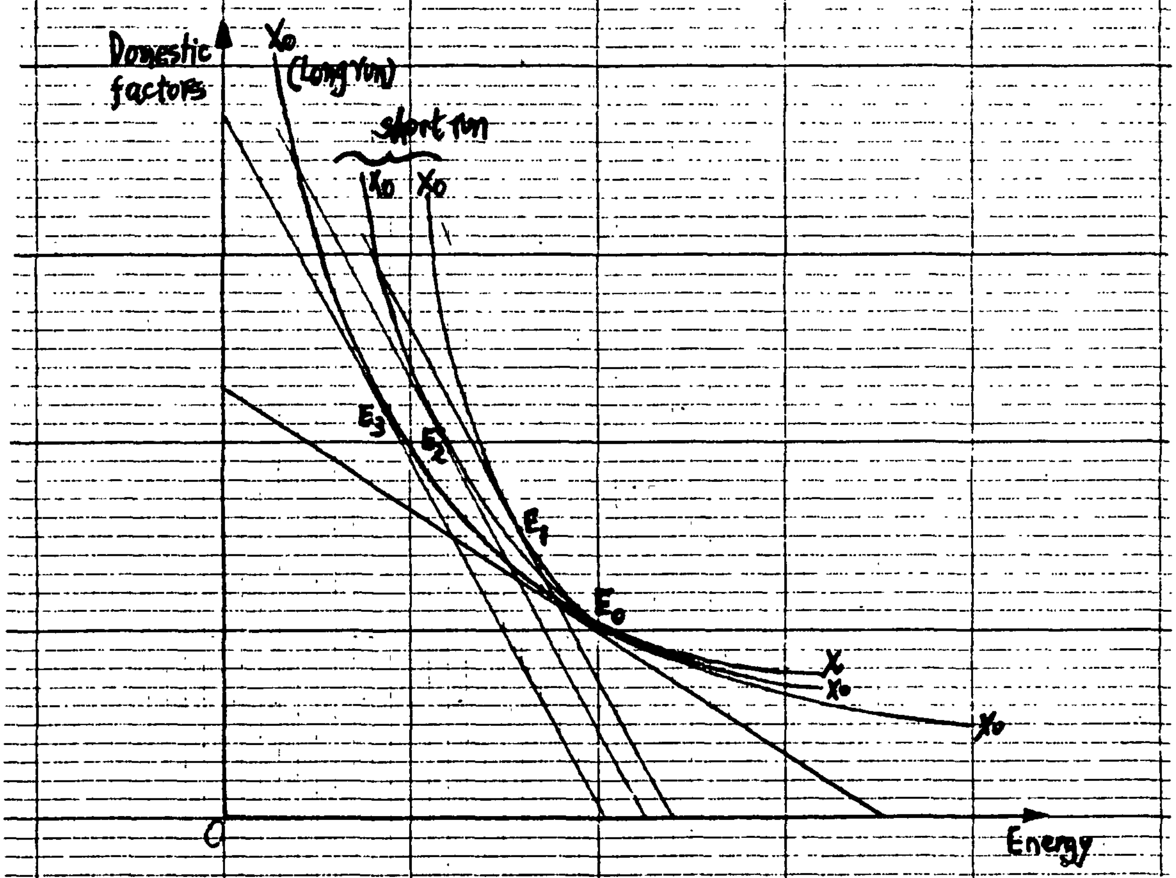
Domestic factors
X_0 (Long run)
short run
X_0
X_0
E_3
E_2
E_1
E_0
X_0
X_0
X_0
O
Energy

Figure 3

of that elasticity in the long run, and a speed of adjustment of $\mu_D = 0.5$, so that half the difference from the long-run value is eliminated in each period.

To explore the sensitivity of the model, we calculated the effect of extreme assumptions on speed of adjustment ($\mu_i = 0$ and $\mu_i = 1$), and of increasing to 3 or reducing to 1.5 the ratio of long-run to short-run substitution.[21/] The results are shown in Table 12.

The base case simulation can be broken down by first simulating changes only in substitution in production (SC_2) and a second simulation where only substitution in consumption increases over time (SC_2). If only substitution in production increases with time, the level of first-period borrowing becomes 0.018 percent of GDP for each percentage-point increase in the international price of the input (case SC_2), instead of 0.034 as in the base case. Similarly, increased substitution in consumption alone, would justify borrowings of 0.021 percent of GDP (case SP_2). These figures show that each substitution lag is responsible for half the borrowing calculated in the base case.

Increased long-run substitutability calls for higher levels of borrowing (cases SP_3 and SC_3), and results in smaller devaluations. The combination of high long-run substitution and rapid adjustment, in both production and consumption, results in borrowing 0.067 percent of GDP for each 1 percent of increase in Π. (for the "typical" country with $a_E = 0.4$ a doubling of the international price of oil would mean additional loans of 2.7 percent of its GDP).

Table 12: SENSITIVITY TO SUBSTITUTABILITY IN PRODUCTION AND CONSUMPTION: BORROWING AND EXCHANGE RATE DURING THE FIRST PERIOD OF A THREE-PERIOD PLANNING HORIZON

Case a/ (a)	Borrowing (percentage of GDP)	Exchange rate	Substitutability in production b/			Substitutability in consumption c/		
			First period	Second period	Third period	First period	Second period	Third period
Base	0.034	0.83	0.2	0.3	0.35	.0588	.0882	.1029
						(.99)	(1.02)	(1.04)
Production								
SP_1: Rapid adjustment	0.041	0.74	0.2	0.4	0.4			
SP_2: Slow adjustment	0.021	1.00	0.2	0.2	0.2	0.0588	0.0882	0.1029
						(0.994)	(1.023)	(1.038)
						[0.398]	[0.565]	[0.648]
SP_3: High long run substitution	0.045	0.69	0.2	0.4	0.5			
SP_4: Low long run substitution	0.028	0.91	0.2	0.25	0.275			
SP_5: High substition Rapid adjustment	0.056	0.54	0.2	0.6	0.6			
Consumption								
SC_1: Rapid adjustment	0.041	0.74				0.0588	0.118	0.118
						(.994)	(1.053)	(1.053)
SC_2: Slow adjustment	0.018	1.04	0.2	0.3	0.35	0.0588	0.0588	0.0588
						(.99)	(.99)	(.99)
SC_3: High long run substitution	0.044	0.69				0.0588	0.1176	0.1471
						(.99)	(1.05)	(1.08)
SC_4: Long run substitution	0.027	0.92				0.0588	0.074	0.081
						(.99)	(1.01)	(1.02)
SC_5: High substitution, Rapid adjustment	0.053	0.58				0.0588	0.1765	0.1765
						(.99)	(1.11)	(1.11)
Extreme cases								
SP_2 and SC_2: Low case	0.000	1.28	0.2	0.2	0.2	0.0588	0.0588	0.0588
						(.99)	(.99)	(.99)
SP_5 and SC_5: High case	0.067	0.40	0.2	0.6	0.6	0.0588	0.1765	0.1765
						(.99)	(1.11)	(1.11)

Notes: (a) The speed of adjustment is 0 in the slow cases, 1.0 in the rapid cases and 0.5 in the other cases. The ratio of long-run substitution to short-run substitution is 1.5 in the low case, 3.0 in the high case and 2.0, as in the base case, in all other cases.

(b) The values shown are the elasticity of substitution in each period (σ^N).

(c) The values shown are the compensated elasticity of demand for nontraded goods (η^*) with C_N = .85; the values in parenthesis are the corresponding uncompensated price elasticity of demand. The numbers in squared brackets are the (uncompensated) price elasticity of demand for traded goods.

V. Extensions: The Effect of Gradual Labor Mobility

In our previous discussion we assumed that only the imported inputs could move freely between sectors following the external shock. Consequently, the other fixed inputs will receive different factor payments across sectors after the increase in the price of imported inputs: first, the sector which uses imported inputs more intensively is more affected by the increase in price, so that its fixed factors will be left with a smaller "residual" available to pay them; and, second, the requirement of external balance will likely result in an increase in the relative price of traded goods (i.e., a devaluation), so that the fixed factors used in that sector will increase their revenue.

The factor payments differentials become eroded with time, as information about its existence spread and the costs and inertia opposing mobility are overcome by the prospective increases in income. The end result is an increase in the overall sustitutability of the economy, much on the same fashion as it was assumed to occur, exogenously, in the previous sections.

We will model now such a process of gradual mobility for one factor, labor. In the background we still have a completely immobile factor ("capital"), reflecting the impossibility of shifting the existing stock of capital and the medium term nature of the analysis. We will also maintain the assumption of full employment and flexible exchange rate.

To keep the model as simple as possible, we assume for the moment that production possibilities can be represented by CES production functions with equal coefficients in both sectors. The demand for labor and supply of output in each sector, $i = N,X$, are:

(23) $$\ell_i = -\frac{\sigma}{1-b}\,[(w_i - p_i) + a(\pi + r - p_i)]$$ and

(24) $$q_i = b\ell_i - a\sigma(\pi + r - p_i) \equiv b\ell_i - \varepsilon(\pi + r - p_i) \; ,$$

where a and b are the shares of imported inputs and labor in GDP (the share of labor in the gross value of the output of each sector is $b_i \equiv b/(1+a)$ when initial borrowing is zero, which is lower as the base now includes the payment to imported inputs),22/ and $\varepsilon_i = a_i\sigma_i/(1-a_i) = a\sigma$ is the elasticity of supply in the absence of labor mobility.

In the short run there is no labor mobility, so that the wage rate in each sector changes so as to make $\ell_i = 0$. That is

(25) $$w_N^o = -a(\pi + r) \quad , \qquad w_X^o = -a\pi + r$$

since $p_N = 0$ and $p_X = r$.

With perfect mobility, wages have to be equal in both sectors. Denoting h as the share of total employment in the nontraded sector, full employment implies $h\ell_N + (1-h)\ell_x = 0$. This, together with (23), results in a change in the equilibrium wage of $w^* = w_N^* = w_x^*$, that can be written as:

(26) $$w^* = a\pi + (1-h-ah)r \; ,$$

so that the change in employment in nontraded is:

(27) $$\ell_N^* = -\,\sigma(1-h)\left(\frac{1+a}{1-b}\right) r = -\,\sigma\left(\frac{1-h}{f}\right) r \; ,$$

with f being the share of the fixed factors in the gross value of production.

We assume that wages in each sector move slowly from w_i^o to w^*, or equivalently, that there is a gradual adjustment in employment to ℓ_i^*. That is, the change in employment in nontraded goods in period t after the shock is

$$(28) \qquad \ell_N(t) = \psi(t)\ell_N^* \qquad\qquad 0 < \psi(t) < 1$$

with $\psi(t)$ an increasing function of t.

Equation (24) gives the resulting change in supply for nontraded goods:

$$(29) \qquad q_N = - \varepsilon_N(\pi+r) - \psi\sigma b \left(\frac{1-h}{f}\right) r$$

For $\psi = 0$ we have the previous model, with no labor mobility. Increasing mobility increases the elasticity of supply ($-d \log Q_N/d \log R$) by an amount that is higher the larger the share of labor in GDP and the share of employment in the traded sector. The vertical shift in the supply function for nontraded goods induced by the price shock is constant over time, because of the assumption of equal factor intensity.

Because full employment is always being maintained, the change in real income induced by the price shock is, as a first approximation, independent from the degree of labor mobility. Similarly, demand behavior is not altered, so that the change in demand for nontraded is given by (18). The devaluation required to clear the market in period t becomes:

$$(30) \qquad r_t = \frac{(a\eta_N-\varepsilon_N)\pi_t - \eta_N B_t}{\eta^* + \varepsilon_N + \psi_t \sigma b(1-h)/f}$$

Table 13 presents the effects of gradual labor mobility for the case of CES production functions with equal factor shares in both sectors, and with substitution parameters in production and consumption which are constant over time. For each 1 percent increase in the price of imported inputs, the relative price of traded goods increases by 1.28 percent, if there is no mobility of labor. However, wages (in terms of nontraded goods) fall by 0.28 percent in the nontraded sector while increasing by 1.15 percent in the traded sector. Full labor mobility results in a reduction of employment in nontraded goods of 0.08 percent (employment in traded goods increases by 0.29 percent, as it occupies only 1/4 of the labor force in the base case), so that wages equalize at a level 0.01 percent below their preshock values. Of course, real wages fall by a larger amount, to the extent that traded goods enter also the consumption basket of workers.

All that is without additional borrowing. The reallocation of labor toward traded goods increases their relative supply, however, so that markets clear at a lower exchange rate: 0.79 percent above its prestock value in the third period after the shock. This creates an opportunity for intertemporal arbitrage that can be best exploited by foreign borrowing; additional loans amounting to 0.022 percent of GDP for each 1 percent of increase in the international price of inputs are just right to stabilize the variation in the exchange rate over the planning horizon (which is the best strategy in the absence of risk aversion). With borrowing, the contraction of the nontraded sector is even larger, as it is also necessary to produce enough traded goods to repay the loan. Real wages in the third period are lower than they would have been without the price shock, but they can increase as a result of borrowing if wage-goods have a large nontraded component.

Table 13: BORROWING INDUCED BY GRADUAL LABOR MOBILITY, HOLDING CONSTANT THE ELASTICITIES OF SUBSTITUTION, FOR EACH 1 PERCENT INCREASE IN THE WORLD PRICE OF IMPORTED INPUTS
(Percentage changes with respect to the preshock path)

Period	Borrowing (Percentage of GDP)	Exchange rate	Employment in nontraded goods	Wages in nontraded goods	Wages in traded goods
1	0.0219	0.99	0.	-0.25	0.86
2	-0.0015	0.99	-0.05	-0.13	0.43
3	-0.0249	0.99	-0.10	-0.01	-0.01
Without borrowing:					
1	0.	1.28	0.	-0.28	1.15
2	0.	0.97	-0.05	-0.13	0.42
3	0.	0.79	-0.08	-0.03	-0.03

Note: The share of labor in GDP (b) is 0.5, and in both sectors the share of wages in the value of output is the same. In the first period labor is fixed and in the third period is perfectly mobile, i.e.,, it reaches a level consistent with wage equalization across sectors. In the second period the change in employment in nontraded goods is half the long run change. In other words, $\psi(1) = 0$, $\psi(2) = 0.5$ and $\psi(3) = 1$. Substitution remains constant over time: $\sigma_S^N = \sigma_L^N = 0.2$, $\sigma^x = 0.2$ and $\sigma^D = 0.05$. All other parameters are the same as in the Base Case, Table 3.

As before, the sign of r following the increase in Π depends on the relative magnitude of the income elasticity for nontraded goods and the elasticity of substitution in production. A devaluation is, thus, the most likely result.

Because ψ_t increases with t, the size of the devaluation will be a decreasing function of time. There is, thus, an incentive for external borrowing to stabilize the value of foreign exchange across periods. This is not, however, the only possible outcome.

When we allow the production functions to be of a more general form and different across sectors, there are "factor intensity" effects in the demand for labor, additional to the impact of the change in relative price of final goods. These effects may even make the devaluation larger after the reallocation of labor. For example, let us assume that production of traded goods is less intensive in the use of the imported inputs, in the sense that its share in costs is smaller than in the nontraded sector (i.e., $a_N > a_X$). Then the direct cost effect of the increase in the price of inputs is smaller for traded goods, so that even in the absence of a real devaluation they would pay higher wages than in the nontraded sector: employment in nontraded goods would decrease with labor-mobility-induced wage equalization.23/ Under the above conditions, gradual mobility results not only on an increasing elasticity of supply, but also on an increasing cost-push shift on the supply of nontraded. The end result is that the amount of the devaluation required to maintain external and internal balance may be higher when mobility is allowed, although the differences in factor intensity needed to obtain that result seems rather large.24/ Similar effects may be obtained as the result of differences in sustitutability between sectors, when a more general production structure is considered. Appendix C contains a discussion of the general case.

The impact of labor mobility is larger, the larger the share of wages in costs. As can be seen from equation (30), a large share of labor in GDP, b, reduces the size of the devaluation after the reallocation of labor in relation to that with immobile labor. A larger expected fall in the price of traded goods makes larger borrowing optimal, as shown in Table 14: if wages represent 75 percent of GDP (instead of 50 percent) the economy should double its additional loans to 0.048 percent of GDP for each 1 percent of increase in π.

Table 14 also explores the effects of different factor intensity in both sectors, with constant overall factor shares in GDP. When production of nontraded goods is more labor intensive than production of traded goods, labor mobility is not so effective in avoiding large increases in the exchange rate, so that borrowing becomes smaller (it can be shown also that the fall in wages is larger in that case). Finally, a larger share of imported inputs in costs in the nontraded sector results in lower borrowing, as discussed before.

When we combine gradual labor mobility with exogenously increasing substitution parameters in production and consumption, we obtain a path for the (changes in the) exchange rate that is more strongly declining than in the two separate cases, as shown in Table 15. Increasing elasticities result in a smaller reallocation of labor required to equilibrate wages (0.06 percent of the employment in nontraded, versus 0.08 percent in the case of constant substitution), when no additional borrowing takes place. However, when additional loans of 0.05 percent of GDP are obtained, as required to eliminate the fall in the price of traded goods during the planning period, employment in nontraded goods falls by a higher percentage than with constant substitution (despite the exchange rate being stabilized at a significantly lower level). As a last point, the table shows that there is a kind of

Table 14: EXTENSIONS OF TABLE 13: SENSITIVITY TO KEY PARAMETERS
(Additional borrowing as percentage of GDP)

Share labor in GDP, (b)	0.1	0.25	0.50	0.75	
Borrowing	0.003	0.008	0.022	0.048	0.078
Relative Labor Intensity (b_X/b_N):	0.25	0.50	1.	2.	
Borrowing	0.006	0.011	0.022	0.038	
Relative energy intensity (a_X/a_N):	0.25	0.50	1.	2.	4.
Borrowing	0.021	0.022	0.022	0.023	0.024

Note: In each case all other parameters have the same values than in Table 13.

Table 15: THE GENERAL CASE: BORROWING INDUCED BY GRADUAL LABOR MOBILITY AND INCREASING SUBSTITUTION FOR EACH 1 PERCENT INCREASE IN THE WORLD PRICE OF IMPORTED INPUTS
(Percentage changes with respect to the preshock path)

Period	Borrowing (Percentage of GDP)	Exchange rate	Employment in nontraded goods	Wages in nontraded goods	Wages in traded goods
1	0.0502	0.62	0.	-0.20	0.49
2	-0.0067	0.62	-0.05	-0.13	0.22
3	-0.0534	0.62	-0.11	-0.05	-0.05
Without borrowing:					
1	0.	1.28	0.	-0.28	1.15
2	0.	1.28	0.	-0.28	1.15
3	0.	0.37	-0.06	-0.08	-0.08

Note: All parameters are fixed at their base values (Tables 3 and 13).

"decreasing returns" to additional sources of substitutability as reasons for borrowing: the amount of borrowing in the general case is smaller than the sum of those for the separate cases.

VI. Limitations of the Model

The model used to calculate optimal borrowing is, of course, a very simplified version of the economy. For example, all goods with prices not directly tied to the exchange rate are aggregated into a single "nontraded" good. We would argue, however, that the main limitations of the model are not those derived from aggregation, but instead, they come from the implicit assumptions about macroeconomic adjustment and the rudimentary treatment of expectations and the effects of uncertainty.

With respect to the first problem, there are at least three different issues to consider. (i) We assume that the economy is on the frontier of its production-possibility set, so that no shock-induced changes in employment are allowed. This could be rationalized by a perfect compensatory macroeconomic policy or by flexibility of prices and wages. An explicit theory of unemployment based on downward rigidity of real wages could easily be added to the model: it would result in higher implied borrowing if markets approach, although slowly, their full employment equilibrium. (ii) We also ignore all asset markets, so that, there are no endogenous capital flows or links between temporary external imbalances and the supply of money. We, thus, have nothing to say on inflation or interest rates.[25/] (iii) Finally, the countries are assumed to allow the national currency to devalue as much as necessary to achieve an external balance, not to adjust to the new terms of trade by reducing imports through quotas or tariffs. One can argue, however, that the equilibrium exchange rate used here would be a good approximation to the shadow exchange rate associated with these policies, so that the calculated levels of borrowing would still represent socially optimal levels of borrowing.[26/]

We have not been very explicit about the expectations of future price shocks--which have been used only as a factor limiting the period over which the country would like to borrow. We have also ignored the effects of uncertainty on the magnitude and timing of these shocks. In the same vein, the increase in substitutability is assumed to be independent of policy actions. A universe compatible with that view is one where economic agents have perfect foresight of the input price path, but still cannot (do not want to) adjust completely to price increases in advance--that is, to go to the long-run substitution frontier immediately after the shock--due to the costs that would involve. The speed of adjustment depends then on the resources invested in learning by doing--to master new processes that are not yet (but will be) profitable--and in discovering new processes. A policy designed to achieve an optimal speed of adjustment would have to weight public investment in that area with the optimal degree of appropriability to private investment (that is, one that gives enough incentives to invest but still makes the new processes discovered as widely and freely available as possible).

The empirical foundation of our assumptions on substitutability are acknowledgedly very weak. Its improvement, as well as the introduction of additional policy variables (such as the level of international reserves), is also left for the future.

Appendix A - Auxiliary Tables

Table A.1: SOME INDICATORS OF FOREIGN TRADE

Countries	Year	Export	Import	Deficit in current Account	Imports of intermediate goods [a]
Low-income					
Bangladesh	1978	6.3	17.9	11.6	9.1
Ethiopia	1976	12.7	13.6	0.9	6.7
Gambia	1975	49.0	62.3	13.3	31.3
India	1977	7.4	7.4	0	4.7
Kenya	1977	34.9	55.6	20.7	30.2
Madagascar	1974	17.7	22.4	4.7	12.5
Malawi	1977	28.4	33.8	5.4	17.6
Pakistan	1977	9.4	17.3	7.9	9.2
Rwanda	1975	5.4	12.8	7.4	6.1
Senegal	1975	36.4	41.9	5.5	18.4
Sierra Leone	1974	28.0	30.4	2.4	14.1
Sri Lanka	1977	33.8	30.2	-3.6	12.8
Average		22.5	28.8	6.4	14.4
Median		22.9	26.3	5.5	12.6
Middle-income					
Brazil	1978	7.1	8.3	1.2	5.1
Costa Rica	1977	31.1	36.5	5.4	18.9
El Salvador	1975	30.4	38.7	8.3	20.4
Guatemala	1975	57.9	44.6	-18.3	24.7
Honduras	1977	37.2	42.4	5.2	21.9
Jamaica	1977	31.6	32.7	1.1	21.4
Korea	1978	33.5	36.3	2.8	20.3
Malaysia	1978	50.8	47.4	-3.4	19.6
Morocco	1977	18.9	87.7	18.8	16.2
Nicaragua	1977	31.9	37.6	5.7	20.0
Panama	1977	42.9	47.0	4.1	28.4
Philippines	1977	18.8	22.5	3.7	13.3
Thailand	1977	20.9	26.5	5.6	16.2
Turkey	1978	4.4	8.8	4.4	5.9
Uruguay	1976	18.0	18.8	0.8	12.1
Average		29.0	32.4	3.4	17.6
Median		31.1	36.5	4.1	19.6

Source: United Nations, 1978 Yearbook of International Trade Statistics.

a/ Defined as items number 2,3,5 (minus 5.5) and 6 of the SITC.

Table A.2: COMPOSITION OF IMPORTS

Countries	Food Imports a/	Capital goods	Imports of intermediate goods b/			Oil imports as percentage of intermediate goods		
			1973	1974	1977	1973	1974	1977
	(percentage of total imports)							
Low-income								
Bangladesh	26.30	15.99	--	--	50.78	--	--	27.2
Ethiopia	5.76	34.58	49.8	54.6	49.57	18.8	26.0	30.8
Gambia	24.03	14.13	46.9	47.5	50.23	11.3	11.1	17.7
India	5.3	19.25	54.6	62.8	62.95	25.4	44.6	40.6
Kenya	3.12	33.96	50.7	64.2	54.36	21.5	35.7	40.4
Madagascar	11.17	24.52	42.9	52.0	55.86	21.8	34.3	35.6
Malawi	7.36	30.30	47.9	47.9	51.95	17.7	21.1	24.2
Pakistan	9.59	28.07	53.9	51.9	52.88	14.3	25.5	29.5
Rwanda	13.54	26.04	51.28	58.4	47.92	17.0	14.6	17.3
Senegal	23.70	26.12	33.2	40.2	43.77	18.3	32.2	27.2
Sri Lanka	39.57	12.17	--	46.96	46.52	--	42.3	52.7
Sierra Leone	25.45	20.91	39.0	41.8	42.27	15.0	27.4	27.0
Average	10.70	22.57	41.95	51.66	50.8	18.11	28.62	37.0
Median	12.3	26.08	44.9	58.4	55.11	14.6	27.4	25.6
Middle-income								
Brazil	9.39	26.12	49.5	64.1	60.91	-28.4	35.5	50.9
Costa Rica	7.24	31.94	51.4	55.7	51.88	12.8	15.7	19.1
El Salvador	11.22	26.63	55.4	60.9	52.60	10.1	15.2	16.0
Guatemala	8.89	27.36	55.5	60.6	55.27	12.7	21.7	24.4
Honduras	7.79	31.49	53.8	59.5	51.56	18.4	27.9	22.9
Jamaica	16.73	12.16	47.5	54.5	65.26	22.3	38.0	44.1
Korea	6.57	33.5	55.2	57.5	55.95	12.7	25.9	27.7
Malaysia	16.00	36.50	42.1	42.8	41.29	15.3	23.3	25.9
Morocco	13.67	37.89	45.0	48.9	42.91	13.4	26.4	25.2
Nicaragua	6.97	31.05	51.8	59.4	53.16	14.2	18.4	25.9
Panama	8.76	19.35	51.6	63.4	60.37	39.4	56.2	52.1
Philippines	9.87	27.90	50.9	57.8	58.87	25.3	34.5	43.8
Thailand	4.36	30.77	55.0	58.5	61.13	20.4	33.6	37.5
Turkey	0.63	30.63	52.9	59.6	66.53	20.4	33.7	45.1
Uruguay	5.68	26.88	--	--	64.44	--	--	52.8
Average	8.52	30.38	51.26	57.37	56.1	18.99	29.00	38.0
Median	16.00	30.63	51.7	58.95	55.95	16.85	27.15	27.7

Source: United Nations, Yearbook of International Trade Statistics, several years.

a/ The actual years for each country are those in Table A.1.
b/ Corresponds to items number 3, 3, 5 (except 5.5) and 6 of the SITC.

Table A.3: SENSITIVITY TO THE IMPORTED INPUT SHARE: EFFECT OF DIFFERENT ASSUMPTIONS ON THE STRUCTURE OF THE ECONOMY

Country	Variable	Constant structure of imports a/				Constant share of total imports b/			
		Constant c_N b/		Constant k_M c/		Constant c_N b/		Constant k_M d,e/	
		$\phi = 0$	$\phi = 2$	$\phi = 0$	$\phi = 2$	$\phi = 0$	$\phi = 2$	$\phi = 0$	$\phi = 2$
	Share of nontraded	0.70		0.94		0.78		0.78	
	Total exports	0.07		0.07		0.23		0.23	
	Production traded	0.31		0.07		0.23		0.23	
Group I	First period exchange rate								
a = 5%	Without borrowing	0.48		0.70		0.60		0.60	
	With borrowing	.30	.35	.46	.50	.39	.44	.39	.44
	First period borrowing	.014	.114	.014	.012	.014	.012	.014	.012
	Share of nontraded	0.70		0.888		0.78		0.82	
	Total exports	0.16		0.16		0.23		0.23	
	Production traded	0.35		0.16		0.27		0.23	
Group II	First period exchange rate								
a = 9%	Without borrowing	0.80		1.07		0.95		1.01	
	With borrowing	.50	.60	.70	.78	.62	.70	.66	.74
	First period borrowing	.025	.020	.025	.022	.025	.021	.025	.021
	Share of nontraded	0.70		0.85		0.78		0.85	
	Total exports	0.23		0.23		0.23		0.23	
	Production traded	0.38		0.23		0.30		0.23	
Group III	First period exchange rate								
a = 12%	Without borrowing	1.01		1.28		1.15		1.28	
	With borrowing	.64	.77	.83	.94	.74	.86	.83	.94
	First period borrowing	.034	.026	.034	.028	.034	.028	.034	.028
	Share of nontraded	0.70		0.775		.78		0.91	
	Total exports	0.37		0.37		0.23		0.23	
	Production traded	0.44		0.37		0.36		0.23	
Group IV	First period exchange rate								
a = 18%	Without borrowing	1.40		1.57		1.44		1.74	
	With borrowing	.91	1.09	1.03	1.20	.92	1.09	1.13	1.28
	First period borrowing	.051	.039	.051	.040	.051	.040	.051	.042
	Share of nontraded	0.70		0.70		0.78		0.97	
	Total exports	0.50		0.50		0.23		0.23	
	Production traded	0.50		0.50		0.42		0.23	
Group V	First period exchange rate								
a = 24%	Without borrowing	1.76		1.76		1.59		2.11	
	With borrowing	1.15	1.39	1.15	1.29	1.01	1.22	1.37	1.56
	First period borrowing	.067	.051	.067	.051	.067	.051	.067	.056

a/ Imports of final goods are assumed to increase proportionately with the imports of inputs (its ratio is .12/.15 = .8).

b/ Total imports of inputs and final goods are 27 percent of initial GDP.

c/ Domestic production of tradables is adjusted to keep consumption of tradables constant.

d/ Here there is no domestic consumption of domestically produced traded goods.

e/ This is the case discussed in the text (table 7). In all four cases there is no domestic production of the inputs.

Appendix B: An Exact CES Model

In this appendix we compare the log-linear model developed in the text with one based on exact solutions of an economy with CES production functions and an additive utility function. The model is presented in Sections 1 to 3; Section 4 contains the numerical comparison with the results in the text.

1. Assume that both sectors have the production functions, so that with only one variable input we have the following supply functions:

$$\text{(B.1)}\quad Q_i = \gamma_i[1-a_i(R\Pi/P_i)^{1-\sigma_i}]^{\sigma_i/(1-\sigma_i)}, \qquad (i = X,N)$$

with the derived demand for the input:

$$\text{(B.2)}\quad E_i = a_i Q_i (R\Pi/P_i)^{-\sigma_i} \qquad (i = X,N)$$

The parameter γ_i reflects the contribution of the fixed factors. At the initial situation, where all prices are equal to one, the parameter a_i gives the share of the input in the value of production. After a change in Π, R, and P_i, that share is:

$$\text{(B.3)}\quad \alpha_i = a_i(R\Pi/P_i)^{1-\sigma_i} \qquad (i = X,N.)$$

Total value added (GNP) is $(1-\alpha_N)Q_N - (1-\alpha_X)RQ_X$. If net transfers from abroad (borrowing) are equal to B,[27/] aggregate income (total expenditures) is:

$$\text{(B.4)} \qquad Y = RB + \gamma_X R\, (1-a_X \Pi^{1-\sigma_X})^{1/(1-\sigma_X)} + \gamma_N (1-a_N (R\Pi)^{1-\sigma_N})^{1/(1-\sigma_N)}$$

where we have set $P_N = 1$ and the international price of exports also is equal to one.

Equation (B.4) defines Y as an increasing concave (if $\sigma_N \neq 0$) function of R. As shown in the text, its total log-differentiation gives:

$$\text{(B.5)} \qquad y = \Theta_F r - \alpha\pi + b \ ,$$

with $\sigma = \Theta_N \alpha_N + \Theta_X \alpha_X = R\Pi E/Y, \quad \Theta_N = Q_N/Y, \quad \Theta_X = RQ_X/Y, \quad \Theta_F = 1-\Theta_N$

and $B = RdB/Y$. As before, small letters represent log-differentials.

2. The demand functions will be assumed to be generated by the following additive indirect utility function (or any monotonic transformation of it):

$$\text{(B.6)} \qquad U = \frac{c_N}{s_N}\left(\frac{Y}{P_N}\right)^{s_N} + \frac{c_F}{s_F}\left(\frac{Y}{P_F}\right)^{s_F}$$

so that the demands for nontraded and imported final goods are

$$\text{(B.7.2)} \qquad D_N = c_N (Y/P_N)^{1+s_N} / \Sigma c_i (Y/P_i)^{s_i} \qquad \text{and}$$

$$\text{(B.7.6)} \qquad D_F = c_F (Y/P_F)^{1+s_F} / \Sigma c_i (Y/P_i)^{s_i} \ .$$

At the initial situation, with $P_i = Y = 1$, the expenditure shares on each good are given by c_i (so that $c_N + c_F = 1$). For the other prices and income the share of nontraded goods is:

$$\text{(B.8)} \qquad \Theta_N = c_N/(c_N + c_F Y^{s_F - s_N} N_F^{-s_F}) \; .$$

$P_F/P_N = R$, since the international price of the final good is assumed to remain constant (its share of $\Theta_F = 1-\Theta_N$, of course).

The income elasticities implied by (B.7) are

$\eta_{NN} \equiv \partial \log D_N/\partial \log P_N = -\, 1-\Theta_F s_N$ and $\eta_{NF} \equiv \partial \log D_N/\partial \log P_F = \Theta_F s_F$.

The compensated price elasticity of demand for nontraded goods is

$\eta^* \equiv \eta_{NN} - \Theta_N \eta_N = -\, \Theta_F(1+\Theta_N s_F+\Theta_F s_N)$.

3. We assume that the markets for nontraded and imported goods clear continuously, so that $Q_N = D_N$ and total expenditures Y in (B.6) and (B.7) is equal to total value added plus transfers (B.4). The model is thus completely determined when we add the equation:

$$\text{(B.9)} \qquad c_N Y/(c_n+c_F Y^{s_F-s_N} N_R^{-s_N}) = \gamma_N(1-a_N(R\Pi)^{1-\sigma_N})^{\sigma_N/(1-\sigma_N)} \; .$$

This equation defines Y as a convex function of R. Its total log differential gives:

$$\text{(B.10)} \qquad \eta_N y = (\eta_{NF}-\varepsilon_N)r - \varepsilon_N \pi \; ,$$

where $\varepsilon_N = \alpha_N \sigma_N/(1-\alpha_N)$ is the elasticity of supply of nontraded goods. The joint solution of (B.5) and (B.10) gives equation (7) in the text.

The welfare effect of a change in prices and income can be measured by the change in income that would produce the same change in the utility index <u>U</u> at the initial prices; that is

$$\text{(B.11)} \quad \frac{c_N}{s_N}(Y^*)^{s_N} + \frac{c_F}{s_F}(Y^*)^{s_F} = \frac{c_N}{s_N}(Y)^{s_N} + \frac{c_F}{s_F}\left(\frac{Y}{R}\right)^{s_F}$$

defines our index of real income Y^*. By total differentiation of (B.11) we obtain, with (B.5) and (B.10), the expression for y^* given in the text as equation (12).

4. Solving equations (B.4) and (B.9) for $t = 1,..,T$, we obtain the effect of the external shock (the increase in Π) on the exchange rate and nominal income. Real income is then obtained from (B.11). As in the text, we standardize variables so that $Y_t = R_t = \Pi_t = 1$ on the base, or reference, path. The substitution parameters σ_i and s_i are assumed to adjust geometrically to their long-run values. As σ_i changes with time, the scale parameters for the supply functions, γ_i, change in such a way as to make the short-run supply function to rotate on the long-run supply at the base prices. That is:

$$\text{(B.12.a)} \quad \gamma_N(t) = c_N(1-a_N)^{\sigma_N(t)/(\sigma_N(t)-1)}, \text{ and}$$

$$\text{(B.12.b)} \quad \gamma_X(t) = (1-c_B-c_N+a_N c_N)(1-a_X)^{1/(\sigma_X(t)-1)},$$

where c_B is the initial level of borrowing (not necessarily constant).

We solved this model of the economy for the cases of no additional borrowing, optimal borrowing with no risk aversion that is, with equalization of the exchange rate through the planning period), and infinite risk aversion (that is, with equalization of real income in all periods). The results are in Table B.1, where we present the changes in borrowing, B, the exchange rate, R, and real income, Y^*, for each 1 percent increase in the price of the inputs.

As expected, for small increases in Π, both the log-linear and CES results are indistinguishable. For higher increases in Π, the automatic updating of shares in the CES model predicts a larger change in the exchange rate and a bigger reduction in real income. The calculated level of additional borrowing falls to .03 percent of GDP (from .034 in the log-linear case) for each percentage point of increase in Π for increases on the order of 50 percent.

Table B.2 is the CES equivalent of Table 7: it compares the effect of the shock in economies with different dependence on imported inputs (the five economies are assumed to have the same foreign trade shares and no domestic production of the input). The values also are expressed as changes by each 1 percent of increase in Π, and are calculated for $\Pi = 1.30$ (a 30 percent increase in the international price of inputs). Comparison with Table 7 again shows that the log-linear model slightly overestimates the additional borrowing (particularly for high values of a) and underestimates changes in the rate of exchange and real income.

Table B.3 presents the sensitivity to the domestic production of imports (it is the equivalent of Table 9 in the text). We find again that the borrowing depends strongly on the amount imported but is almost independent of the total input use.

Table B.4 confirms the low interest elasticity of the demand for borrowing, and Table B.5 shows that borrowing increases about 30 percent when the planning horizon is increased from three years to five.

Table B.5, presents the sensitivity to the substitutability in production. (The cases are similar to those in Table 12: Short-run substitution is kept at its value in the base case and the "high" and "low" cases correspond to long-run substitution that is either 3 or 1.5 times its short-run value not 2 as in the base case). Now substitutability in the traded goods sector enters the results, but its effects are fairly small.

In summary, the main qualitative difference between the CES and log-linear models is the fact that the first still allows for some borrowing, even with extreme risk aversion, because it predicts a larger fall in real income immediately after the shock. (The amount is very small however, less than .006 percent for each 1 percent of increase in Π in the base case).

Table B.1: SENSITIVITY TO THE SIZE OF THE INCREASE IN Π

Input price	Borrowing		Exchange rate			Real Income		
			No	With borrowing		No	With borrowing	
	ϕ=0	ϕ=oo	borrowing	ϕ=0	ϕ=oo	borrowing	ϕ=0	ϕ=oo
	.034	.0000	1.28	.83	1.28	-.120	-.086	-.120
Π = 1.01	.009	.0000	.75	.83	.75	-.120	-.129	-.120
	-.031	.0000	.60	.83	-.50	-.120	-.161	-.120
	.033	.0023	1.33	.85	1.29	-.124	-.088	-.122
Π = 1.10	.009	-.0009	.76	.85	.77	-.121	-.131	-.122
	-.030	-.0018	.60	.85	.62	-.120	-.152	-.122
	.032	.0042	1.38	.86	1.31	-.129	-.090	-.124
Π = 1.20	-.009	-.0015	.77	.86	.79	-.122	-.132	-.124
	-.029	-.0035	.61	.86	.64	-.120	-.153	-.124
	.031	.0058	1.42	.88	1.32	-.134	-.092	-.126
Π = 1.3	-.009	-.006	.78	.88	.80	-.123	-.134	-.126
	-.028	-.0014	.61	.88	.65	-.120	-.154	-.126
	.030	.0083	1.51	.91	1.33	-.142	-.096	-.129
Π = 1.5	-.009	-.0029	.80	.91	.83	-.125	-.137	-.129
	-.027	-.0069	.61	.91	.69	-.120	-.156	-.129
	.026	.0117	1.65	.96	1.32	-.163	-.107	-.136
Π = 2.0	-.008	-.0039	.82	.96	.89	-.129	-.143	-.136
	-.023	-.0100	.62	.96	.75	-.120	-.153	-.136

Table B.2: SENSITIVITY TO THE IMPORTED INPUT SHARE

Imported input share	Period	Borrowing $\phi=0$	Borrowing $\phi=00$	Rate of Exchange: Without borrowing	Rate of Exchange: With borrowing $\phi=0$	Rate of Exchange: With borrowing $\phi=00$	Real income: Without borrowing	Real income: With borrowing $\phi=0$	Real income: With borrowing $\phi=00$
	1	.0136	.0014	.62	.39	.59	-.052	-.036	-.050
a = .05	2	-.0038	-.0005	.35	.39	.36	-.049	-.050	
	3	-.0123	-.0012	.28	.39	.29	-.049	-.062	-.050
	1	.0239	.0036	1.09	.68	1.02	-.097	-.068	-.092
a = .09	2	-.0067	-.0013	.60	.68	.62	-.091	-.100	-.092
	3	-.0215	-.0030	.47	.68	.50	-.089	-.114	-.092
	1	.0314	.0058	1.42	.88	1.32	-.134	-.092	-.126
a = .12	2	-.0089	-.0006	.78	.88	-.80	-.123	-.137	-.127
	3	-.0281	-.0014	.61	.88	.65	-.120	-.156	-.126
	1	.0454	.0113	2.06	1.25	1.85	-.213	-.145	-.195
a - .18	2	-.0132	-.0040	1.10	1.25	1.15	-.190	-.208	-.195
	3	-.0405	-.0093	.85	1.25	.94	-.184	-.237	-.195
	1	.0568	.0054	2.78	1.67	1.72	-.305	-.207	-.271
a = .24	2	.0168	-.0019	1.45	1.67	1.46	-.262	-.287	-.271
	3	.050	-.0045	1.11	1.67	1.38	-.250	-.323	-.271

Table B.3: SENSITIVITY TO DOMESTIC PRODUCTION OF IMPORTED INPUTS: BORROWING, RATE OF EXCHANGE AND REAL INCOME DURING THE FIRST PERIOD

Imported Input			Borrowing		Rate of exchange			Real Income		
Domestic Production	Imports	Total use	ϕ=0	ϕ=00	No borrowing	With borrowing ϕ=0	With borrowing ϕ=00	No borrowing	With borrowing ϕ=0	With borrowing ϕ=00
.08	.04	.12	.0108	.0015	.13	.01	.12	-.037	-.026	-.035
.06	.06	.12	.0162	.0021	.39	.19	.37	-.058	-.041	-.056
.051	.069	.12	.0185	.0024	.51	.27	.48	-.068	-.047	-.065
.04	.08	.12	.0215	.0030	.69	.39	.64	-.081	-.057	-.077
.024	.096	.12	.0255	.0040	.95	.57	.89	-.101	-.070	-.096
0	.12	.12	.0314	.0058	1.42	.88	1.32	-.134	-.092	-.126
.06	.12	.18	.0317	.0053	.90	.50	.83	-.123	-.086	-.126
.09	.12	.21	.0318	.0051	.70	.36	.64	-.119	-.083	-.113
.12	.12	.24	.0318	.0050	.54	.24	.49	-.116	-.081	-.110
.24	.12	.36	.0318	.0048	.07	-.11	.04	-.105	-.074	-.100

Note: ϕ is the risk-aversion coefficient. For ϕ = 0, the exchange rate is uniform over the planning period; for ϕ = 00 real income is stabilized.

Table B.4: SENSITIVITY TO THE COST OF BORROWING

Cost of borrowing (percent)	Period	Borrowing		Rate of exchange			Real Income		
				No borrowing	With borrowing		No borrowing	With borrowing	
		$\phi = o$	$\phi = oo$		$\phi = o$	$\phi = oo$		$\phi = o$	$\phi = oo$
0	1	.033	.0062	1.42	.86	1.31	-.134	-.091	-.125
	2	-.007	-.0017	.78	.86	.80	-.123	-.131	-.125
	3	-.029	-.0044	.61	.86	.65	-.120	-.151	-.125
10	1	.031	.0058	1.42	.88	1.32	-.134	-.092	-.126
	2	.009	-.0006	.78	.88	.80	-.123	-.134	-.126
	3	.029	-.0014	.61	.88	.65	-.120	-.154	-.126
20	1	.030	.0056	1.42	.90	1.32	-.134	-.094	-.126
	2	-.011	-.0024	.78	.90	.81	-.123	-.136	-.126
	3	-.030	-.0051	.61	.90	.66	-.120	-.157	-.126

Table B.5: SENSITIVITY TO THE PLANNING HORIZON

Planning horizon	Period	Borrowing		Rate of exchange			Real income		
				No borrowing	With borrowing		No borrowing	With borrowing	
		$\phi = 0$	$\phi = \infty$		$\phi = 0$	$\phi = \infty$		$\phi = 0$	$\phi = \infty$
T = 3	1	.0314	.0058	1.42	.88	1.32	-.134	-.092	-.126
	2	-.0089	-.0006	.78	.88	.80	-.123	-.137	-.126
	3	-.0281	-.0014	.61	.88	.65	-.120	-.156	-.126
T = 5	1	.0408	.0078	1.42	.73	1.28	-.134	-.081	-.123
	2	.0044	.0001	.78	.73	.78	-.123	-.118	-.123
	3	-.0131	-.0026	.61	.73	.63	-.120	-.135	-.123
	4	-.0217	-.0037	.54	.73	.57	-.119	-.144	-.123
	5	-.0259	-.0043	.51	.73	.55	-.118	-.148	-.123

Table B.6: SENSITIVITY TO THE DEGREE OF SUBSTITUTION. BORROWING, RATE OF EXCHANGE AND REAL INCOME IN THE FIRST PERIOD

Ratio of long run to short run substitution	Borrowing		Rate of exchange			Real income		
			No borrowing	With borrowing		No borrowing	With borrowing	
	ϕ = o	ϕ = oo		ϕ = o	ϕ = oo		ϕ = o	ϕ = oo
Base Case	.031	.005	1.42	.88	1.32	-1.34	-.092	-.126
SP_3: High LR substitution: Nontraded	.051	.0082	1.42	.58	1.27	-.134	-.069	-.122
SP_4: Low LR substitution: Nontraded	.025	.0044	1.42	.94	1.34	-.134	-.010	-.128
SX_3: High LR substitution Traded	.032	.0061	1.42	.87	1.31	-.134	-.092	-.125
SX_4: Low LR substitution Traded	.031	.0057	1.42	.38	1.32	-.134	-.092	-.126
SC_3: High LR substitution: Consumption	.040	.0066	1.42	.74	1.30	-.134	-.081	-.124
SC_4: Low LR substitution: Consumption	.026	.0053	1.42	1.00	1.33	-.134	-.010	-.126
SP_3, SX_3, and SC_3: High case	.050	.0089	1.42	1.18	1.26	-.134	-.070	-.121
SP_4, SX_4, and SC_4: Low case	.018	.0035	1.42	1.10	1.36	-.134	-.109	-.129

Note: Short Run substitution is as in the base case ($\sigma_S^N = .2$, $\sigma_3^X = .2$, $\sigma_3^D = .05$). In the "high" and "low" cases long run elasticities are 3.0 and 1.5 times their short run values, respectively.

Appendix C: The General Case of Labor Mobility

1. In Part V we discussed the effect of labor mobility under the assumption that both sectors have equal production functions, and that the substitution possibilities between all three factors could be represented by a unique parameter, σ . We will consider now more general production structures.

Any three factors, constants-returns-to-scale production function is characterized up to a second order approximation by just five parameters: two can be interpreted as the shares of two factors in the value of output when factors are paid their marginal product (the third share is given as a residual), and three define the curvature of the isoquants, i.e., the degree of substitution among factors. These parameters also determine all the own and cross elasticities of demand for factors and supply of output.

There are many ways of defining the three substitution parameters. We will use here a specification that has the advantage of being easily reduced to a two-stages CES production function, popular in the literature on general equilibrium numerical models.[28/] Two of the substitution parameters, σ_i^E and σ_i^L, represent the elasticity of factor demand with respect to the price of output; the third parameter, σ_i^o, represent the cross elasticity of factor demand.

Let e_i, ℓ_i and q_i be the log-changes in the use of the imported input, E, labor, L, and output, Q, in each sector; a_i, b_i and f_i the shares of E, L and the fixed factor in the value of output; and $\pi+r$, w_i and p_i the change in the prices of E_i, L_i and Q_i. Then we have the following system of factor-demands and output-supply system for i = N,X:

$$\text{(C.1)} \qquad q_i = - [a_i\sigma_i^E(\pi+r-p_i) + b_i\sigma_i^L(w -p_i)]/f_i$$

(C.2) $\quad e_i = - [(\sigma_i^E - b_i\sigma_i^o)(\pi + r - p_i) + b_i\sigma_i^o(w_i - p_i)]/f_i$

(C.3) $\quad \ell_i = - [a_i\sigma_i^o(\pi + r - p_i) + (\sigma_i^L - a_i\sigma_i)(w_i - p_i)]/f_i$

Convexity of the production function requires:

(C.4) $\quad \sigma_i^E - b_i\sigma_i^o > 0, \quad \sigma_i^L - a_i\sigma_i^o > 0 \quad$ and $\quad \sigma_i^* \equiv \sigma_i^E\sigma_i^L - \sigma_i^o(a_i\sigma_i^E + b_i\sigma_i^L) > 0$

The first two conditions guarantee that both factors have negative own price elasticities of demand. The third, which is equivalent to convexity of the isoquants on E and L with given levels of the fixed factor, implies a positively sloped supply function (i.e., $a_i\sigma_i^E + b_i\sigma_i^L > 0$).

The above formulation allows for the variable factors to be gross substitutes or complements: the elasticity of demand for labor with respect to the price of imported inputs is $\eta_{LE}^i = - a_i\sigma_i^o/(1 - a_i - b_i)$, so that if $\sigma_i^o < 0$ an increase in the price of the imported input increases the demand for labor. With gross substitute factors we may even have an inferior factor of production 29/, that is a negative σ_i^L or σ_i^E (although not both).

2. The assumption of a two-stages production process, i.e., of separability of the production function, implies that two of the three substitution parameters are equal. With $\sigma_i^L = \sigma_i^o$ the demand for labor is equally affected by an increase in the price of output and an equivalent reduction in the cost of the other variable factor; this is equivalent to a first stage production function on L and K alone (with elasticity of sustitution $\sigma^V = (1 - a_i)\sigma_i^E - b_i\sigma_i^L$) producing an intermediate output which combines with E (with elasticity of substitution $\sigma_i^L = \sigma_i^o$) to produce final

output. In a similar way, $\sigma_i^E = \sigma_i^o$ is equivalent to (E,K) separability and when $\sigma_i^E = \sigma_i^L$ the production function is separable in (E,L) and the fixed factor K. In all these cases, the convexity condition (C.4) implies that the variable factors are gross complements, i.e.,, $\sigma_i^o > 0$.

3. We will consider now the effect of gradual labor mobility on the supply for nontraded goods. From (C.1) and (C.3) it is easy to obtain the change in output as a function of the change in employment:

$$q_i = -\varepsilon_i(\pi+r+p_i) + \frac{b_i \sigma_i^L \ell_i}{\sigma_i^L - a_i \sigma_i^o}, \tag{C.6}$$

$$\text{with} \quad \varepsilon_i = a_i \sigma_i^* / f_i(\sigma_i^L - a_i \sigma_i^o) > 0$$

In the absence of labor mobility, the wage rates change as a result of the change in prices by an amount obtained from (C.3) when $\ell_i = 0$.

$$w_N^o = -\frac{a_N \sigma_N^o}{\sigma_N^L - a_N \sigma_N^o}(\pi + r) \qquad w_X^o = -\frac{a_X \sigma_X^o}{\sigma_X^L - a_X \sigma_X^o}\pi + r \tag{C.7}$$

The effect on wages of the increse in Π is negative in the "normal" case, i.e., when the input are gross complements.

With full labor mobility, wages are equalized in both sectors. If h_i is the initial share of employment in the i^{th} sector, the equilibrium wages and employment in nontraded change by

$$w_N^* = -\Sigma \frac{h_i}{f_i}[\sigma_i^L p_i - a_i \sigma_i^o(\pi+r)] / \Sigma \frac{h_i}{f_i}(\sigma_i^L - a_i - \sigma_i^o) \tag{C.8}$$

$$\ell_N^* = -\frac{h_X^*}{f_X}\left[\frac{a_N \sigma_N^o \sigma_X^L - a_X \sigma_X^o \sigma_N^L}{\sigma_X^L - \alpha_X \sigma_X^o}\pi + \sigma_N^L r\right] \tag{C.9}$$

$$\text{with}\quad h_X^* = \frac{h_X(\sigma_X^L - a_X\sigma_X^o)}{f_X\ \Sigma h_i\ (\sigma_i^L - a_i\sigma_i^o)\ /\ f_i} > 0 .$$

If we ignore as irrelevant the case of labor being an inferior factor of production, i.e., assuming $\sigma_i^L > 0$, a devaluation has a negative effect on employment in the nontraded sector. The direct effect on employment of the increase in Π is zero if both sectors are equally energy-intensive and the production function is separable in the imported input and capital (i.e., $\sigma_i^L = \sigma_i^o$); but it can be positive or negative with different factor intensity or substitution parameters.

Under the assumption of gradual mobility

$$\text{(C.10)}\qquad \ell_N = \psi\ell_N^* \qquad\qquad 0 < \psi < 1$$

with ψ an increasing function of time.

The resulting supply function for nontraded goods will then shift to the left with the increase in Π by an amount which is declining (increasing) with time if the factor intensity or substitutability condition is such that $\ell_N^* > 0$ (< 0) ; its elasticity with respect to the relative output price, R, is in all cases an increasing function of time.

That shifting supply function generates, together with the demand function $d_N = \eta^* r + \eta_N(-a\pi + B)$, and equilibrium path for the exchange rate. When production is biased against employment in the nontraded sector (i.e., when $a_N\sigma_N^o/\sigma_N^L > a_X\sigma_X^o/\sigma_X^L$), increased mobility reduces production of nontraded and may result in <u>increasing</u> devaluations. That, of course, would make foreign exchange more valuable in the future, acting against the real income effect as an argument for short-term borrowing. The magnitude of the devaluation is given by:

$$\text{(C.11)} \qquad r_t = \frac{a\eta - \varepsilon_N - \psi_t g_N (a_N \sigma_N^o \sigma_X^L - a_X \sigma_X^o \sigma_N^L)/(\sigma_X^L - a_X \sigma_X^o)}{\eta^* + \varepsilon_N + \psi_t g_N \sigma_N^L} \pi_t$$

where $\quad g_N \equiv b_N \sigma_N^L h_X^* \;/\; f_X(\sigma_N^L - a_N \sigma_N^o) > 0 \quad ,$

so that in order to obtain increasing devaluation, the bias has to be big enough for the following inequality to hold.

$$\text{(C.12)} \qquad \frac{1 - a_N \sigma_N^o/\sigma_N^L}{1 - a_X \sigma_X^o/\sigma_X^L} < \frac{\eta^* + a\eta_N}{\eta^* + \varepsilon_N} \; .$$

Footnotes

1/ World Development Report 1980, p. 10.

2/ This assumption will be revised in a future extension.

3/ Because the relative price of exports and imported final goods remains constant throughout the analysis, they can be aggregated into one single (bundled) commodity called traded goods. Hence Q_X can be interpreted as the domestic production and D_F as the domestic consumption, of both exportables and final importables.

4/ Under competitive assumptions, total value added $Y = Q_N + RQ_X - R\Pi E + RT$ is maximized at each moment with respect to Q_N, Q_X and E; that is, $dQ_N + RdQ_X - R\Pi dE = 0$ for all feasible changes in these variables. Thus, when prices change

$dY_X = Q_X dR - Ed(R\Pi) + d(RT)$,

from which we obtain

$$y = \left(\frac{dY}{Y}\right) = \left(\frac{R}{Y}\right) [Q_X - E\Pi + T]\ r - \left(\frac{rE\Pi}{Y}\right) \pi + \frac{RdT}{Y}$$

this is (4), as $\frac{R}{Y} \cdot [Q_X - E\Pi + T] = c_F$; $\left(\frac{RE\Pi}{Y}\right) = a$, and B $\left(\frac{dT}{Y}\right)$

5/ Given that aggregate expenditures are assumed to be always equal to aggregate income. Alternatively we could work with $d_N = q_N$ and the balance of payment constraint $D_F + \Pi E = Q_X + T$.

6/ Expression (11) is derived from $d_F = [(\frac{1-c_F}{c_F})\ \eta^* + \eta_F c_F]\ r + \eta_F y$, where the term in brackets represents the uncompensated own-price elasticity for final imported goods. The compensated own-price elasticity for nontraded goods, η^* has been substituted by using the symmetry properties of demand in the two goods cases.

7/ The sign of r will depend on:

$$a\eta_N \gtrless (\frac{a_N}{1-a_N})\ \sigma_N\ .$$

Because the nontraded sector is by far far the larger, the magnitudes of a and $a_N/(1-a_N)$ are quite similar. Consequently the sign of r depends on the magnitude of η_N relative to σ_N. Our presumption is that η_N is substantially larger than σ_N .

8/ After allowing for any difference between the social rate of discount and the cost of borrowing. We should make it explicit that the borrowing we are considering is <u>additional</u> to any (positive or negative) amount the country was already borrowing before the external shock. The optimum level of borrowing in the absence of shocks depends on the social rate of discount, the cost of borrowing, the productivity of physical capital, the expected increases in productivity or in the amount of factors available, etc. We will abstract in this paper of these long run factors, although we will assume that the country is following a borrowing strategy optimally adapted to them.

9/ This condition is obtained as the solution of the problem

$$\underset{B_t}{\text{Max}}\ \Sigma V(R_t, Y.(R_t, B_t))\ \delta^{-t} \qquad \text{subject to } \Sigma B_t \rho^{-t} = 0(*)$$

where $V(R,Y)$ is the indirect utility function (that is, $V(R,Y) = \text{Max } V(D_N, D_F)$, subject to $D_N + RD_F \leq Y$), and $Y(R_t, B_t) + R_t B_t$ represents the maximum of total expenditures in terms of nontraded goods achievable when the rate of exchange is R_T and B_t is being borrowed abroad. The first order conditions for solving that problem are, for all t:

$$(\partial V/\partial R_t) + (\partial V/\partial Y_t)/(\partial Y_t/\partial R_t) = 0 \text{ , and}$$

(13.a) $$(\partial V/\partial Y_t)\ R_t \delta^{-t} = \lambda_o \rho^{-t}$$

where λ_o is the Lagrange multiplier associated to the repayment condition (*). Equation (13.a) is the same that (13) as, by definition, $\lambda_t = \partial V/\partial Y_t$.

10/ If $V(R,Y)$ is the indirect utility function, as in the preceeding footnote, $\lambda = V_Y \equiv \partial V/\partial Y$, so that:

$$d \log \lambda = (YV_{YY}/V_Y)\ d \log Y + (RV_{YR}/V_Y)\ d \log R = -\ \phi y + (RV_{YR}/V_Y)r.$$

The demand for the imported final good, D_F, by the Roy identity is $d_F = -V_R/V_Y$, so that its income elasticity is:

$$\eta_F = YV_{RY}/V_R - YV_{YY}/V_Y = YV_{RY}/V_R + \phi\ .$$

With enough smoothness in $V(R,Y)$ the cross derivates V_{RY} and V_{YR} are equal, so that:

$RV_{YR}/V_Y = -(RD_R/Y)(YV_{RY}/V_R) = -\Theta_F(\eta_F - \phi)$.

Replacing the right-hand side of this equation in the expression for $d\log\lambda$ above, we obtain (14), as $y^* = y - \Theta_F r$.

11/ Recall that in the log-linear model differential substitution in the two periods does not induce a difference between Y_1^* and Y_2^*. In both period the decline in income with respect to the trend is $a\pi$, where a is the initial share of imported inputs in GNP.

12/ In this case GNP is equal to $Y = Q_N + D_F = Q_N + k_M(X+T-E)$ where X+T-E is the amount of foreign exchange available to import final goods. Hence $c_N + k_M(c_X + c_B - a) = 1$.

13/ This can be justified by simply assuming that energy (E) and other imported inputs (M) enter the production function as a composite index $I^*(E,M)$, where I^* is homogeneous of degree one. Within the log-linear approximation of the model in Parts II and III, the substitutability between both types of imports is irrelevant (in the same way that σ_X is).

14/ Positive savings in the present can be expected if the discounted utility of one dollar saved is larger than its value today:

$$\frac{(1+RRK)(1-\phi RGC)}{1+SRD} > 1, \quad \text{or } RRK-SRD > \phi RGC,$$

where RRK = real rate of return to capital; RGC = (g-1) = rate of growth of per capita consumption, and SRD = (δ-1) = social rate of discount. If the expected rate of growth of per capita income and consumption is 3.0 percent a year (the average for middle income countries in the period 1960-78 was 3.7 percent, World Development Report, 1980) a rather high value of ϕ, would imply that savings would take place only if the difference between RRK and SRD is very high, around 10 percent. If $\phi = 3$ and RRK is as high as 15 percent no capital accumulation ought to take place if the social discount rate is above 5 percent.

If SRD = .05 and RRK = 0.10 (the cost of borrowing used in our analysis) positive savings would not be consistent with growth of per capita income of 3 percent values of ϕ larger than 1.66.

15/ It depends less on the variability of the share of imported inputs in total imports, which ranges between 40 and 60 percent. See Table A.2 in Appendix A.

16/ The calculations are made under the assumption that as a increases total imports remain constant, so that imports of final goods are reduced (with total consumption of the imported good also falling or domestic production making up the difference). An alternative assumption, and perhaps more realistic, would be to take as constant the composition of imports, so that total imports (and, hence, exports given the constant initial deficit, c_B) would change proportionally with the share of imported inputs in GDP (again, the change in imports of final goods can be assumed to result in lower consumption or higher domestic production of traded goods).

We have, thus, four different ways of defining the economies with different values of a. They are presented in the Appendix to this section, in Table A.3. The implied levels of borrowing are remarkably similar in all cases (see also the discussion below on the effect of changes in c_N and k_M).

17/ By definition $(d \log D_N/\partial \log P_F)^{\bar{u}} = -(\partial \log D_N/\partial \log P_N)^{\bar{u}} = \eta^* = \sigma^D/c_N$) and $(d \log D_F/\partial \log P_N)^{\bar{u}} = -(d \log D_F/\partial \log P_F)^{\bar{u}} = \sigma^D/(1-c_N)$.

18/ Remember that the elasticity of supply for good i (i = N,X) is $\varepsilon_i = \sigma_i a_i/(1-a_i)$, where σ_i is the elasticity of substitution and a_i the input share.

19/ A recent survey of results on elasticity of demand for energy in the U.S. is Energy Modeling Forum, Aggregate Elasticity of Energy Demand, vol.1, August 1980. Additional estimates and extensive references to the literature can be found in E.R. Berndt and D.O. Wood, "Engineering and Econometric Interpretation of Energy-capital Complementarity," American Economic Review, 1979, pp. 342-54. Three recent numerical models centered on the energy sector--for the U.S. (A.S. Manne, Long term Energy Projection for the U.S.A., Stanford University, September 1979); Sweden (L. Bergman, Energy Policy in a Small-open Economy: the Case of Sweden, International Institute for Applied Systems Analysis, Austria, November 1978); and the world (A.S. Manne, S. Kin and T.F. Wilson, A Three Region Model of Energy International Trade and Economic Growth, Stanford University, March 1980)--use for their base case, "judgemental estimates" of the elasticity of substitution between energy and other inputs of .30, 0.25, and 0.25, respectively.

20/ In fact we worked with the symmetric part of the compensated elasticity of demand, $\sigma^D = c_N\eta^*$, as noted in the discussion of the sensitivity to the share of nontraded goods, p. 37.

21/ The calculated levels of borrowing are much more sensitive to the increase in substitution than to its absolute value (which, however, affects strongly the estimated change in the exchange rate). Thus, we present only the results with short-run substitution fixed at its base values.

22/ By definition of the CES function, $\sigma = (q_i - \ell_i) = (p_i - w_i) = (q_i - p_i)/(p_i - \pi - r)$; and as only L_i and E_i are variable, $q_i = a_i e_i + b_i \ell_i = (a\ell_i + b\ell_i)/(1+a)$. From these equations we can derive (23) and (24).

23/ There is an exception to that: if labor and the imported inputs are "gross substitutes" in production (i.e., if an increase in the price of one of them increases the demand for the other at given output prices and with the third factor fixed), the fixed factor bears the brunt of the adjustment to higher input prices. In that case, labor would move toward the nontraded sector, despite its higher energy intensity. The assumption of "gross substitution" is incompatible with a CES (or any other separable) three inputs production function; it does not imply that labor or the imported input are an "inferior factor of production" (i.e., one with a demand function that decreases when the price of output increases).

24/ From Appendix C (equation C.12) it is seen that when both production functions are CES but the factor shares are different in both sector, an increase in the labor mobility factor, ψ, reduces the value of the change in the rate of exchange, r, if and only if

$$(40) \quad \frac{1-a_N}{1-a_X} > \frac{\eta^* + a\eta_N}{\eta^* + \varepsilon_N} = 1 + r_o$$

where r_o is the devaluation without labor mobility. Considering a devaluation of 0.83, as in the base case (Table 5), and an aggregate imported input share a = 0.12, the share of imported inputs in the traded sector should be at least four times as big as in the nontraded sector to produce a declining devaluation.

25/ There are several models in the literature considering the impact of the oil shock with capital mobility: Dornbush (1980), Bruno and Sachs (1978), van Wijnbergen (1980), Findlay and Rodriguez (1977).

26/ Commercial policy would also introduce different incentives for exportables versus importables, and for the domestic market versus exports, so that the precise nature of the aggregated "traded good" in production and consumption would likely be affected. That would change some of the sensitivity analysis in the text.

27/ If there is any (price-independent) domestic production of the imported input, Q_E, B should be replaced by $B + \Pi Q_E$ in all that follows.

28/ For a good survey of theory, and applications see Dervis, de Melo and Robinson, (1980).

29/ For a discussion of 'factor inferiority' see C.E. Ferguson, The Neoclassical Theory of Production and Distribution (Cambridge University Press, 1969), Chapter 9.

References

1. Balassa, B. (1980), "Policy Responses to External Shocks in Selected Latin American Countries," World Bank processed October 1980.

2. Bergman, L. (1978), Energy Policy in a Small Open Economy: The Case of Sweden, International Institute for Applied Systems.

3. Berndt and D.O. Wood (1979), "Engineering and Econometric Interpretation of Energy-capital Complementarity," American Economic Review, 1979, pp. 342-54.

4. Chenery, H. and M. Syrquin (1975), Patterns of Development 1950-1970, (Oxford University Press).

5. Bruno, M. and J. Sachs (1978), Macroeconomics Adjustment with Import Price Shocks: Real and Monetary Aspects, Seminar paper No. 118, Institute for International Economic Studies, Stockholm.

6. Dervis, K., J. de Melo, and S. Robinson, (1980), Planning Models for Developing Countries.

7. Dornbush (1980), "Inflation, Stabilization and Capital Mobility," Lecture in memory of M. Sidrausky at the meeting of the Econometric Society, Buenos Aires, July, 1980.

8. Energy Modelling Forum (1980), Aggregate Elasticity of Energy Demand, vol. 1, Stanford University, IMF Report 4, August 1980.

9. Ferguson, C.E. (1969), The Neoclassical Theory of Production and Distribution (Cambridge University Press).

10. Findley, R. and C.A. Rodriguez (1977), "Intermediate Imports and Macroeconomic Policy Under Feasible Exchange Rates", Canadian Journal of Economics, May 1977, pp. 208-17.

11. International Monetary Fund, International Financial Statistics, several issues.

12. Katseli-Papapaefstratiov, L.T. (1980), "Transmission of External Price Disturbances and the Composition of Trade," Journal of International Economics 10, 1980, pp. 357-75.

13. Lucas, R.F. (1980), "Tariffs, Nontraded Goods and the Optimal Stabilization Policy," American Economic Review, September 1980, p. 611-25.

14. Manne, A. G. (1979), Long-term Energy Projections for the U.S.A, Stanford University, International energy programs report, September 1979.

15. __________ (1980), A Three Regions Model of Energy, International Trade and Economic Growth, Stanford University, Department of Operations Research, March 1980.

16. de Melo, J. and S. Robinson (1980), "An Economic and Political Analysis of Alternative Trade Adjustment Policies in Three Archetype Developing Economies," World Bank, Staff Working Paper, No.442.

17. United Nations, Yearbook of International Trade Statistics, Trade by Country, U.N., New York, several years.

18. van Wijnbergen, S. (1980), "Oil Price Shocks and the Current Account: and Analyis of Short Run Adjustment Measures," World Bank processed, September 1980.

19. World Bank (1980), World Development Report, 1980, The World Bank, Washington,D.C.

RECENT PAPERS IN THIS SERIES

No.	TITLE OF PAPER	AUTHOR
450	Education and Basic Human Needs	A. Noor
451	Economics of Supplemental Feeding of Malnourished Children: Leakages, Costs and Benefits	O. Knudsen
452	Land Tenure Systems and Social Implications of Forestry Development Programs	M. Cernea
453	Industrial Prospects and Policies in the Developed Countries	B. Balassa
454	Labor Migration from Bangladesh to the Middle East	S. Ali, A. Arif A.K. Habibullah, R. A. Hossain, W. Mahm S. Osmani, Q. Rahma A. Siddiqui (consul
455	Managerial Structures and Practices in Manufacturing Enterprises: A Yugoslav Case Study	M. Schrenk
456	Nutritional Consequences of Agricultural Projects: Conceptual Relationships and Assessment Approaches	Per Pinstrup-Anderse (consultant)
457	Industrial Strategy for Late Starters: The Experience of Kenya, Tanzania and Zambia	R. Gulhati U. Sekhar (consultant
458	Comparative Study of the Management and Organization of Irrigation Projects	A. Bottrall (consulta
459	Size of Land Holding, Living Standards and Employment in Rural Western India, 1972-73	P. Visaria
460	Some Aspects of Relative Poverty in Sri Lanka, 1969-70	P. Visaria
461	Incidence of Poverty and the Characteristics of the Poor in Peninsular Malaysia, 1973	P. Visaria
462	Regional Aspects of Family Planning and Fertility Behaviour in Indonesia	O. Meesook D. Chernichovsky
463	What is a SAM? A Layman's Guide to Social Accounting Matrices	B.B. King
464	Structural Adjustment Policies in Developing Countries	B. Balassa
465	Cost-Benefit Evaluation of LDC Industrial Sectors which have Foreign Ownership	G. Pursell