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FOREIGN DEBT, ECONOMIC GROWTH, AND THE PROBABILITY OF DEFAULT

by

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A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

Doctor of Philosophy

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HOUSTON, TEXAS
APRIL 1983

Abstract

Foreign Debt, Economic Growth, and the Probability of Default

Ronald L. Leven

Most less developed countries are dependent on external borrowing to achieve high sustained economic growth. However, external borrowing requires fixed payments independent of the actual return on the invested funds. If a country either invests the money inefficiently or is subject to unexpected difficulties, it may not be able to meet contracted service payments. Potential debt servicing problems have existed for many years, and recently, the actual occurrence of service interruptions has become much more frequent.

Despite the difficulty of servicing debt, it is optimal, in an economic sense, for less developed countries to borrow abroad. Foreign capital goods are usually scarce in less developed countries so their productivity is relatively high. Foreign borrowing allows more imports of capital without forcing down consumption. As long as the productivity of the capital exceeds its cost, debt servicing problems should not arise.

A study of Honduras indicates that real GDP growth can be increased through foreign borrowing. However, the higher level of debt raises the likelihood of debt servicing difficulties. Even when the use of debt is efficient, a heavier debt burden makes Honduras more susceptible to unexpected shocks. But if GDP growth is not overly ambitious, the debt servicing burden stabilizes and may eventually begin to decline. The greatest danger arises when future debt servicing requirements are ignored. A sharp increase in external debt may allow high GDP growth in the short run but eventually the resulting debt service will become unsustainable.

Acknowledgements

Any document which has spanned as much time and space as this dissertation collects a lot of help along the way. There are my colleagues at work who have provided me with the intellectual guidance and stimulation which are necessary to keep a work alive. There was my father and younger brother (he received his Ph.D. almost a year ago) who showed me the importance of finishing this project. Without the heroic patience of my secretary, May Sanon, completion would not have been possible. My committee, particularly Dr. Smith, has been helpful in all of these ways. Finally, I would like to thank my wife and my mother who both helped me keep this project in perspective.

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CHAPTER I

Review of the Literature

By using foreign borrowing to finance imports, a country can compensate for external shocks as well as increase potential economic growth. However, foreign borrowing will also increase the debt servicing commitment in future years. This dissertation will examine the relationship between foreign borrowing, economic growth, and the ability to service external debt. A theoretical economic model will be developed in Chapter II which will indicate at what point the positive impact of external borrowing on growth is outweighed by the negative impact generated by the need to service the debt. An empirical model will be developed in Chapter III to determine the actual relationship between growth and external debt. As a case study, the model will be estimated for Honduras and growth will be simulated under conditions of constrained and unconstrained foreign borrowing.

Most LDCs (less developed countries)[1/] are dependent on foreign capital inflows to achieve high sustained economic growth. The general effect of foreign capital inflows is to increase a country's command of global production. In other words, it raises the amount of imports a country can finance, given the level of

exports. A capital inflow thus increases the availability of real resources at a given point in time.

Minimum consumption levels, and thus maximum levels of domestic savings, usually are constrained in most countries by social factors. Increased imports of consumption goods can free more domestic output for investment, thus allowing a higher level of growth. Alternatively, if perfect substitutes for domestic capital can be imported then foreign capital can directly supplement domestic savings. Imports may themselves be a constraint on economic growth in LDCs. Certain imported inputs may be critical for domestic production. If imports are constrained by foreign exchange availability, then bottlenecks may develop which inhibit economic growth.

Foreign capital inflows thus play a dual role in raising economic growth in LDCs. First, they allow a higher level of imports of goods which cannot be produced domestically. Secondly, it can substitute for domestic production, thus supplementing domestically generated investment. The relative importance of these two roles will vary between countries and over time.

The two forms of foreign capital flows are external borrowing and direct investment. In 1980, direct investment in non-OPEC LDCs was around $10 billion and

external borrowing was around $30 billion.[2/] One distinction between these two forms of inflows is that borrowing requires an explicit contracted repayment schedule, but in the case of direct investment repayment is implicit. The significance of this distinction is that external borrowing generates fixed payments of amortization and interest regardless of the actual return on the investment. Thus, if a country borrows and either invests the money inefficiently or is subject to unexpected difficulties, it may not be able to meet contracted service payments. For a country to benefit over time, the higher growth generated by the inflow must be more than sufficient to repay the debt.

In a world of certainty, a country would always have sufficient income to service external debt. Since the impact of imports on future income would be predictable, a country could avoid contracting debt which would not generate sufficient returns to cover repayment. While a high relative value on current consumption might lead a country to attempt to borrow capital which it could not repay, lenders would be unwilling to provide the funds. Uncertainty, however, can easily lead to difficulties in servicing external debt. An unexpected decline in exports or an increase of import prices could

reduce the foreign exchange available for servicing the debt. An unexpected decline in foreign exchange would not create a servicing problem if borrowing was unlimited since maturing debt and interest could continually be repaid through new borrowing. Limits on borrowing, however, do exist. Since there is a competitive world market for capital, to increase capital inflows an LDC must increase the interest rate it pays. In addition, lenders may be unwilling to lend to a country regardless of the interest rate if the perceived risk is high.

LDCs have sporadically fallen into arrears, but only in a few instances has external debt been renounced. In the early 1930's, several Latin American countries defaulted on bonds held by foreign countries. In the 1950's, several countries, notably Argentina and Brazil rescheduled their debt. More recently, Peru, Chile, and Zaire among others have had difficulty servicing their debt.[3/]

As indicated above, potential debt servicing problems have existed for many years. However, several trends developed in the 1970's which intensified concern. First, the level of LDCs' publicly guaranteed external debt increased almost fivefold between 1969 and 1980 reaching $300 billion.[4/] The relative burden of the

debt has also risen rapidly in recent year. The average ratio of external debt to GDP for non-OPEC LDCs rose from about 10 percent in 1970 to about 19 percent in 1980.[5/] Secondly, LDCs have become increasingly dependent on private sources, especially banks, as a source of capital. The consequence of the rapid growth of external debt is clear since as debt rises so do debt service payments. The trend toward higher service payments is intensified by the greater reliance on private sources since these credits usually carry higher interest rates and shorter maturities. Finally, over the last few years, many LDCs have been faced with the twin burden of higher oil prices and rising interest rates in international capital markets. Between 1978 and 1980, oil prices rose over 125 percent. Consequently, non-oil producing LDCs found their import costs rising rapidly. Heavy recourse to external borrowing was the only means to avoid a sharp drop in economic growth rates. However, during this same period LIBOR rose from 9 percent to 14 percent. Thus increasingly, countries that borrowed to finance higher import spending had difficulty servicing external debt. This trend is reflected on Table 1.1 by the rapid rise of countries in arrears on external debt since 1978.

Table 1.1

Countries with Reported Arrearages*
1960 - 1980

1960	1961	1963	1964	1965	1966
Brazil Ghana	Argentina	Brazil	Argentina Chile Turkey Yugoslavia	Ghana Egypt Indonesia	Indonesia

1967	1969	1970	1971	1972
Ghana Indonesia Peru	Ghana Indonesia Philippines	Egypt Pakistan Yugoslavia	Cambodia Chile Pakistan Turkey	Pakistan

1973	1974	1976	1977
Chile Ghana	Chile Sierra Leone Zaire	Congo Egypt Gabon Ghana Guinea Guinea-Bissau Guyana Jamaica Madagascar Pakistan Peru Sierra Leone Sudan Togo Turkey Uganda Zaire Zambia	Congo Gabon Ghana Guinea Guinea-Bissau Guyana Jamaica Madagascar Nicaragua Sierra Leone Sudan Togo Turkey Uganda Zaire Zambia

*Souce: IMF, Annual Report on Exchange Restrictions

Table 1.1 (continued)

Countries with Reported Arrearages

1978	1979	1980
Bolivia	Central Afr. Rep.	Bolivia
Congo	Chad	Central Afr. Rep.
Dominican Rep.	Congo	Chad
Gabon	Dominican Rep.	Congo
Ghana	Ghana	Costa Rica
Guinea	Grenada	Dominican Rep.
Guinea-Bissau	Guinea	Gambia
Guyana	Guinea-Bissau	Ghana
Iran	Guyana	Grenada
Jamaica	Iran	Guinea
Madagascar	Jamaica	Guinea-Bissau
Nicaragua	Liberia	Guyana
Sierra Leone	Madagascar	Jamaica
Sudan	Mauritania	Madagascar
Togo	Nicaragua	Mauritania
Turkey	Sierra Leone	Nicaragua
Uganda	Sudan	Senegal
Zaire	Tanzania	Sierra Leone
	Togo	Somalia
	Turkey	Sudan
	Uganda	Tansania
	Zaire	Togo
	Zambia	Turkey
		Uganda
		Zaire
		Zambia

Models of Foreign Borrowing

The "two-gap" model was one of the first methods of modeling the role of foreign borrowing in determining economic growth. The basic two-gap model is outlined in Chenery and Strout (1966). This model uses the two accounting identities:

$$(1.1) \qquad Y_t = C_t + S_t$$

$$(1.2) \qquad S_t = I_t - F_t$$

where Y is GNP, C is consumption, S is savings, I is investment and F is net foreign capital movements. The upper bound of GNP is determined by the level of investment:

$$(1.3) \qquad Y_t \leq Y_o + 1 \sum_{t=0}^{T-1} I_t \text{ where } k = \frac{I_{t-1}}{Y_t - Y_{t-1}}$$

Similarly, the upper bound on savings is determined by:

$$(1.4) \qquad S_t \leq S_o + a'(Y_t - Y_o)$$

Investment is assumed to grow exogenously and a target growth rate of GNP is also assumed. Since the time path of savings is determined by the growth of GNP it need not equal the rate of investment. The difference between I_t and S_t, the savings gap, is assumed to be offset by an equal inflow or outflow of foreign capital.

Similarly, a foreign exchange gap can arise because exports are assumed to grow exogenously while imports are a function of GNP. An inflow of foreign capital may be required if imports are greater than exports in a given year. Thus, once the target growth rate of GNP is specified the required inflows of foreign capital is determined by the larger of the two gaps.

The Chenery-Strout model was not intended to determine foreign borrowing but rather was designed to indicate the level of foreign aid that LDCs needed. Thus, there is no account taken of the need to finance existing debt. An attempt to utilize the two gap framework to model foreign capital movements in a dynamic situation was made by Mikesell (1968).

Mikesell's gap model indicates under what circumstances a nation can utilize foreign borrowing to finance a gap without generating an unserviceable debt burden. By definition, the savings gap is the difference

between domestic savings and investment. Like Chenery and Strout, Mikesell assumes that investment and savings are proportional to GNP and the rate of growth is exogenous. Mikesell's measure of the savings gap (F^S) is derived as:

$$(1.5.1) \quad F_o^S = I_o - S_o = Y_o k - Y_o s = Y_o(k - s)$$

where k is the incremental capital output ratio, s is the average savings ratio in the initial year and g is the target growth rate for GNP (Y). The amount of foreign capital required to fill the gap in the subsequent year can be derived from (1.4):

$$(1.5.2) \quad F_1^S = I_1 - S_1 = F_o^S + Y_o g(kg - s')$$

where s' is the marginal savings rate.

Similarly, if the foreign exchange gap is relevant, given initial values for GNP and the exchange gap (F^E) in subsequent periods it is derived as:

$$(1.6) \quad F_1^E = M_1 - E_1 = F_o^E + Y_o g(u' - e')$$

where M_1 and E_1 are imports and exports respectively

and u' and e' are the marginal propensities to import and export.

Mikesell's major concern is determining whether dependency on foreign capital is a transitory phenomena. The determinant of this is whether $F_1 < F_o$. In general he finds that under a savings constraint a declining foreign capital requirement occurs if $s' > k$; if there is an exchange constraint then the foreign capital requirement will decline if $e' < u'$. Thus, in Mikesell's model the flow of capital over time depends on the marginal propensities to save and import.

The major shortcoming of Mikesell's approach is that it is an accounting model which ignores the need to finance foreign debt. Mikesell does address the problem of debt service but as an issue in isolation. Mikesell's basic model of estimating the capacity to service debt is based on an earlier model by Aramovic (1964). The basic premise of the model is that debt capacity is directly related to foreign capital inflows. If the foreign exchange available (including additional borrowing) to a country is less than debt service payment then default is a necessity. Mikesell claims that export earnings are the most crucial component of debt service capacity. Thus, he claims that highly variable export earnings coupled with a

high ratio of debt service to exchange earnings indicates a poor ability to service debt.

Mikesell's only means of incorporating debt service capacity into his gap model is his calculation of a critical interest rate. The definition of the critical interest rate (i) is "the highest rate that the country can afford to pay on external borrowing to cover the interest savings gap without letting interest charges rise faster than its national product".[6/] Given Mikesell's gap model this rate can be calculated as:

$$(1.7) \qquad i = \frac{g(s_o - s')}{s_o - k_t}$$

where s_o is the initial savings to output ratio. The basic premise of the critical interest rate is that borrowing at a higher rate would yield service payments which will be greater than export revenues, necessitating continued borrowing to obtain sufficient capital to service the debt. Under this criterion, if the debt service payments are permitted to exceed export earnings then the level of debt will grow without limit.

Default Indices

Frank (1970) uses the debt service export ratio as an indicator to determine whether the debt is

serviceable. He observes that throughout the 1950's and 60's, there has been a significant correlation between the debt-service ratio and the appearance of arrears. Thus, like Mikesell, he feels that the serviceable level of debt is constrained by the relative value of debt service and export earnings. Both of these authors, however, admit the inaccuracy of using this relationship to predict arrearages. Frank observes that countries with ratios as high as 44 percent have successfully serviced foreign debt. Other countries have accumulated arrears with a ratio as low as 16 percent.[7/]

Frank and Cline (1971) in a later study recognized that factors other than the debt-service ratio may affect the level of debt which can be successfully serviced. They hypothesized that a country with a high growth rate for exports is less likely to reschedule debt since the prospects are good for increasing foreign exchange holdings in the near future. If export revenues are highly variable, however, then this increases the probability of an unanticipated foreign exchange shortage. A composition of imports which prevents a rapid reduction of imports during a balance of payments crisis increases the probability of servicing interruptions. Frank and Cline measure the "non-compressibility" of

imports by the ratio of intermediate goods, capital good, and basic foodstuffs to total imports. It is also hypothesized that a country with low imports to GDP can more easily withstand a short-term reduction in imports. It is assumed that countries with higher per capita income will be more flexible in dealing with a balance of payments crisis. The average maturity of the debt will effect debt servicing since a country with predominantly long-term debt has little ability to reduce debt servicing in the short run. Finally, the ratio of imports to reserves is included to indicate the extent that the country is protected from random fluctuations of the balance of payments.

Using discriminant analysis, an index for estimating a composite index (Z) of debt servicing capacity was estimated as

$$(1.8) \quad Z = -.22 + 1.50X_1 - .05X_2 - .072X_3 - .11X_4 + .02X_5 - 1.37X_6 - .27X_7 - .04X_8$$

where

X_1 = debt-service ratio

X_2 = growth rate of exports

X_3 = export fluctuations

X_4 = index of import "non-compressibility"

X_5 = per-capita income

X_6 = ratio of amortization to total debt

X_7 = ratio of imports to GNP

X_8 = ratio of imports to reserves

The critical value of Z = 0, so any country which generates a negative value for the index is predicted to default.

Frank and Cline's estimated t statistics indicated that of the eight variable in the index only the debt-service ratio, the ratio of amortization to debt, and the ratio of imports to reserves were significant. Furthermore, they found that the ability to predict reschedulings was improved if X_8 was also excluded from the index. Thus, they concluded that by using discriminant analysis on only X_1 and X_6 an index could be generated which can successfully predict debt reschedulings.

Feder and Just (1977) have developed an index of the factors affecting debt servicing capability by using logit analysis. They utilize all the variables in the Frank-Cline study with the exception of import

compressibility. Import compressibility was excluded because Feder and Just were unable to gather data which was consistent across countries. Two additional indicators were added, capital inflows, and per capita growth of domestic product. Capital inflows were included because they are an important source of foreign exchange which can be used for servicing the debt. A higher capital inflow thus should be associated with a lower probability of debt-service interruption. Growth of per capita domestic product was included because of Aramovic's (1964, p. 69) statement "the only important factor from the long run point of view is the rate of growth of production".

Feder and Just initially estimated a logit-index using all nine variables, however, they found that the coefficients for X_3 and X_7 seemed to be misspecified since the estimated coefficients for both variables were negative. Thus, they excluded these two variables from subsequent estimates. Since the coefficient for GDP growth was not statistically significant an estimate was also made excluding this variable. Finally, an estimate excluding the amortization-debt ratio was also made because the data was unreliable. The results of their estimates were:

Table 1.2

Logit estimates of default probability*

Variable	Case (a)	(b)	(c)	(d)
Debt service ratio	53.6619 (2.5731)	59.2085 (3.2861)	35.9826 (3.3768)	38.0096 (3.6181)
Import/reserves	0.3946 (1.8323)	0.3867 (1.7877)	0.3614 (1.8622)	0.3535 (1.7895)
Amort./debt	-34.6172 (1.6535)	-39.6368 (2.1808)		
Income capita	-0.0116 (2.4708)	-0.0124 (2.8337)	-0.0113 (3.0333)	-0.0142 (3.5523)
Capital inflow/ debt service	-2.6685 (2.9576)	-2.8591 (3.3930)	02.1301 (3.4862)	-2.2730 (3.6666)
GDP growth	-18.1495 (-0.4011)		-50.3238 (1.4274)	
Export growth	-44.8634 (1.7120)	-52.6046 (2.7077)	-30.5812 (1.6159)	-47.3640 (2.8498)
Likelihood ratio index	0.9222	0.9217	0.9086	0.9019
Likelihood ratio stat.	304.2605	304.0954	299.7940	297.5613

*Figures in parentheses denote t-values.

Their estimates allow the probability of default for a given country to be estimated once the values of the variables included are known. Feder and Just suggest that a critical probability P* can be determined beyond which

countries would be unlikely to be able to service their debt. If P* is set anywhere between 18 and 50 percent

Table 1.3

Variable	Model 1 (first-order approximation) Coef.	Asymptotic t-ratio	Model 2 (second-order approximation) Coef.	Asymptotic t-ratio
Debt service/ exports	20.140	6.19	44.13	3.49
[Debt service/ exports]^2			-46.10	-2.32
GNP/US GNP	-22.840	-3.46	-18.86	-2.94
Reserves/Imports	-3.993	-2.70	-14.48	-2.94
[Reserves/Imports]^2		13.06	2.27	
Exports/GNP	-3.834	-1.46	5.58	-1.76
Noncommercial Inflows				
Debt Service	-.670	-2.03	-.685	-1.89
Commercial Inflows				
Debt Service	-1.069	-4.54	-1.312	-2.35
Commercial Inflows				
Debt Service			-.829	-1.63
Constant Term	-2.188	-2.11	-3.318	-1.91
Likelihood Ratio Index	.850		.873	

then the number of countries which have a probability above the critical value yet do not default is minimized. In applying their index to test data Feder and Just found that between 95 and 97 percent of the countries which were predicted to default actually did.

Feder, Just, and Ross (1981) extended the earlier Logit study of Feder and Just. The major difference in the newer study is that capital inflows from official and commercial sources are treated as distinct variables. The results are presented on Table 1.3. Another difference between the two models is that model 2 contained several inter-mixed variables. Only the significant coefficients in the newer model are reported in the table. An additional model was estimated with dummy variables denoting different regions but the coefficients were not significant.

While default indices help establish an upper bound on the debt that a country is willing to service, it does not indicate the level of debt which is needed to realize target growth rates. Thus it is not possible to determine the trade off between growth policies and the probability of default solely on the basis of default indices. In order to deal with this, Feder (1980), uses a gap model similar to Mikesell's to simulate debt growth

for different types of LDCs. He then uses these simulations to relate government policies with the Feder-Just default index.

The economy portrayed by his gap model has no monetary sector and trade is exogenous. Assuming that growth of GDP is proportional to investment and that consumption is linearly related to investment he derives the time period after which debt begins to taper off. Assuming that the savings gap is relevant he calculates this time period to be

$$(1.9) \qquad t^* = 1/g \ln \left| \frac{\bar{s}' - s_o/y_o}{\bar{s}' - kg} \right|$$

The most notable feature of this formula is that t^* is independent of the interest rate on foreign debt. This would seem to support Mikesell's having ignored service payments. In fact, equation (1.9) is very similar to the time period after which foreign aid will cease in Mikesell's gap model. In Mikesell's model the savings gap at time t is calculated from equation (1.5.1)

$$(1.10) \qquad I_t = S_t = Y_o kg(1 + g)^t - s_o - s'Y_o(1 + g)^t + s'Y_o.$$

Setting the gap to zero and solving for t yields

$$(1.11) \quad t' = \frac{1}{\ln(1+g)} \ln\left[\frac{s' - s_o/Y_o}{s' - kg}\right]$$

Both of these equations indicate that the time required to eliminate the gap will rise with both the desired rate of growth and the capital-output ratio. The debt flow over time will be a function of the difference between the desired growth rate of the capital stock and the growth of domestic savings.

By running simulations on his gap model, Feder derives estimates of five of the variables comprising the Feder-Just Index (he ignores reserves). By running separate simulations for high and middle income LDCs and varying the other exogenous variables in the system, he identifies the economic structure and debt policies which are likely to generate high probabilities of default. In general, high debt, a small export sector, low average savings rates, and low per capita income contribute to a high risk of default. Feder also examines the effect of GNP growth; he finds that reducing the target growth rate of GNP reduces the probability of default to a point after which the probability rises. Raising the growth of exports always reduces the probability of default but

increasing the marginal savings rate is only effective in lowering the probability of default if the rate is low.

There are several problems with Feder's model. The most obvious is his failing to incorporate foreign reserves. He defends this exclusion by the relatively low coefficient associated with foreign reserves. One of the roles of foreign reserves is to reduce the chance that a random shortfall in foreign exchange will occur. Thus, Feder's model cannot be used to examine the impact of exogenous fluctuations on servicing debt.

The second problem with Feder's model is that it assumes a savings gap. As a result of the savings gap assumption, the debt path over time is determined by

$$(1.12) \quad D(t) = D_o - \frac{S_t}{1 - ik} - \frac{(S' - Kr)\, Y_o\,(e^{rt} - 1)}{(1 - ik)n}$$

where i is the interest rate on foreign capital and S' is the hypothetical level of saving when Y = 0. In many LDCs, however, the production processes are critically dependent on imports. There are also, frequently, constraints on the ability to generate additional exports. In this instance it would be inappropriate to

assume that domestic savings could substitute for foreign borrowing.

Finally, Feder implicitly assumes that the supply of loans is perfectly elastic. He places no constraints on the level of borrowing and the rate of interest is fixed. However, a study by Feder and Just (1977) on determining spreads in Eurocurrency markets indicates that the supply is not elastic. In fact, many of the variables which raise the probability of default also lead to higher spreads. Thus, it appears that countries which are more likely to default must pay a risk premium on foreign borrowing.

Optimal Control

In order to evaluate the trade-off between the current benefits arising from foreign borrowing and the future cost of debt service payments, several authors have modeled foreign borrowing as an optimal control problem.[8/] One of the earliest attempts to incorporate debt service in an optimal control framework was made by Hamada (1969). He models a one-good economy in which the objective is to maximize the present value of all future consumption. Per-capita output is assumed to be a function of the capital labor ratio. While the growth

rate of labor is exogenous, the supply of capital is endogenously determined by consumption and net foreign borrowing. Hamada, thus, is able to have the future impact of debt service influence debt accumulation.

He assumes that production is a linearly homogeneous function of capital and labor.

(1.13) $Y_t = F(K_t, L_t) = L_t K(K_t/L_t, 1) = L_t f(k_t)$

where $k_t = K_t/L_t$ and

$f'(k) > 0$, $f''(k) < 0$, $\lim_{k \to \infty} f'(k) = 0$.

By not distinguishing between foreign and domestic capital in the production function Hamada is implictly assuming that they are perfect substitutes. Hamada assumes that the growth rate of labor is exogenous and is calculated as

(1.14) $n = \dot{L}_t/L_t > 0$.

The interest rate is assumed to be a function of the country's per capita indebtedness. Thus, if per-capita indebtedness $d_t = D_t/L_t$ then

(1.15) $r_t = r(d_t)$ for $-\infty < d_t < +\infty$

where the interest rate, i, is an increasing function of d. The total cost of borrowing is

(1.16) $r(d)D = Lg^*(d)$ or $g^*(d) = r(d)d$,

thus, $g^*(d)$ is the per-capita cost of borrowing. Since there is no uncertainty in this model, the assumption that the cost of borrowing is a function of the level of debt implies that the country is a large borrower (i.e. a monopsonist). In a world of uncertainty this relationship need not depend on the monopsonistic powers of the borrower but rather on the higher risk associated with a higher level of debt. Hamada assumes that the per-capita cost function can be reformulated into a per-capita return function $g(z)$ such that

(1.17) $g(z) = -g^*(-z)$ for $-\infty < z < \infty$

and $g'(z) \geq 0$, $g''(z) < 0$, $g(0) = 0$, $g'(0) = r(0)$.

where z is per capita capital invested abroad. Per capita income can be reformulated as

(1.18) $y = f(k) + g(z)$.

Hamada then assumes the existence of two control variables, s_1, the proportion of net income invested domestically, and s_2 the proportion of net income invested abroad. If s_2 is negative then the country is

a net borrower. The restrictions on s_1 and s_2 are

$$(1.19) \quad s_1 \geq 0,\ s_2 \geq -\beta\ ,\ 1 - s_1 - s_2 \geq 0.$$

The first restriction prevents decumulation of capital, and the second implies that there is an institutional limit on the level of borrowing. The last relationship is equivalent to excluding negative consumption. If c_t is per-capita consumption then the optimal debt accumulation in Hamada's model can be found by

$$(1.20) \quad \max \int_0^\infty e^{-pt} U(c_t)dt =$$

$$\int_0^\infty U[(1-s_1 - s_2)(f(k_t) + g\ (z_t))]e^{-pt}dt$$

such that

$$\dot{k} = s_1\ (f(k) + g(z)) - nk$$

$$\dot{z} = s_2\ (f(k) + g(z)) - nk$$

where U(c) is the utility function of consumption and

$$(1.21) \quad U'(c) > 0,\ U''(c) < 0$$

and p is the time discount rate which is assumed to be constant. At the initial point (t = 0) the amount of domestic

capital and foreign debt is given by

$$(1.22) \qquad k(0) = k_o \quad z(0) = z_o$$

and it is assumed that $f(k_o) + g(z_o) > 0$.

Applying Pontryagin's Maximum Principle to the above system yields the Hamiltonian

$$(1.23) \quad H = U\,[(1-s_1-s_2)\,f(k) + g(z)] + u_1(s_1 f(k) + g(z) - nk) + u_2(s_2 f(k) + g(z) - nz)$$

where u_1 and u_2 are the shadow price of domestic capital and foreign capital respectively, for which the following conditions hold

$$(1.24) \quad 1) \quad \dot{k} = \partial H/\partial u_1 = s_1 f(k) + g(z) - nk$$
$$\dot{z} = \partial H/\partial u_2 = s_2 f(k) + g(z) - nz$$
$$2) \quad \dot{u}_1 = rp_1 - \partial H/\partial k = (p + n)u_1 - lf'(k)$$
$$\dot{u}_2 = rp_2 - \partial H/\partial Z = (p + n)u_2 - qg'(Z)$$

where $l = (1 - s_1 - s_2)\,U'(c) + u_1 s_1 + u_2 s_2$,

3) s_1 and s_2 maximize H for all t, and

4) The transversality condition

$$\lim_{t\to\infty} u_1 e^{-pt} = 0, \quad \lim_{t\to\infty} u_2 e^{-pt} = 0.$$

Hamada examines the implications of the solution being bounded by the constraint set defined by (1.16). He concludes that the transversality condition only holds for an interior solution. This condition is met when

$s_1 > 0$, $s_2 < \beta$, $1 - s_1 - s_2 > 0$

which by Kuhn-Tucker and the first order conditions imply that $u_1 = u_2 = U'(c) = q$.

It will be useful to reinterpret Hamada's work in terms of maximizing consumption with explicit account taken of debt service payments. The formulation of per capita income in (1.15) now becomes

(1.25) $y(t) = f(k(t)) + b(t) - r(d(t))d(t)$

where $b(t)$ is per capita borrowing in time t and $b(t) > 0$ implies the country is a net lender in period t. The restrictions outlined in (1.16) can be rewritten as

(1.26) $c \leq f(k) + b - r(d)d$, $b \leq \tilde{\beta}$, $c \geq 0$

where the first condition insures that capital is not decumulated. The second condition insures that borrowing

does not exceed institutional limits. Finally, the last condition insures non-negative consumption.

The maximization problem as stated in (1.17) can now be rewritten as

$$(1.27) \qquad \max \int_0^{\infty} e^{-pt}\, U(c_t)dt$$

such that

$$\dot{k} = f(k) - nk - c - r(d)d + b$$
$$\dot{d} = b - nd.$$

Again the initial capital stock and foreign debt are assumed given so

$$(1.28) \qquad k(0) = k_o \text{ and } d(0) = d_o.$$

The current value Hamiltonian now takes the form

$$(1.29) \qquad H = U(c) + u_1 (f(k) - nk - c - i(d)\, d + b) + u_2 (b - nd)$$

for which the following conditions hold:

1) $\dot{k} = \partial H/\partial p_1 = f(k) - nk - c - r(d)\,d + b$

$\dot{d} = \partial H/\partial p_2 = b - nd$

2) $\dot{u}_1 = ru_1 - H/k = u_1(p + n) - f'(k))$

$\dot{u}_2 = ru_2 - H/d = u_2(p + n) + u_1 G(d)$

where $G(d) = r'(d)d + r(d)$

3) c and b maximize H for all t.

The transversality conditions are the same as those stated in (1.21.4) and, as Hamada has shown, only hold for an interior solution. The first order conditions now are $u_1 = -u_2 = U'(c)$. Thus $\dot{u}_2$ can now be written as

(1.30) $\dot{u}_2 = u_2(p + n) - u_2 G(d)$

For the system to be in a stationary state the following condition must hold

(1.31) $\dot{u}_1 = \dot{u}_2 = 0$

$\overline{u_1} \quad \overline{u_2}$

Combining (1.31) with equations (1.29.2) results in the steady state optimalty condition for capital stock and debt.

(1.32) $G(d) = f'(k) = p + n$

This is the same steady state result that Hamada derives and he has shown that it only occurs with an interior solution for c and b. In the case of a boundary solution the system will move over time to a new phase with a non-boundary solution.

A more recent derivation of foreign debt in a dynamic framework was made by Bazadrich (1978). The major difference between these two works is that Bazadrich models a two-good economy. The country produces a capital good and a consumption good. Output is determined by

(1.33) $q_I = f_I(k_I), q_C = f_C(k_C)$

$f'_I(k) > 0, f'_C(k) > 0,$

where q_C and q_I are per capita output of the consumption and investment good. k_C and k_I represent the capital labor ratio in each industry.

Given the overall capital-labor ratio for the economy, k, and the production functions in (1.33) a production possibility curve for the economy can be generated. Once the production possibility curve is determined, choosing relative prices determines q_C and

q_I. Equation (1.33) can be rewritten as a function of relative prices (P).

(1.34) $q_C = f_C(P, k) \quad q_I = f_I(P, k)$.

The state equations for Bazadrich's model are

(1.35) $\dot{k} = q_I - nk$ and

(1.36) $\dot{d} = b - nd$

where d is per-capita debt and n is the growth rate of the labor force. Bazadrich assumes that foreign borrowing is used to supplement domestic consumption, so the maximand becomes,

(1.37) $\int_0^\infty e^{-pt} U(c(t) + b(t) - r(d(t))d(t))dt$

The balance of payments constraints takes the form

(1.38) $c - q_C + r\dot{d} = b$

While the use of foreign capital varies between the Hamada and Bazadrich models they both represents versions of a savings gap model. In the Hamada model

foreign capital substitutes directly for domestic capital, thus it supplements domestic saving. In Bazadrich's model, imports of consumption goods allow more of the country's domestic resources to be devoted to investment which in effect is an increase of the domestic rate of savings. Thus in both models, the role of foreign capital is to boost domestic savings.

A problem which both of these models face is preventing infinite borrowing. Hamada puts a limit on debt by the constraint

$$(1.39) \qquad d(t) \leq \alpha k(t) \qquad\qquad 0 < \alpha < 1.$$

Whether this constaint is a result of the policies of lenders or creditors, this assumption implies that the loan market is not competitive. Bazadrich assumes that borrowing at any specific time is unconstrained, but imposes the dynamic constraint

$$(1.40) \qquad \lim_{t \to \infty} e^{-(r-n)t} d(t) \leq 0.$$

This constraint implies that at some point in time interest will be paid without recourse to further borrowing.

While both of these articles model LDCs facing a savings gap, their results are contradictory. Hamada's model implies that a stage growth will occur in which a country initially borrows, but moves from a state of net debtor to net creditor over time. Bazadrich, however, concludes that if it is initially optimal for a country to borrow the country will eternally be a net debtor. This is largely a consequence of the different constraints. In Hamada's model, there is an external constraint on how large debt can grow. Bazadrich's model imposes a dynamic constraint. Moreover, his constraint only becomes effective if the growth generated by debt is less than the resulting interest payments. Thus, an LDC will continue borrowing as long as the income generated is sufficient to repay interest. Thus, in equilibrium, the marginal increment to income of the last dollar borrowed will equal the marginal cost of funds. Unless an exogenous variable changes, (especially the interest rate) the equilibrium level of debt will be held forever.

CHAPTER II

Optimal Control Model of Debt Accumulation

Imports play a critical role in determining economic growth in LDC's as there are numerous imported goods for which domestically produced substitutes are not readily available. As was stated earlier, oil is the most notable recent example of such an import. In early 1980, a shortage of supply caused the price of oil to rise dramatically. Most LDC's either reduced oil imports and experienced slower growth or their current account deficit and foreign borrowing grew rapidly.

In this chapter an optimal program for determining foreign borrowing will be determined. Imports appear in the economy either as a non-substitutable complement to domestic capital or as a supplement to domestic output. While it is possible that no substitute for domestic capital exists, it is unlikely. In general, LDCs can import close substitutes to domestic output. A neo-classical approach similar to Hamada's will be the basis of the model. It is assumed that output is determined by

$$(2.1) \qquad Q(t) = F[K(t), L(t), KM(t)]$$

where Q is GDP, K and KM are domestic and imported capital, and L is the supply of labor. L(t) is assumed to grow exogenously, so $L(t) = e^{nt}$ Lo where n is the growth rate of the effective supply of labor.[9/] As was the case in Hamada's model, F is a concave production function.

It is assumed that F(K, KM, L) is homogenous of degree 1 in all three variables

$$(2.2.1) \quad Q = F(K, KM, L) = F(K, KM\ e^{nt}L_o)$$

by the homogeneity assumption,

$$(2.2.2) \quad Qe^{-nt}L = F(Ke^{-nt}L, KMe^{-nt}L, 1)$$

By defining per capita income $q(t) = Q(t)/e^{nt}Lo$ then output can be respecified as

$$(2.2.3) \quad q = f(k, km)$$

where

$$(2.3) \quad k = Ke^{-nt}Lo, \quad km = KMe^{-nt}Lo$$

k and km are the ratios of capital to the effective units of labor.

In the absence of depreciation, 10/

(2.4) $dK/dt = \dot{K}(t) = I(t)$ and $dKM/dt = \dot{KM}(t) = M(t)$

where I is domestic investment and M is non-substitutable capital imports. The flow equations of the capital-labor ratios can be calculated as:

(2.5) $dk/dt = \dot{k} = e^{-nt}\dot{K} - ne^{-nt}K$

$= e^{-nt}\dot{K} - nk = i - nk$

$dkm/dt = \dot{km} = e^{-nt}\dot{KM} - ne^{-nt}KM$

$= e^{-nt}\dot{KM} - nkm = m - nkm$

So, $\dot{k}(t) = i - nk$ and $\dot{km}(t) = m - nkm$ are the flow equations which determine changes in the level of capital-labor ratios at any point in time. It is implicitly assumed that investment is reversible since i and m are not constrained to be positive. In a growing economy, both of these variables will be positive since the capital stock itself will by necessity be growing and there will be no incentive to trade existing capital for consumer goods.

Imports can be financed with export revenues or capital borrowed in foreign credit markets. Thus, the economy's instantaneous external budget constraint B is:

$$(2.6) \qquad B = C + I - F(K, KM, e^{nt}Lo) + r(d)D + M$$

where C is the level of consumption and D is the level of external debt. The rate of interest on new loans is assumed to increase positively with the level of per-capita debt. The average interest rate r(d) thus is also an increasing function of the level of per-capita debt. As Hamada demonstrated, if this functional relationship does not hold then countries will either contract an infinite level of debt or not borrow at all. In addition, there is strong empirical evidence (see Feder and Just (1977))[11] that such a relationship actually exists in commercial credit markets.

If it is assumed that population grows at the same rate as the labor force then the borrowing constraint can be rewritten as

$$\begin{aligned}(2.7) \qquad b = e^{-nt}LoB &= e^{-nt}LoC + e^{-nt}LoI \\ &\quad - e^{nt}LoF(K, KM, e^{nt}L) + r(d)e^{-nt}LoD \\ &\quad + e^{-nt}LoM \\ &= c + i - f(k, km) + r(d)\ d + m\end{aligned}$$

$c + i - f(k, km)$ represents the trade balance of the domestically produced goods and may be either positive or negative. If domestic output is exported in order to finance imports then the balance will be negative. In contrast, if demand is greater than production then a substitute for domestic output will be imported and the balance will be positive. As an accounting identity,

$$\dot{D} = B. \tag{2.8}$$

So, since $d = e^{-nt}D$

$$\dot{d} = e^{-nt}\dot{D} - ne^{-nt}D = b - nd \tag{2.9}$$

is the flow equation which determines the changes in the level of per-capita debt.

The economy has two positive assets, k and km and a negative asset, d. These assets are state variables which have been show to be determined by the flow equations:

$$\begin{aligned} \dot{k} &= i - nk \\ \dot{km} &= m - nkm \\ \dot{d} &= b - nd \end{aligned} \tag{2.10}$$

The maximand of this system is the sum of the discounted utility of consumption over an infinite time horizon.

$$(2.11) \qquad V = \max \int_0^{\infty} e^{-pt} U(c)dt$$

where $p > o$ is the time discount rate and $U' > o$, $U'(o) = \infty$ and $U'(\infty) = o$. The constraints on maximizing V are the three state equations and the external budget. There are four control variables: c, b, m and i which can be used to target the utility function subject to these constraints.

Putting this system in the form of the current-valued Hamiltonian yields:[12/]

$$(2.12) \qquad H = U(c) + u_1(i - nk) + u_2(m - nkm) + u_3(b - nd) + v(b - c - i + f(k, km) - r(d)d - m)$$

where u_1 u_2, and u_3 are the costate variables associated with the three flow equations. In essence they represent the shadow prices associated with the three assets in the model. The variable v is the lagrangian multiplier associated with the constraint on the external balance.

The Pontryagin Maximum Principle states that: let $c(t)$, $i(t)$, $m(t)$, and $b(t)$ for $t > o$ maximize

(2.13) $\int_0^{\infty} e^{-pt} U(c)dt$

subject to the conditions,

$$\dot{k} = i - nk$$

(a) $$\dot{km} = m - nkm$$

$$\dot{d} = b - nd,$$

the external budget constraint, and initial conditions on the state variables. Then there exist auxiliary variables which are functions of time, $u_i(t)$ $(i = 1, 2, 2)$ such that, for each t

(b) $c^*(t)$, $i^*(t)$, $b^*(t)$, and $m^*(t)$ maximize

$$H = U(c) + u_1(i - nk) + u_2(m - nkm + u_3(b - nd) + v(b - c - i + f(k, km) - r(d)d - m)$$

Subject to the constraints in (a) and the variables u_i satisfy the differentials equations

(c) $$\dot{u}_1 = u_1 p - \partial H/\partial k = u_1(p + n) - vf_k$$

$$\dot{u}_2 = u_2 p - \partial H/\partial km = u_2(p + n) - vf_{km}$$

$$\dot{u}_3 = u_3 p - \partial H/\partial d = u_3(p + n) - vG(d)$$

evaluated at $[k, km, d] = [k(t), km(t), d(t)]$

$[c, b, i, m] = [c^*(t), b^*(t), i^*(t), \text{and } m^*(t)]$

and $[u_1, u_2, u_3] = [u_1^*(t), u_2^*(t), u_3^*(t)]$

and p is the rate at which future utility is discounted.

(d) The lagrangian multiplier v is such that the partial derivatives of the Hamiltonian with respect to the control variables are zero and $v(t)\ (b - c - i + f(k, km) - r(d)d - m) = 0$ for all t.

The optimal path is the solution of the differential equations in (a) and (c). However, since there are six equations and only three state variables the system is under-determined. Introducing the transversality condition closes the system. Assuming that the Hamiltonian is a concave function (i.e. that an interior solution exists) then any policy is optimal which maximizes the Hamiltonian subject to the stated conditions and satisfies the transversality conditions:

$$(2.14) \qquad \lim_{t\to\infty} u_1(t)e^{-pt} \geq 0, \quad \lim_{t\to\infty} u_2(t)e^{-pnt} \geq 0,$$

$$\lim_{t\to\infty} u_3(t)e^{-pt} \geqq o$$

and $\lim_{t\to\infty} u_1(t)k(t)e^{-pt} = o$, $\lim_{t\to\infty} u_2(t)km(t)e^{-pt} = o$,

$$\lim_{t\to\infty} u_3(t)d(t)e^{-pt} = o$$

Since u_i are the shadow prices of the state variables, the transversality conditions imply that the current value of a positive quantity of a state variable infinitely in the future converges to zero.

The first order conditions for maximizing the current-valued-Hamiltonian are

$$\begin{aligned}
(2.15)\quad \partial H/\partial c &= U'(c) - v \geqq 0,\ v(U'(c) - v) = 0 \\
\partial H/\partial i &= u_1 - v \geqq 0,\ v(u_1 - v) = 0 \\
\partial H/\partial m &= u_2 - v \geqq 0,\ v(u_2 - v) = 0 \\
\partial H/\partial b &= u_3 + v \geqq 0,\ v(u_3 + v) = 0
\end{aligned}$$

Since it is assumed that an interior solution exists (i.e., the equations (2.15) hold with equality) then (2.15) can be substituted into (2.13c) to yield:

$$(2.16) \quad \dot{u}_1 = u_1 (p + n - f_k)$$
$$\dot{u}_2 = u_2 (p + n - f_{km})$$
$$\dot{u}_3 = u_3 (p + n - G(d)).$$

A steady state occurs only when

$$(2.17) \quad \dot{u}_1/u_1 = \dot{u}_2/u_2 = \dot{u}_3/u_3 = 0;$$

assuming a steady state, (2.17) can be rewritten as:

$$(2.18) \quad p + n = f_k = f_{km} = G(d).$$

In other words, in a steady state, both the marginal product of domestically produced and the marginal product of imported capital equal the marginal cost of an increase of external debt. The relationship between domestic capital and the external cost of borrowing is a consequence of the external budget constraint. Since $c + i - f(k, km)$ is not constrained to be positive, it is implicit that a perfect substitute for domestic output can be imported. Thus, as long as the marginal product of domestically produced capital is more than the external cost of borrowing it will be optimal to use borrowed funds to

import capital to supplement the domestic capital stock. Similarly, it will be optimal to increase the stock of nonsubstitutable foreign capital as long as its marginal product is less than the cost of borrowing.

Given that the first order conditions all hold with equality, equation (2.16) can be used to determine the time path of c(t). From (2.16) it can be concluded that:

$$(2.19)\quad \dot{u}_3/u_3 = p + n - G(d),$$

using equation (2.19) it can be determined that

$$(2.20)\quad -\ln u_3(t) = -\int_0^{\infty} \frac{du_3}{u_3} = -\int_0^{\infty} \frac{du_3/dt}{u_3}\,dt$$
$$= -\int_0^{\infty} \frac{\dot{u}_3}{u_3}\,dt = -\int_0^{\infty} (p + n - G(d))\,dt$$

So,

$$(2.21)\quad \ln u_3(t) = (p + n - G(d))t$$

By taking the exponential of (2.21) and using the first order conditions,

$$(2.22) \quad U'(c(t)) = -u_3(t) = -u_3(0)e^{(p + n - G(d))t}$$

The restrictions on the utility function listed in (2.11) imply that the function is invertable; thus the time path for $c^*(t)$ can be described by

$$(2.23) \quad c^*(t) = U'^{-1}\left(-u_3(0)e^{(p + n - G(d))t}\right)$$

where $U'^{-1}(\cdot)$ is the inverse of $U'(\cdot)$.

If the system is stable, the time path of borrowing can easily be determined if it is assumed that the optimal level of consumption (c^*) is constant through time (i.e., $p + n, = i$ see Appendix A for the case where $c(t)$ varies). If this assumption holds then

$$(2.24) \quad \dot{k}\partial c^*/\partial k + \dot{km}\partial c^*/\partial km + \dot{d}\partial c^*/\partial d = 0$$

This equation reflects the fact that total wealth must change over time in such a manner that the optimal level of consumption (c^*) is constant. If $J(t)$ is the current value of horizon utility from time t then,

$$(2.25)\qquad J(t) = \int_t^{\infty} e^{-p(s-t)} U(c(s))ds$$

$$= \int_t^{\infty} e^{-p(s-t)} U(c^*)ds = U(c^*)/p.$$

Assuming all constraints are satisfied, the maximum principle implies that

$$(2.26)\qquad u_1(t) = \partial J(t)/\partial k(t) = \frac{U'(c^*)\partial c/\partial k(t)}{p}$$

$$= u_1(t)/p\partial c^*/\partial k$$

$$u_2(t) = \partial J(t)/\partial km(t) = \frac{U'(c^*)/\partial c^*/\partial km}{p}$$

$$= \frac{u_1(t^*)\partial c^*/\partial km}{p}$$

$$u_3(t) = \partial J(t)/\partial d(t) = \frac{U'(c^*)/\partial c^*/\partial d(t)}{p}$$

$$= \frac{u_1(t)\partial c^*/\partial d(t)}{p}$$

Thus,

$$(2.27)\qquad \partial c^*/\partial k = p$$

$$\partial c^*/\partial km = pu_2(t)/u_1(t)$$

$$\partial c^*/\partial d = pu_3(t)/u_1(t)$$

From the first order conditions stated in (2.15) it can be concluded that

$$(2.28) \qquad u_2(t)/u_1(t) = -u_3(t)/u_1(t) = 1.$$

By substituting into (2.24), d can be calculated as

$$(2.29) \qquad \dot{d} = k\dot{m} + \dot{k}$$

Equation (2.29) indicates that, as in Bazadrich's model, external debt will accumulate as long as the economy is growing. Moreover, all capital build-up will be financed through foreign borrowing. This unusual result arises because there is no upper bound on the time path of consumption. Thus since consumption is not limited, it could well be in excess of total output. In this instance, all investment would necessarily be financed abroad. In order to prevent this extreme result, consumption will be constrained to be less than national income as was the case in Hamada's model. Let

$$(2.30) \qquad c + i \leq f(k, km) + b - r(d)d$$

The current-valued Hamilton now becomes

$$(2.31) \quad H = U(c) + u_1(i - nk) + u_2(m - nkm) + u_3(b - nd) + v_1(b - c - i + f(k, km) - r(d)d - m) + v_2(c + i - f(k, km) - b + r(d)d)$$

for which the following conditions hold:

$$(2.31.1) \quad \dot{k} = i - nk$$
$$\dot{km} = m - nkm$$
$$\dot{d} = b - nd$$

$$(2.31.2) \quad \dot{u}_1 = pu_1 - \partial H/\partial k - u_1(p + n) + (v_2 - v_1)fk$$
$$\dot{u}_2 = pu_2 - \partial H/\partial km = u_2(p + n) + (v_2 - v_1)f_{km}$$
$$\dot{u}_3 = pu_3 - \partial H/\partial d = u_3(p + n) + (v_1 - v_2)G(d)$$

(2.31.3) c, i, n, and b maximize H for all t, and

(2.31.4) the transversality conditions

$$\lim_{t\to\infty} u_1(t)e^{-pt} \geq 0, \quad \lim_{t\to\infty} u_2(t)e^{-pt} \geq 0,$$

$$\lim_{t\to\infty} u_3(t)e^{-pt} \geq 0, \quad \lim_{t\to\infty} u_1(t)k_t e^{-pt} = 0,$$

$$\lim_{t\to\infty} u_2(t)km(t)e^{-pt} = 0, \quad \lim_{t\to\infty} u_3(t)d(t)e^{-pt} = 0.$$

The first order conditions are

(2.32) $\partial H/\partial c = U'(c) + v_2 - v_1 \leq 0,$

$(v_2 - v_1)(U'(c) + v_2 - v_1 = 0$

$\partial H/\partial i = u_1 + v_2 - v_1 \leq 0,$

$(v_2 - v_1)(u_1 + v_2 - v_1) = 0$

$\partial H/\partial m = u_2 - v_1 \leq 0, \; v_1(u_2 - v_1) = 0$

$\partial H/\partial b = u_3 + v_1 - v_2 \leq 0,$

$(v_1 - v_2)(u_3 + v_1 - v_2) = 0$

It is assumed that an interior solution exists so substituting from the first order conditions into (2.31.2) yields:

(2.33) $$\frac{\dot{u}_1}{u_1} = p + n + f_k$$

$$\frac{\dot{u}_2}{u_2} = p + n + \frac{u_1}{u_2} f_{km}$$

$$\frac{\dot{u}_3}{u_3} = p + n - G(d)$$

A steady state occurs when $u_1/u_1 = u_2/u_2 = 0$ which implies that

$$(2.34) \qquad f_k = \frac{u_1 f_{km}}{u_2} \qquad \text{or} \qquad \frac{f_k}{u_1} = \frac{f_{km}}{u_2}$$

u_1 and u_2 are the shadow prices of domestic and foreign capital, respectively. In the unconstrained model the first order conditions indicated that $u_1 = u_2$. If this were the case then the steady state condition in (2.34) would become $f_k = f_{km}$ which is the steady state condition for the unconstrained equation in equation (2.18).

The determination of the time path of consumption remains unchanged since $U'(c) = -u_3(t)$ and $\dot{u}_3/u_3 = p + n - G(d)$ in both models. The time path of debt however does change. The current valued horizon utility function remains the same as (2.25)

(2.35) $J(t) = U(c^*)/p.$

Assuming all constraints are satisfied, the maximum principle now implies that,

(2.36)
$$-u_1(t) = \partial J(t)/\partial k(t) = \frac{u'(c^*)\partial c^*/\partial k(t)}{p}$$
$$= -(u_3(t)/p)\ \partial c^*/\partial k$$
$$u_2(t) = \partial J(t)/\partial km(t) = \frac{U'(c^*)\partial c^*/\partial km}{p}$$
$$= -(u_3(t)/p)\ \partial c^*/\partial km$$
$$u_3(t) = \partial J(t)/\partial d = \frac{U'(c^*)\partial c^*/\partial d}{p}$$
$$= -(u_3(t)/p)\,\partial c^*/\partial d$$

Thus,

(2.37)
$$\partial c^*/\partial k = \frac{-u_1(t)}{u_3(t)}\,p = p$$
$$\partial c^*/\partial k_m = \frac{-u_2(t)}{u_3(t)}p = \frac{u_2(t)}{u_1(t)}p$$
$$\partial c^*/\partial d = -\,p$$

By substituting into (2.24), $\dot{d}$ can be calculated as

(2.38)
$$\dot{d} = \dot{k} + \frac{u_2(t)}{u_1(t)}\,\dot{km}$$

Equation (2.38) concurs that debt will increase as long as the economy is growing. However, in the constrained model the increase in debt will normally moderate over time. When a country is in an early stage of development, foreign capital is usually scarce and domestic capital is relatively abundant. Thus the shadow price of domestic capital $u_1(t)$ will be low. Consequently the ratio $u_2(t)/u_1(t)$ will be relatively large and debt will grow rapidly. As foreign capital accumulates, its shadow price will fall causing the growth of debt to slow. In the limit, when the economy reaches a steady state, debt will stop growing.

CHAPTER III

Econometric Model of Debt Accumulation

The models developed in Chapter II indicate that it is optimal for LDCs to hold foreign debt for at least a limited period. In general, the theoretical path of borrowing is determined by the time path of consumption and investment, and the production function. In addition, it is assumed that the economy always uses resources efficiently to maximize a known utility function. There are several problems with applying this type of model to estimating actual debt projections. First the control model is a continous model but data can only be collected for discrete intervals of time. Thus, behavioral and structural relationships of an economy must be expressed as discrete functions if they are to be estimated. Second, welfare functions are not observable so a substitute for determining policy variables must be developed. Finally, institutional rigidities and uncertainty prevent LDC economies (as well as other economies) from operating efficiently.

In order to estimate debt projections for Honduras, an econometric model will be developed. As was the case in the control model, imported and domestically

generated capital will continue to be treated as separate factors of production. While the econometric model will not generate an optimal time path of external debt, it will be a useful tool for determining practical limits on financing economic development by borrowing abroad.

Econometric Model

The economic model will be similar to the model used by Feder (1980) but with a few notable exceptions. Feder assumes that domestic and imported capital were strictly complements in the production of GDP. Moreover, the production function indicated that the two types of capital can only be used in fixed proportions. The major shortcoming of this formulation is that it does not permit any substitution between domestic savings and foreign borrowing. If a country can substitute domestic capital for foreign capital then the impact of a forced drop off of imports could be partially countered by increasing the domestic rate of savings. Export growth in Feder's model is assumed to be an exogenous constant. This implies that internal factors of production are not responsive to relative shifts in world demand. Again, the ability to shift productive factors rapidly into the export sector will affect a country's reaction to a shortage of foreign

exchange. Moreover, it may also influence long-term decisions on whether to finance imports through export revenue or foreign borrowing. Finally, Feder excludes reserves from his model. This may bias the demand for foreign borrowing since countries often borrow to build reserves. It also prevents an analysis of a country's ability to continue servicing foreign debt when there are unexpected fluctuations in foreign exchange inflows. While the model used bears some similarity to Feder's model it will avoid the shortcomings noted above.

Output will be determined by a constrained Cobb-Douglas production function. The degree of substitutability between the capital stocks will be a product of empirical estimations.

$$(3.1) \qquad Q_t = aKD_t^b KM_t^c L_t^d$$

where $b + c + d = 1$. As an accounting identity, K and KM can be determined by

$$(3.2) \qquad KD_t = (1 - z_{KD})KD_{t-1} + I_t$$

$$KM_t = (1 - z_{KM})KM_{t-1} + MK_t$$

where MK is imports of real capital goods, I is total investment less MK, and z_{KD} and z_{KM} are the depreciation rates of the two capital stocks. Labor is assumed to grow exogenously.

The behavioral equations for real consumption and investment in domestic capital will be determined by

$$(3.3) \qquad C_t = a_2 + b_2 Q_{t-1}$$

and

$$(3.4) \qquad I_t = a_3 + b_3 Q_{t-1} + c_3 r_t$$

where r is the domestic rate of interest. Consumption is assumed to be independent of interest rates because most Hondurans do not have access to financial markets (see p. 81 below). The private and public sectors in Honduras, as is the case in most LDCs are intermingled. Government owned enterprises exist in both the industrial and agricultural sectors of the economy. Consequently, the econometric model does not distinguish between private and public expenditures. C and I represent the combined consumption and investment of both the private and public sectors.

If MC_t is imports of consumption goods then total real imports

$$(3.5) \qquad M_t = MK_t + MC_t + MS_t$$

Where MS is imports of services. MC is assumed to be a funtion of total consumption

$$(3.6) \qquad MC_t = a_4 + b_4 C_t$$

Service imports, excluding interest payments, $\tilde{MS}$ primarily consist of freight and insurance expences so they will be a function of merchandise imports.

$$(3.7) \qquad \tilde{MS}_t = a_5 + b_5(MC_t + MK_t)$$

Total service imports then can be calculated as

$$(3.8) \qquad MS_t = \tilde{MS}_t + r^b D_{t-1}$$

$r^b D$ is interest payments on external debt. Foreign borrowing net of amortization will be determined by the balance of payments identity:

$$(3.9) \qquad B_t = M_t + \Delta R_t - X_t - DI_t$$

DI is transfers and non-borrowed capital inflows such as direct investment. However, transfers have always been a relatively small flow for Honduras and direct investment has dwindled in recent years due to growing political uncertainty in Central America. In fact, in 1981 there was a small net outflow of direct investment capital. Debt at time t is determined by

$$(3.10) \qquad D_t = D_{t-1} + B_t$$

The optimal control models developed in Chapter II, did not incorporate reserve holdings. This is because there is no reason to hold reserves in a deterministic world. Since the future availability and need for foreign exchange are known with certainty an unexpected shortfall would never occur. However, foreign exchange flows are normally subject to random fluctuations. Precautionary reserves are held in order to counteract the effects of random shortfalls of foreign exchange. In addition, countries hold reserves in order to smooth discrepancies between inflows and desired expenditures of foreign exchange.

Several authors have developed models which estimate the demand for foreign reserves. Whalen (1966) developed a model which equates the marginal benefit and marginal cost of holding reserves. The benefit of reserves is the avoidance of any cost associated with a foreign exchange shortage. The total expected cost of managing reserves is estimated as:

$$e = Ri + pc \tag{3.11}$$

where

R = foreign reserves

i = opportunity cost of holding reserves,

c = cost per occurrence of a reserve shortage.

Tchebycheff's inequality states that where the value of net reserve losses is a continuously distributed random variable:

$$p \leq \frac{S_L^2}{R} \tag{3.12}$$

where S_L^2 is the variance of the distribution of net reserve losses. The highest possible value of p is found

if (3.12) is an equality. Solving for p in equation (3.11) and substituting into (3.12) yields:

$$(3.13) \qquad R^* = (2S_L^2 C/i)^{1/3}$$

where R* is the optimal level of reserves. Barth and Bennot (1974) modified Whalen's model to differentiate the cases where cash outflows are greater or less than reserves. They conclude that the optimal level or reserves can be estimated by

$$(3.14) \qquad R^* = \left| \frac{2S_L^2}{\frac{1}{p} - 1} \right|^{1/2}$$

There are essentially two problems with estimating reserves using one of these models. Countries may not, in fact, hold optimal levels of reserves because of inadequate knowledge or external constraint. Moreover, formulations of optimal reserve holdings only reflect precautionary balances. Foreign reserves are also held for transactions purposes. Reserves can be used to smooth short-run discrepancies between export earnings and expenditures on imports. The demand for reserves for transactions is thus usually a function of the level of

trade. Iyoha (1976) has developed a model of foreign reserve holdings which differentiate between desired and optimal reserves and incorporates the influence of trade flows.

Iyoha assumes that actual reserves adjust to optimum reserves with a lag. He claims that this suggests a modified partial adjustment model of the form:

$$(3.15) \qquad \Delta R = a(R^* - R_{t-1}) + b \; R_{t-1}; \; o < a < 1, \; b < 1$$

If b is close to zero then the model becomes a partial adjustment model indicating that the change in reserves is detemined solely by the divergence of actual reserves from the optimum. If b is not zero then there will be a trend in reserve changes which prevent movements to the optimum. Iyoha determines optimal reserves by finding the level which maximizes the discounted sum of future national income rather than minimizing the cost of maintaining precautionary balances. Based on this assumption, he claims reserves are a function of four variables; expected export receipts (Xe), variability of export earnings (σ), interest rate on foreign exchange holdings (r), and openess of the economy (p). Openess is measured by the ratio of imports to GDP. An open economy

will be more sensitive to external disturbances, and thus the optimum level of reserves will be higher. Similarly, if exports receipts are highly variable, then the optimum level of reserves will also be higher. Unlike Whalen, Iyoha claims that optimal reserves will vary positively with interest rates. This discrepancy arises because Whalen uses interest as a measure of the opportunity cost of holding assets as liquid reserves instead of investing them in the economy. In Iyoha's model, the interest rate determines the income generated by holding liquid reserve assets.

Expected export receipts are the anticipated foreign exchange inflows during the coming period. In general, there will be positive correlation between export earnings and reserves, as a consequence of the demand for transactions balances. Hence, the higher expected exports, the higher the optimum level of reserves. Expected exports of goods and services are estimated by assuming that decision- makers behave according to the rational expectations hypothesis (Muth (1961)). Thus, expectations are based on unbiased predictions by an appropriate economic model. Adelman and Chenery (1966), used a model which estimated export receipts as a function of time and world income. If world exports (W) are used

as a proxy for income and lagged exports are used to denote the time trend then exports can be estimated as

$$(3.16) \qquad X_t = a_6 + b_6 X_{t-1} + c_6 W_{t-1} + e_t$$

where e_t is a stochastic error term. Assuming that expectations are rational this equation correctly captures the behavior of export earnings, then expected export earnings can be estimated as

$$(3.17) \qquad Xe_{t+1} = a_6 + b_6 X_t + c_6 W_t$$

Using (3.17) to determine expected exports, Iyoha estimates that international reserves in less developed countries are detemined by

$$(3.18) \qquad \begin{aligned} R = {} & \underset{(-2.36)}{-151.49} + \underset{(1.79)}{.09X^e} + \underset{(3.87)}{.0004\sigma^2} \\ & + \underset{(2.23)}{12.58r} + \underset{(1.95)}{468.36p} - \underset{(-.57)}{70R_{t-1}} + \underset{(4.99)}{.76R_{t-2}} \end{aligned}$$

where the values in parentheses are the t-statistics. Iyoha used the central bank's discount rate as a proxy for r. However, as Shinkai (1979) indicated, the discount rate may not be an appropriate measure of the return on

reserves, since many countries arbitrarily set the rate. In addition, the opportunity cost of holding reserves is omitted which may bias the results. Iyoha notes that earlier studies indicate that reserves were not found to be significantly effected by interest levels. If the income on reserves is approximately equal to the opportunity cost as defined by Whalen then the level of interest rates should have little impact on optimal reserve levels. Moreover, Frankel and Jovanovich (1981) recently developed an estimate of reserve holdings in which the coefficient for interest was not significant at the .05 percent level. Omitting interest rates from equation (3.17) and substituting for X^e, allows the level of reserves to be estimated by

$$(3.19) \quad R_t = a_7 + b_7 X_{t-1} + c_7 W_{t-1} + d_7 \sigma^2 + e_7 p + f_7 R_{t-1} + g_7 R_{t-2}$$

An equation for export growth relevant to Honduras will be developed below (see equations 3.20 and 4.21). This equation will in turn be used to generate expected exports.

In developing the optimal control models in Chapter II, exports were never explicitly determined. Since the economy modeled only produced one good, the

trade balance was determined by supply less demand for domestic output. With this formulation, a country with a negative trade balance would not export. It is obvious that this situation is not reflected in the real world. The reason for this discrepancy is that in actuality countries do not produce a single homogeneous good. Moreover, there are usually substantial technical and social barriers which impede the movement of resources between sectors of the economy. The level of integration of the export sector with the rest of the economy may vary considerably. Honduras relies heavily on exports of coffee and bananas to industrial countries. In this case, domestic demand for output of the export sector does not vary much with economic activity. Consequently, the level of exports will be relatively insensitive to shifts in other sectors of the economy, particularly if there are barriers preventing intersectoral movements of factors of production. If export production were highly integrated in the economy and also demanded internally, then changes in the domestic economy could have a substantial impact on exports.

The degree to which exports can vary in the short run may have some implications for a country's ability to service foreign debt. Thus, the equation for determining

exports should reflect both the long-term trends and the degree to which exports are sensitive to shifts in external demand. Equation (3.16) suggests that in general, exports are determined by both a long-term time trend as well as short-term fluctuation in world trade levels. However, if extensive internal barriers prevent rapid movement of productive factors to the export sector then an expansion of world trade levels should have less impact on exports. In order to indicate more fully the degree to which exports are integrated into the economy, they will be assumed to be a function of overall output as well. In this case, (3.16) now becomes

$$(3.20) \quad X_t = a_6 + b_6 X_{t-1} + c_6 W_{t-1} + d_6 Q_{t-1}$$

which is a reduced form for the simultaneous system of supply and demand functions for exports. Using (3.20) to determine expected exports generates a new reserve equation.

$$(3.21) \quad R_t = a_5 + b_5 X_{t-1} + c_5 W_{t-1} + d_5 \sigma^2_{t-1} + e_{5p} + f_5 R_{t-1} + g_5 R_{t-2} + h_5 Q_{t-1}$$

Summarizing the equations developed and assuming that there are no limits on borrowing yields the following system:

$$Q_t = aK_t^b KM_t^c L_t^d$$

$$K_t = (1 - z_K)K_{t-1} + I_t$$

$$KM_t = (1 - z_K)KM_{t-1} + MK_t$$

$$C_t = a_2 + b_2 Q_{t-1}$$

$$I_t = a_3 + b_3 Q_{t-1} - c_3 r_t$$

$$MC_t = a_4 + b_4 C_t$$

$$MS_t = a_5 + b_5 (MC + MK) + r^b D_{t-1}$$

$$M_t = MK_t + MC_t + MS_t$$

$$X_t = a_6 + b_6 X_{t-1} + c_6 Q_{t-1} + d_6 W_{t-1}$$

$$R_t = a_7 + b_7 X_{t-1} + C_7 Q_{t-1} + d_7 \sigma^2$$

$$+ e_7 p + f_7 R_{t-1} + g_7 R_{t-2} + h_7 Q_{t-1}$$

$$B_t = M_t + R_t - X_t - DI_t$$

KM can be determined by the rate of GDP growth tg.

$$(3.22) \quad tg = \frac{Q_{t+1} - Q_t}{Q_t} = \frac{a K_t^b KM_t^c L_t^d}{Q_t}$$

Solving for KM yields

$$(3.23) \quad KM_t = \left| \frac{(1 + tg) Q_t}{a K_t^b L_t^d} \right|^{1/c}$$

Equation (3.23) indicates that there will be a positive relationship between the target growth rate and the level of capital imports. If it is assumed that the government always achieves growth targets for GDP, then MK will be indirectly determined by the policy on growth.

If there were constraints on borrowing then MK could not be set arbitrarily. In this instance, it might be necessary for the government to reduce domestic

consumption in order to achieve a targeted rate of growth. Thus, MK would now be determined by the availability of foreign exchange and domestic investment would be tailored to meet the targeted growth rate. If $\bar{B}$ is the constrained level of borrowing and the determination of reserves remains unchanged then total imports are constrained by

$$(3.24) \qquad M_t = \bar{B}_t - \Delta R_t + X_t + DI_t$$

By equation (3.5), as long as MC is positive, MK can be increased by reducing consumption. However, a reduction in consumption will have little immediate impact on exports. Thus once MC falls to zero, MK will have reached an upper bound MK. Further increases in growth will require further reductions in consumption but now reduced consumption will be transfered into domestic investment. The domestic capital stock will be determined by

$$(3.25) \qquad KD_t = \left| \frac{\bar{l} + t_g Q_t}{aKM_t^c L_t^d} \right|^{1/b}$$

and domestic investment will be determined by the change of the stock. The total resources available for domestic

use in any year is

$$(3.26.1) \quad Q_t + B_t + M_t - r^b D_{t-1}$$

Consumption will be constrained so that the use of resources does not exceed the supply hence

$$(3.26.2) \quad C_t \leq Q_t + B_t + M_t - r^b D_{t-1} - I_t - X_t$$

and the trade balance, $X_t - M_t$, will be constrained by the availability of financing. The level of forced savings will be

$$(3.27) \quad S = a_2 + b_2 Q_{t-1} - C_t$$

Debt servicing problems not only arise because of inappropriate policies but also from unanticipated fluctuations in foreign exchange receipts. The planner's expectations may not be met because of unpredictable events such as a crop failure, deterioration of the terms of trade, or changes of interest rates in international capital markets. Such events occur frequently but usually do not have a major effect on the economy. However, in some instances the impact may be strong enough to force a

country to substantially increase foreign borrowing in order to maintain policy targets. Thus it is essential that the sensitivity of projections to random fluctuations be tested.

Since sensitivity tests can never capture all potential impacts of random fluctuations, it may also be useful to utilize an estimate of the probability of an interruption of debt service payments associated with a given growth scenario. As was outlined in Chapter I, Feder and Just (1977) developed a logit estimate of the probability of a debt service interruption. Their estimte is

$$\begin{aligned}(3.28)\quad \ln[p/(1-p)] &= 36 \ln DS/X + .41 \ln M/R \\ &\quad -.011 \ln q - 2.13 \ln B/DS - 501 \ln Q/Q \\ &\quad -31 \ln X/X\end{aligned}$$

where DS is debt service payments (interest plus amortization), q is per-capita GDP. This study was updated by Feder, Just, and Ross in 1981. The updated study is more difficult to utilize for projections since it differentiates between private and official capital flows. Moreover, the likelihood ratio indices in the two studies were not significantly different. Thus, the

results of the 1977 study will be used for projecting the probability of default. Aside from DS, the explanatory variables in (3.28) are all determined within the economic model. If it is assumed that the average maturity of foreign debt is fairly stable over time then amortization can be estimated as

$$(3.29) \quad DS'_t = aD_{t-1}$$

Total debt service is determined by adding interest payments to amortization.

The Honduran Economy

Honduras is predominantly an agricultural economy. While the contribution of agriculture to GDP has declined somewhat since 1970, it remains over 30 percent. Moreover, about two-thirds of the work force is employed in the rural sector. Agricultural goods constitute over 60 percent of export earnings.[13/]

There is a strong duality in the agricultural sector between small traditional farmers and larger commercial establishments. In 1974, 80 percent of the farmers accounted for less than 20 percent of the farmed lands. Small farmers generally produce beans and maize

for domestic consumption and their incomes are low and subject to wide variations. Most small farmers lack the necessary commercial and credit connections to shift production to more profitable export crops. In recent years, price ceilings have served as a disincentive to increasing output of foodstuffs. There are a large number of landless rural families last estimated in 1974 at 120,000.[14/] The income level of the landless is even lower than small farmers.

The major export crops (coffee and bananas constitute over 50 percent of exports) are produced on larger farms. Many of the largest farms are foreign owned. Coffee production has grown very rapidly in the late 1970's in response to higher coffee prices which doubled in 1976 and again in 1977. Coffee exports grew from $19 million in 1970 to $204 million in 1980. Further expansion of production is underway. However, falling world coffee prices since 1980 have led to declines in export earnings. Bananas have traditionally been the major export although their share has been declining; it fell from 75 percent of total exports in 1950 to about 25 percent by 1980. The declining share is largely due to recurrent hurricane damage and increases in production of other products. Bananas and coffee are now about equal as

sources of export earnings. The export value of bananas has doubled over the last ten years. Banana prices have remained relatively firm so export earnings have continued to increase.[15/]

Both coffee and banana production have traditionally been dominated by foreign investors. However, in recent years several factors have stalled new foreign investment. Agricultural prices, especially for coffee, have been poor this year. Political problems in some nearby countries (Nicaragua, El Salvador and Guatemala) have slowed foreign investment throughout Central America. Implementation of a land redistribution program within Honduras has added to the political uncertainties. At the same time the government's role in agriculture is increasing. COHBANA, a government owned producer of bananas, plans to increase its farming 15 thousand acres by 1985. Several government owned sugar mills have been opened in recent years. Moreover, the government provides subsidized credits to small independent farmers to promote their development.

Manufacturing accounted for 17 percent of GDP and employed about 12 percent of the working force in 1979.[16/] The government has actively promoted this sector through its industrial finance corporation,

CONADI. The government has also directly invested in several heavy industrial projects like cement and power plants. Manufacturing has grown rapidly but is not competitive outside the Central American Common Market. The growing political instability and economic slowdown in neighboring countries has led to a recesssion in the manufacturing sector.

The economy of Honduras has slowed significantly over the last three years, after performing well in the 1970's. The slowdown has been widespread with agriculture and construction most affected. Public sector expenditures rose to almost 9 percent of GDP in 1981. Inflation rose over 15 percent due to the growing fiscal deficit and shortages of some basic commodities.[17/] A shortage of credit to the private sector appeared in late 1980 reflecting the need to finance public sector deficits and reduced lending by foreign banks. An IMF Extended Fund Facility negotiated in 1979 has been suspended twice, most recently in September 1981. Failure to comply with fiscal targets was the source of the suspension. The IMF program is designed to finance infrastructure development, reduce oil dependence, and diversify exports.

Despite efforts to diversify, Honduras continues to be heavily dependent on the agricultural sector for foreign exchange earnings. Consequently, the balance of payments remains vulnerable to changing world demand for coffee and bananas. The exchange rate is fixed to the dollar, so imports are largely determined by the level of domestic demand. Import growth has been rapid due to the effect of growing government spending and higher oil prices. Current account deficits have largely been financed from official sources. In the mid-1970's the government began borrowing from commercial banks. However, since 1979, private banks have become reluctant to lend long-term, and total bank claims have remained constant.[18/] The reluctance to lend is a consequence of the growing political instability in Central America. Constraints on financing sources has made it more difficult for Honduras to service its debt. Some arrears on commercial debt have appeared recently and Honduras may seek a rescheduling of external debt in the near future.

Data Required for Estimation

1) Maturity and interest rates on external debt.

The data on debt was taken from the World Bank's World Debt Tables of December 1982. It gives a detailed

presentation of Honduras' external debt both in terms of the type of lender and borrower. The table presents the average terms for all public and publicly guaranteed debt. The maturity of debt from official lenders has averaged about 26 years during the period 1971 to 1980. Since there does not appear to be any strong trend on this debt, it will be assumed that this average applies in all projection years. Non-guaranteed debt from official sources is very small (less than 2 percent in 1980) and thus will not significantly affect the average terms.

The average maturity of debt from private sources between 1971 and 1980 was six years. Non-guaranteed private debt constitutes about 40 percent of debt from private sources so it will significantly affect the average maturity. However, it appears that the term structure of these two types of debt are very similar. For the period 1977 through 1979, the average ratio of principle payments to disbursed debt is 50 percent for guaranteed debt and 40 percent for non-guaranteed debt. Moreover, the average ratio of interest payments to disbursed debt is also very close at 7.5 percent for guaranteed debt and 7.6 percent for non-guaranteed debt.

The interest rates on commercial debt is determined by Feder and Just's (1977) estimate of the spread over LIBOR (London Interbank Offer Rate). Their estimate is

$$(3.30) \quad SPREAD = -3.5 - .0001q - 1.4\Delta Q + .056\ MAT + 1.8XS + .67M/Q + .024M/R + 1.31DS/X$$

where MAT is the average maturity of the debt, XS is the variance of exports and DS is debt service. While Feder and Just did not include Honduras in their data set, they did include several similar countries, such as Costa Rica, the Dominican Republic, and El Salvador. LIBOR is assumed to remain constant at the end-1981 rate of 16.8 percent. It is assumed that LIBOR also represents the rate of return of foreign exchange reserves.

2) Factors of production

Flow data on capital formation and capital imports will be used to determine the stock of imported and domestic capital. The data on capital formation are taken from the IMF's International Financial Statistics (IFS). The data on capital imports are published in the Central Bank of Honduras' annual report. Domestic capital formation is calculated by subtracting imported capital

from total capital formation. Nominal imported capital is adjusted by the world consumer price index presented in the IFS to yield real capital flows. Domestic capital formation is converted by Honduras' consumer price index which is also listed in the IFS.

By assuming that the average life of capital is ten years, the following stocks of capital can be calculated for Honduras. The assumption that the average life of capital is ten years, is arbitrary. Thus, estimates of the production function will also be made with an assumed capital stock life of both eight and twelve years to assure that the assumption is not seriously biasing the estimates (see Appendix B).

Data on the number of economically active individuals in Honduras for the years 1970 through 1980 are available in an unpublished World Bank study. In order to extend the series to earlier years the functional relationship between economically active individuals and total population was estimated. The results of the linear regression with a suppressed intercept and a correction for first order auto-correlation is

(3.31) $L_t = .29\ POP_t$

(66.07)

$R^2 = .9990$ DW = 1.36

Using this equation and the population data in the IFS, the working population can be estimated for earlier years. Data on the remaining variables are available in the IFS.

Table 3.1
Honduras: Capital Formation
(millions of U.S. dollars)

Year	Capital Formation	Imported		Domestic	
	Nominal	Nominal	Real*	Nominal	Real*
1950	24.5	8.9	31.1	15.6	32.5
1951	31.0	12.5	39.3	18.5	34.1
1952	38.0	19.5	58.9	18.5	33.9
1953	42.5	16.0	47.8	26.5	45.6
1954	34.5	12.8	37.8	21.7	38.1
1955	39.0	12.7	37.1	26.3	43.0
1956	40.0	15.6	44.1	24.4	41.1
1957	44.0	19.5	53.0	24.5	41.0
1958	42.0	19.5	50.9	22.5	37.3
1959	39.5	17.0	43.1	22.5	38.0
1960	42.0	21.3	52.7	20.7	35.0
1961	38.5	18.2	43.9	20.3	33.7
1962	53.0	23.3	54.2	29.7	48.8
1963	61.0	29.9	66.5	31.1	49.6
1964	61.5	28.7	61.5	32.8	50.1
1965	66.0	32.7	66.9	33.3	49.2
1966	79.5	39.0	75.9	40.5	59.7
1967	106.5	42.2	78.9	64.3	93.7
1968	113.0	41.9	75.0	71.1	101.1

*1975 dollars

Table 3.1 (continued)
Honduras: Capital Formation
(millions of U.S. dollars)

Year	Capital Formation	Imported		Domestic	
	Nominal	Nominal	Real	Nominal	Real
1969	122.0	50.2	85.4	71.8	100.3
1970	134.0	66.8	107.2	67.2	91.3
1971	126.5	51.6	78.3	74.9	99.5
1972	122.5	51.6	73.9	70.9	89.4
1973	162.5	79.5	103.9	83.0	100.1
1974	205.0	108.0	122.4	97.0	103.2
1975	242.5	110.8	110.8	131.7	131.7
1976	275.0	138.7	124.7	136.3	129.9
1977	355.5	184.0	148.5	171.5	150.7
1978	470.5	211.9	155.8	258.6	215.0
1979	556.0	245.3	160.9	310.7	237.5
1980	655.0	285.0	161.8	370.0	235.8

Table 3.2 - Honduras: Capital Stocks
(millions of 1975 U.S. dollars)

Year	Imported Capital	Domestic Capital
1959	443.1	382.3
1960	464.7	387.1
1961	469.3	386.7
1962	464.6	401.6
1963	483.7	405.6
1964	507.4	417.6
1965	537.2	423.8
1966	569.0	442.4
1967	594.9	495.1
1968	619.0	558.9
1969	661.3	621.2
1970	715.8	677.5
1971	750.2	733.3
1972	769.9	783.9
1973	806.9	834.4
1974	867.9	887.5
1975	911.7	970.0
1976	960.5	1040.2
1977	1030.1	1097.2
1978	1110.9	1211.1
1979	1186.4	1248.3
1980	1241.0	1492.8

Table 3.3 - Honduras: Population
(in thousands)

Year	Total Population	Working Population
1959	1,800	522*
1960	1,850	537*
1961	1,910	554*
1962	1,970	571*
1963	2,040	592*
1964	2,110	612*
1965	2,180	632*
1966	2,260	655*
1967	2,280	611*
1968	2,310	670*
1969	2,450	711*
1970	2,640	778
1971	2,720	800
1972	2,810	823
1973	2,902	848
1974	2,990	875
1975	3,090	906
1976	3,200	937
1977	3,320	971
1978	3,440	1,007
1979	3,560	1,044
1980	3,690	1,083

* estimated

CHAPTER IV

Debt Projections for Honduras

Estimation

As was indicated, the production function is assumed to be of the Cobb-Doublas form. However, it will be difficult to reliably estimate parameters for this function due to multicolinearity between the two capital stocks. Whenever there is an incentive to invest, it is likely that the domestic and foreign capital stock will both increase. Similarly, in a recession the growth of both stocks would tend to slow. The colinear relationship between these two stocks is evident in Honduras by the statistically significant relationship.[19/]

(4.1) $KD_t = 214 + .72KM_t$

$(11.11)^* \quad (31.20)^*$

$R^2 = .9809$

The high degree of colinearity will make estimates of any linear production function, such as a Cobb-Douglas or trans-log, unreliable. In fact, in estimations of these types of functions, the coefficient for KM would shift

from negative to positive when KD was excluded from the equation.

The strong colinearity also suggests that the elasticity of substitution between the two types of capital differs from the elasticity between either of the capital stocks and labor. In this instance the Cobb-Douglas or any Constant Elasticity of Substitution (CES) production function will not be appropriate. Sato (1967) developed a "two-level" CES production function to investigate the relationship between two types of capital, buildings and machinery, in the U.S. economy.

The basic form of the two-level CES production assumes that the n factors of production can be divided into s subgroups. For all x_i which are elements of groups s', $z_{s'}$ is defined as

$$(4.2)\quad z_{s'} = f_{s'}(x_i) = \left[\sum_{i \epsilon N_s} b_i (X_i)^{-\rho_{s'}} \right]^{-1/\rho_{s'}}$$

$$b_i > 0,\ -1 < \rho_{s'} = \frac{1-\sigma_{s'}}{\sigma_{s'}} < \infty$$

$z_{s'}$ can be regarded as a quantum index of the effective utilization of all elements in group s'. Output is assumed then to be a function of the indices, z_s.

$$(4.3)\quad y = F(Z) = \left[\sum_{s=1}^{S} a_s z_s^{-\rho} \right]$$

$$a_s > 0,\ -1 < \rho = \frac{1-\sigma}{\sigma} < \infty$$

y then is a CES function in Z and z_s in turn is a CES function in X_{is}. Thus, y is a "two-level" CES function in X. σ_s represents the elasticity of substitution within the sth input group, while σ is the elasticity of substitution between input groups. If all intra-class elasticities are equal to the inter-class elasticity then the function reduces to the standard CES production function.

Sato applies his model to an economy with three factors of production, two types of capital (K_1, K_2) and labor (L).

σ_K is denoted as the intra-class elasticity for the aggregate index of the capital stock, K. Thus

$$(4.4)\quad K_t = (b_1 K_1^{-\rho_K} + b_2 K_2^{-\rho_K})^{-1/\rho_K}$$

$$\text{where } \rho_K = \frac{1-\sigma_K}{\sigma_K} \text{ and } b_1 + b_2 = 1$$

The aggregate production function is given by

$$(4.5)\quad Q_t = [a_L L_{t-1}^{-\rho} + a_K K_{t-1}^{-\rho}]^{-1/\rho}$$

$$\rho = \frac{1 - \sigma}{\sigma}, \quad a_L + a_K = 1$$

Sato then assumes that the price of each factor is given and that entreprenuers are profit maximizers. Thus, in equilibrium, the ratios of the marginal product to price for each factor will be equal. Consequently, the equilibrium ratio of capital stocks is determined by

$$(4.6)\quad p_t = \frac{p_{2t}}{p_{1t}} = \frac{b_2}{b_1} \left|\frac{\bar{K}_2\bar{t}}{\bar{L}_1\bar{t}}\right|^{-\rho_K - 1}$$

$$\text{or} \quad k_t = \frac{K_{2t}}{K_{1t}} = \left[\frac{b_2}{b_1}\right]^{\sigma_K} \left|\frac{\bar{p}_1\bar{t}}{\bar{p}_2\bar{t}}\right|^{-\sigma_K}$$

By denoting the equilibrium ratio of the capital stock as k* (4.6) can be written as

$$(4.7)\quad k_t^* = b^{\sigma_K} p k_t^{-\sigma_K} \text{ where } b = b_2/b_1$$

Sato assumes that a deviation of the actual capital stock from the equilibrium ratio would cause entrepreneurs to move toward the optimum. Stocks

adjustment would occur by adjustment of the relative rate of investment in the two types of capital. The adjustment process is assumed to be an imperfect or lagged adjustment. Denoting λ as the reaction coefficient,

$$(4.8)\quad k_t^* = k_{t-1}^{1-\lambda} k_t^{1-\lambda}, \quad o < \lambda < 1$$

substituting (4.7) into (4.8) yields

$$(4.9)\quad k_t = b^{\sigma_K \lambda} k_{t-1}^{1-\lambda} p_t^{-\sigma_K \lambda}$$

$$\text{or } \log k_t = \sigma_K \lambda \log b + (1-\lambda) \log k_{t-1} - \sigma_K \lambda \log p_t$$

Thus, estimating the linear equation

$$(4.10)\quad \log k_t = a' + b' \log k_{t-1} + c' \log p_t$$

will yield estimates of λ, σ_K, and b. σ_K will in turn yield an estimate of ρ_K.

Sato applied this model to the U.S. economy assuming that there are two types of capital, buildings and equipment. p was derived by taking the ratio of the general price index for each type of capital. Thus to apply this model to the Honduran economy requires only

that the two capital stocks be redefined as domestic and foreign capital and that p be the ratio of domestic price levels to foreign price levels. However, an additional assumption will be imposed. Uzawa (1962) has shown that for the "two-level" CES function to be linear homogeneous, that σ must equal one. In other worlds, the relationship between output and the two factors, labor and the capital stock index will be Cobb-Douglas.

The wholesale price index for U.S. capital equipment is available in the IMF's International Financial Statistics. This series was used as an indicator of the relative price of Honduran capital imports. Unfortunately, only components of the consumer price index are available for Honduras. The price index for housing was taken as the best indicator available for capital costs in Honduras. The series was taken from the Bulletin Mensual of the Central Bank of Honduras. Equation (4.10) was estimated by letting $k_t = KD_t/KM_t$ and by letting p equal the ratio of the price index of Honduran capital to imported capital. The results of the estimate are

$$\log k_t = \underset{}{-.022} + \underset{(1.52)}{.64} \log k_{t-1} + \underset{(3.26)*}{.58} \log p_t \qquad (4.11)$$
$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (2.78)*$$

$$R^2 = .9038$$

Since $b' = 1 - \lambda$, (4.11) indicates that $\lambda = .36$ or about one-third of the adjustment occurs in one year. Similarly, $c' = -\sigma_K$ so σ_K is estimated to be 1.61. Finally, $a' = \sigma_K \lambda \log b$, so $b = b_{KD}/b_{KM}$ can be calculated as .90. Since $b_{KD} + b_{KM} = 1$, b_{KD} and b_{KM} equal .47 and .53 respectively. Thus, K can be estimated by

$$(4.12)\quad K_t = (.47KD_t^{.38} + .53KM_t^{.38})^{2.64}$$

Since the coefficients for KD and KM are close, this indicates that the two types of capital are close substitutes.

In order to restrict the production function to the Cobb-Douglas format, the following specification can be used

$$(4.13)\quad Q = aK^{b}L^{(1-b)}$$

$$\text{so } \log Q = \log a + b \log K + (1-b) \log L$$

$$\text{or } \log Q - \log L = \log a + b (\log K - \log L)$$

Thus

$$(4.14)\quad \log (Q/L) = \log a + b \log (K/L)$$

Estimating (4.14) and correcting for first order autocorrelation yields

$$(4.15)\quad \log\ (Q_t/L_t) = \underset{}{.11} + \underset{(9.39)*}{.23}\ \log\ \underset{(1.75)*}{(K_t/L_t)}$$

$$R^2 = 7902$$

or

$$(4.16)\quad Q = 1.29\ K^{.23}\ L^{.77}$$

This equation is reasonably consistent with the 75 percent of GDP which is distributed as wages and salaries.[24/]

Honduras is a small open economy with a fixed exchange rate. Consequently, interest rates in Honduras must be comparable to general world rates. Any marked deviation between Honduran and world rates would lead to unsustainable private capital flows. The Central Bank of Honduras has published annual average maximum interest rates on one-year loans since 1972. The relationship between this rate and overseas rates can be seen by regressing the real Honduran rate (r) on the real discount rate (d) in the U.S. In both cases the interest rates are deflated by using the consumer price index. The result with a correction for first order auto-correlation is

$$(4.17)\quad r_t = \underset{}{.32} + \underset{(3.18)*}{1.52}\ d_t$$

$$R^2 = .9219$$

Thus, the Honduran interest rate is exogenously determined. As was indicated in Chapter III, demand for

domestic investment is assumed to be a function of GDP and interest rates. Supply of investment goods is perfectly elastic since imports can be used to fill any gap between domestic savings and investment demand. The estimated determinant of investment of domestically produced capital is corrected for first order autocorrelation is

$$(4.18)\quad I_t = 19.47 + .27Q_{t-1} - 13.49r_t$$
$$(.067)\ (2.28)^* \qquad (1.69)$$

$$R^2 = .9219$$

As was indicated in the previous chapter, real consumption is assumed to be solely a function of GDP. Most of the Honduran population does not have access to financial markets, so their consumption decisions will not be affected by movements of market interest rates. Moreover, nominal interest rates on small savings accounts have been kept at the artificially low level of 3 percent since the late 1960's. Thus, the estimate of consumption with a correction for first order auto-correlation can be expressed as

$$(4.19.1)\quad C_t = \underset{(2.56)^*}{-84.10} + \underset{(25.80)^*}{.98}\, Q_{t-1}$$

Consumer imports were calculated as merchandice imports less capital imports. Their estimated relation to total consumption is

$$(4.19.2)\quad MC_t = \underset{(-4.42)^*}{-\ 200} + \underset{(9.34)^*}{.5C}$$

$$R^2 = .7985$$

Non-interest service imports were calculated by subtracting the interest payments listed in the World Bank Debt Tables from total service imports. Based on these estimates, service imports are determined by

$$(4.19.3)\quad MS_t = \underset{(3.61)^*}{55} + \underset{(4.25)^*}{.15}\ (MC + MK) + r^{b}D_{t-1}$$

$$R^2 = .6934$$

Exports of goods and services were initially estimated on the basis of (3.20) however the coefficient for lagged exports was not significant. Consequently the equation was respecified as

$$(4.20)\quad X_t = a_4 + b_4 Q_{t-1} + c_4 W_{t-1}$$

Estimating (4.16) with data from 1954 through 1981 from the international financial statistics and correcting for first order auto-correlation yields

$$(4.21)\quad X_t = \underset{(1.94)*}{-94.57} + \underset{(3.13)*}{.27Q_{t-1}} + \underset{(2.47)*}{.20W_{t-1}}$$

$$R^2 = .7864.$$

Equation (4.20) is assumed to yield a "rational expectation" of future exports. Thus, the lagged export term will drop out of equation (3.21), and reserves will be determined by

$$(4.22)\quad R_t = a_7 + b_7W_{t-1} + c_7XS_t + d_7p_t + e_7Q_{t-1} + f_7R_{t-1} + g_7R_{t-2}$$

The variance of exports XS_t at time t is measured as the variance of exports over the previous five years. Openness, p_t is measured as the average ratio of imports to GDP over the previous five years. Data from 1955 to 1981 were used to estimate (4.22) and yielded

$$(4.23)\quad R_t = \underset{}{-17.07} + \underset{(.74)}{.045W_{t-1}} + \underset{(1.74)*}{.0018XS_t} + \underset{(2.09)*}{3.13p_t} + \underset{(1.98)*}{}$$

$$\underset{(2.90)*}{-.067Q_{t-1}} + \underset{(5.30)*}{1.15R_{t-1}} - \underset{(-8.27)*}{.95R_{t-2}}$$

$$R^2 = .9699$$

The coefficient for Q is both significant and negative. While one would expect reserves to vary positively with income there are some factors which may be tending to generate a negative correlation. First, when growth increases it can be seen in both equations (4.19.1) and (4.19.2) that consumption and consumer imports both rise. All else equal then, higher growth will lead to larger imports and a widening trade deficit. Financing this deficit may lead to a drawdown in real reserve levels. Moreover, there is a positive correlation between income and the ability of a country to borrow on international capital markets. A country may feel that if it can easily raise funds on international market then there is less need to carry large reserves. In fact, over the last decade, the ratio of reserves to imports has trended downward for many countries.[23/]

Projections of exogenous variables

Several of the variables in the model are determined exogenously to the Honduran economy. Thus, making projections of the Honduran economy, requires that independent projections be made of the exogenous variables. The projections of the exogenous variables were made to be consistent with historical values. Where necessary, studies were done to determine the sensitivity of the projections to the exogenous variables.

While the level of debt is determined endogenously, debt service payments are to some extent the function of exogenous variables. Real international interest rates on both loans and deposits are assumed to remain at 8 percent during the entire projection period. This rate is close to the average level of real interest rates Honduras currently pays on commercial external debt. Real domestic interest rates are assumed to be constant at 10 percent since this was the rate in 1980 and they are closely tied to international rates. Interest rates were intentionally assumed to remain constant to insure that the projections did not simply reflect random fluctuations of interest rates. The impact of varying the international interest rates will be specifically investigated.

Not all of Honduras' debt is at commercial rates. At end-1980, Honduras owed about $700 million to other governments or multilateral organizations. Most of this debt carried interest rates far below commercial rates. On average, interest rates on Honduras' official source debt have deviated from commercial rates by 60 percent. Therefore, the interest rate on official source debt is assumed to be 3 percent during the projection period.

The supply of official debt does not follow any strong time trend. In some years, official lending rose sharply while in other years it actually declined. Thus, instead of utilizing a time trend for official lending, it is assumed to remain at its average level over the last decade of $60 million per year.

Debt service payments are a function, not only of interest payments but also of amortization. Amortization payments, in turn are a function of the maturity structure of the debt. Over the last decade, there has been little change in the maturity structure of Honduras' debt. In 1980, official debt had an average maturity of about 25 years. Commercial debt had an average maturity of about six years. It is assumed that the average maturity of these two types of debt remain unchanged. Of course, the

overall average maturity of the debt will change if commercial borrowing increases relative to official debt.

Equations (4.21) and (4.22) indicate that Honduras' reserve holdings and exports are, to some extent, functions of world exports. Honduras' exports are very small compared to world exports. Obviously, world exports are not significantly affected by the Honduran economy. As in the case of interest rates, the growth of world exports is held constant during the projection period. The growth rate is assumed to remain at the average level over the last decade of about 10 percent. The impact of varying world growth will be specifically investigated.

Projection-Base Assumptions

The following tables present 10-year projections of Honduras' economy at various real GDP growth rates. It is assumed that Honduras can borrow unlimited funds at the fixed international rate.

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Table 4.1 - Honduras: Base Case*
Real GDP Growth = 2%

	GDP	Domestic Capital	Imported Capital	Consumption
1982	1,523	1,606	1,076	1,379
1983	1,553	1,753	835	1,408
1984	1,584	1,979	639	1,438
1985	1,616	2,008	484	1,469
1986	1,648	2,132	358	1,500
1987	1,681	2,252	259	1,531
1988	1,715	2,369	181	1,564
1989	1,749	2,482	122	1,597
1990	1,784	2,593	78	1,630
1991	1,820	2,701	46	1,664

	Imports	Exports	Reserves	Debt	Probability Index
1982	688	683	44	1,392	.7707
1983	705	710	15	1,359	.7653
1984	720	728	23	1,358	.7582
1985	731	758	76	1,384	.7349
1986	783	791	147	1,402	.7259
1987	741	825	192	1,363	.7247
1988	761	863	191	1,261	.7136
1989	782	903	161	1,108	.6965
1990	803	947	136	940	.6964
1991	824	995	147	780	.6959

*Figures in the following tables are in millions of 1975 U.S. dollars except. The probability index is an actual number and the spread where relevant is in percents.

Table 4.2
Honduras: Base Case
Real GDP Growth = 4%

	GDP	Domestic Capital	Imported Capital	Consumption
1982	1,553	1,604	1,274	1,379
1983	1,616	1,753	1,189	1,438
1984	1,679	1,886	1,108	1,498
1985	1,747	2,032	1,039	1,562
1986	1,816	2,182	970	1,628
1987	1,889	2,335	907	1,696
1988	1,965	2,491	845	1,767
1989	2,043	2,653	789	1,841
1990	2,125	2,819	736	1,918
1991	2,210	2,990	682	1,998

	Imports	Exports	Reserves	Debt	Probability Index
1982	862	683	44	1,566	.7496
1983	783	718	19	1,607	.7627
1984	834	745	33	1,709	.7585
1985	881	784	89	1,862	.7564
1986	915	826	160	2,023	.7577
1987	953	871	204	2,149	.7602
1988	980	919	203	2,208	.7607
1989	1,002	971	173	2,210	.7678
1990	1,006	1,026	149	2,165	.7645
1991	1,045	1,087	155	2,130	.7462

Table 4.3 - Honduras: Base Case
Real GDP Growth = 6%

	GDP	Domestic Capital	Imported Capital	Consumption
1982	1,583	1,604	1,495	1,379
1983	1,678	1,753	1,644	1,467
1984	1,778	1,894	1,806	1,560
1985	1,995	2,057	1,995	1,659
1986	1,998	2,233	2,196	1,763
1987	2,118	2,420	2,422	1,874
1988	2,245	2,621	2,688	1,991
1989	2,380	2,835	2,949	2,116
1990	2,522	3,064	3,260	2,248
1991	2,673	3,309	3,595	2,388

	Imports	Exports	Reserves	Debt	Probability Index
1982	1,116	683	44	1,821	.7440
1983	1,093	726	27	2,171	.7684
1984	1,230	762	58	2,669	.7805
1985	1,386	811	137	3,325	.7915
1986	1,545	863	232	4,100	.8027
1987	1,737	920	295	4,981	.8136
1988	1,941	981	311	5,958	.8222
1989	2,183	1,046	301	7,085	.8292
1990	2,443	1,117	303	8,412	.8354
1991	2,698	1,194	342	9,955	.8405

Table 4.4 - Honduras: Base Case
Real GDP Growth = 8%

	GDP	Domestic Capital	Imported Capital	Consumption
1982	1,612	1,604	1,741	1,379
1983	1,741	1,743	2,221	1,496
1984	1,881	1,902	2,809	1,623
1985	2,031	2,083	3,547	1,759
1986	2,194	2,285	4,442	1,906
1987	2,369	2,509	5,551	2,066
1988	2,559	2,758	6,903	2,238
1989	2,763	3,031	8,584	2,423
1990	2,985	3,331	10,647	2,624
1991	3,223	3,658	13,144	2,841

	Imports	Exports	Reserves	Debt	Probability Index
1982	1,400	683	44	2,104	.7402
1983	1,517	734	35	2,878	.7772
1984	1,853	779	87	4,004	.7982
1985	1,281	838	201	5,560	.8152
1986	2,782	903	336	7,575	.8302
1987	3,428	972	444	10,138	.8436
1988	4,205	1,048	508	13,358	.8546
1989	5,202	1,131	556	17,477	.8638
1990	6,413	1,221	630	22,743	.8721
1991	7,830	1,319	760	29,384	.8793

The initial stock of imported capital is more than sufficient to sustain a growth rate of 2 percent. So with this growth rate, the stock of imported capital declines as it depreciates. In fact, by the end of the ten-year period the stock of imported capital has dwindled almost to zero. During most of the period the trade balance is in surplus, this allows for a steady decline in external debt. This reflects that the need to finance reserve increases and interest payments both slow the downward trend.

The probability index is already high in the beginning of the period. This reflects the substantial debt service ratio of about 30 percent which Honduras currently faces. The probability of default, however, is almost a full percentage point lower at the end of the projection period. This reflects the positive impact of the reduced debt level, higher exports, and the increase of the ratio of reserve to imports from 6 percent in 1982 to almost 10 percent in 1991. On the other hand, the slower growth rate and reduced capital inflows prevent the index from falling faster.

When growth is increased to 4 percent, the level of imported capital still declines over time. However, in this case the rate of decline is slower than the rate of

depreciation (i.e. one-tenth of the previous years capital stock) so imports of capital are slightly positive. The capital imports, along with the higher demand for consumption and investment goods leads to an increase in imports relative to exports. Consequently, the trade balance is in deficit during most of the projection period. The need to finance the larger trade deficits leads to a rise in external debt. By 1989, debt peaks at over $2 billion, more than double the level reached when growth is 2 percent. After 1989, the emergence of a trade surplus leads to a modest decline in the debt. Reserves initially rise to a higher level in the case with 4 percent growth. In 1987 reserves peak at $204 million compared with a peak of $197 when growth is 2 percent. Reserves decline in both cases in later years but they remain slightly higher in the case of 4 percent growth. When growth is 4 percent in 1991 both debt and the probability index are higher. The value of the index is .7462 in 1991 compared with .6959 when growth is only 2 percent. This contradicts Feder's finding that the probability of default varies negatively with growth when growth is low.

When growth is increased to 6 percent, for the most part, the same pattern continues. The most significant difference is that achieving this pace of growth requires an increasing stock of imported capital. Debt is up sharply by the end of the projection period reaching almost $10 billion. Reserves follow a different pattern, rising throughout the period. Despite the higher level of reserves, the probability index reaches .84 by the end of the projection period.

With 8 percent GDP growth, debt reaches almost $30 billion by the end of the period. The sharp rise in debt is due to the much higher level of imported capital needed to sustain growth. Imported capital reaches $13 billion at the end of the period compared with only $3.5 billion when growth is 6 percent. It appears then that there is generally a positive relationship between GDP growth and the probability index. By the end of the projection period, the probability index is higher when growth is higher. This is true even at low rates of growth. However, during the early part of the projection period, the relationship between the probability index and growth is reversed. In the first projection year the probability index is .7707 when growth is 2 percent. When growth is 8 percent the index falls to .7402 in the first

projection year. This reflects the contrary effects that growth and debt have on the probability index. Early in the projection period debt is relatively low so that higher GDP growth dominates movements of the index. However, debt and debt servicing increase faster than GDP when growth is high. By the end of the projection period, the higher debt dominates the index.

To insure that the relationship between the index and growth was not sensitive to interest rates the projections were made with interest rate reduced by five percentage points. Of course, at lower rates, the debt servicing burden will be lessened. Consequently, the debt is somewhat lower, only about $20 billion at the projection-end if GDP growth is 8 percent. Nevertheless, the same relationship is displayed between GDP growth and the probability index.

Endogenous Spread on External Debt

While utilizing the probability index indicates some general relationships between economic growth and debt servicing problems, the results are unreliable when the debt is very high. In the base case with 8 percent growth, the probability index reaches about 88 percent. However, the debt service ratio at this point is over 200 percent. There has never been a case where a country was

able to sustain a debt servicing ratio of even 100 percent without developing substantial arrears. The reason that the probability index is not sufficiently sensitive to the debt service ratio is because of the offsetting impact of the capital inflows. When debt servicing is high capital inflows also become high and this tends to moderate the index. However, in realty capital inflows are not free of constraints. Lenders may insist on higher interest rates or refuse to lend altogether.

When countries borrow in international markets, the rates on the loans normally carries a spread over prevailing rates. For most international loans the London Inter-Bank Offer Rate (i.e. LIBOR) is used as the base rate. The spreads over LIBOR can vary substantially both between countries and over time. At a given point in time if a country is paying a relatively high spread this usually indicates that the perceived risk in the country is high. Consequently one would expect many of the same variables which effect the probability index also effect the spread on foreign borrowing. As was indicated by equation (3.31), Feder and Just (1977) estimated an equation which determines the spread over LIBOR. The spread at a given point in time will only be applied to new and maturing debt. Other debt

will continue to carry the spread applicable at the time the debt was incurred. It is assumed that the spread is never negative.

The result of projecting the Honduran economy with an endogenous spread appears in the following tables. Only projections for imports, debt, the probability index, and the spread are shown. The other variables in the model remain unchanged from the base case. Since the spread is an addition to the base interest rate the debt servicing burden will be higher at any given debt. In addition, the need to finance the higher service payments in turn leads to a higher debt. Thus, regardless of the growth rate, debt is significantly higher at the end of the projection period when the spread is endogenously determined. The higher debt in turn leads to a higher level for the probability index, except when growth is only 2 percent. In this instance the negative impact of the higher debt is outweighted by the positive impact of larger capital inflows. In effect, Honduras is raising its credit rating by showing that it is capable of successfully servicing debt at commercial rates.

Since the spread is closely tied to the same variables as the probability index, it is not surprising that they display a similar pattern. At the end of the projection,

Table 4.5.1
Honduras: Market Determined Spread

Growth = 2%

	Imports	Debt	Spread	Probability
1982	688	1,392	0	.7707
1983	705	1,359	0	.7653
1984	720	1,358	0	.7582
1985	731	1,384	0	.7349
1986	738	1,402	0	.7259
1987	741	1,363	0	.7247
1988	761	1,261	0.3	.7136
1989	782	1,108	0.8	.6965
1990	803	1,939	0.7	.6964
1991	825	780	0.7	.6959

Growth = 4%

	Imports	Debt	Spread	Probability
1982	862	15667	0	.7496
1983	783	1,607	0	.7627
1984	834	1,709	0	.7585
1985	881	1,862	0	.7564
1986	915	2,022	0.2	.7578
1987	955	2,151	0.4	.7605
1988	983	2,214	0.8	.7612
1989	1,007	2,222	1.2	.7627
1990	1,013	2,185	1.4	.7570
1991	1,045	2,159	1.5	.7472

Table 4.5.2
Honduras: Market Determined Spread

Growth = 6%

	Imports	Debt	Spread	Probability
1982	1,116	1,909	0	.7431
1983	1,093	2,375	0	.7702
1984	1,230	2,985	0	.7848
1985	1,391	3,760	0.7	.7972
1986	1,566	4,677	1.7	.8100
1987	1,793	5,742	2.4	.8225
1988	2,060	6,991	3.5	.8332
1989	2,408	8,503	4.6	.8420
1990	2,841	10,382	5.6	.8501
1991	3,375	12,755	6.6	.8577

Growth = 8%

	Import	Debt	Spread	Probability
1982	1,400	2,125	0	.7399
1983	1,517	2,918	0	.7759
1984	1,856	4,018	0.1	.7967
1985	2,315	5,521	1.7	.8145
1986	2,911	7,492	3.3	.8314
1987	3,765	10,090	4.9	.8473
1988	4,978	13,576	7.1	.8613
1989	6,850	18,400	9.6	.8737
1990	9,823	25,229	12.4	.8855
1991	14,901	35,988	15.9	.8966

the spread is clearly larger when growth is higher. The s]read is not directly affected by capital inflows consequently it is more sensitive to the debt service ration. In fact, the spread reaches almost 16 percent in the case whre growth is 8 percent. Recorded spreads for Honduras, however, have never exceeded 2 percent and they have never exceeded 4 percent for any country. The spread then may serve as an alternative measure of an unsustainable debt burden when it exceeds normally observed limits.

Constraints on external borrowing

Projections of the Honduran economy were made assuming that no new commercial borrowing occurs when the spread is in excess of 4 percent. Under these conditions, external debt can only increase by borrowing from official sources. It is assumed that when borrowing is constrained, target growth is reduced to 4 percent. Table 4.8 indicated that this growth rate can maintain the spread below 4 percent. Consumer imports are initially cut to finance capital imports. If an elimination of consumer imports is not sufficient to sustain growth, consumption is cut further in order to increase investment in domestic capital.

Table 4.6 - Honduras: Limited External Borrowing
Targeted GDP Growth = 6%
Actual GDP Growth = 5%

	GDP	Domestic Capital	Imported Capital	Consumption
1982	1,583	1,604	1,495	1,379
1983	1,678	1,743	1,644	1,467
1984	1,778	1,894	1,806	1,560
1985	1,885	2,057	1,995	1,659
1986	1,998	2,233	2,196	1,763
1987	2,118	2,420	2,422	1,874
1988	2,245	2,621	2,688	1,991
1989	2,334	2,628	2,699	1,195
1990	2,428	2,646	2,719	1,201
1991	2,525	2,615	2,775	1,289

	Imports	Exports	Reserves	Debt	Probability Index
1982	1,116	683	44	1,820	.7440
1983	1,093	726	27	2,171	.7684
1984	1,230	762	58	2,669	.7805
1985	1,391	811	137	3,330	.7920
1986	1,566	863	232	4,128	.8045
1987	1,743	920	296	5,065	.8170
1988	2,060	981	315	6,163	.8277
1989	1,111	1,046	310	6,217	.8446
1990	1,184	1,105	291	6,277	.8455
1991	1,246	1,168	273	6,337	.8456

Table 4.7 - Honduras: Limited External Borrowing
Target GDP Growth = 8%
Actual GDP Growth = 6%

	GDP	Domestic Capital	Imported Capital	Consumption
1982	1,612	1,604	1,741	1,379
1983	1,741	1,743	2,221	1,496
1984	1,881	1,902	2,809	1,623
1985	2,031	2,083	3,547	1,759
1986	2,194	2,285	4,442	1,906
1987	2,281	2,714	3,970	769
1988	2,417	3,269	3,998	712
1989	2,514	3,770	3,586	762
1990	2,653	4,360	3,598	694
1991	2,761	4,939	3,228	687

	Imports	Exports	Reserves	Debt	Probability Index
1982	1,400	683	44	2,104	.7402
1983	1,517	734	34	2,878	.7771
1984	1,856	779	87	4,007	.7985
1985	2,315	838	201	5,598	.8172
1986	2,909	903	337	7,740	.8350
1987	920	972	450	7,800	.8621
1988	1,075	1,025	460	7,860	.8609
1989	1,247	1,093	365	7,920	.8614
1990	1,333	1,153	246	7,980	.8602
1991	1,350	1,229	185	8,040	.8591

When targeted growth is 6 percent, imported capital continues to accumulate after the interruption of foreign borrowing. The available foreign exchange is more than sufficient to finance interest payments. The slowdown of GDP growth allows for a smaller accumulation of domestic capital than in the base with 6 percent growth. Despite the reduced demand for investment, consumption drops 40 percent in 1989. Although it subsequently begins to rise it remains only about 50 percent of GDP.

When growth is 8 percent however, it is not possible to replace depreciating foreign capital due to the increased interest burden. In order to compensate for the declining stock of foreign capital domestic capital is forced to grow much faster than in the base case. This places an increasingly heavy burden on consumption. By the end of the projection period consumption falls to only 25 percent of GDP. It appears that severe austerity measures are necessary to continue servicing external debt following a disruption in access to further debt. It is interesting to note that in both cases the probability index initially increases when the lending constraint is imposed. It then steadily falls in subsequent years. It thus may be the case that the danger of debt service

interuptions may be highest when banks initially become nervous and their willingness to lend declines.

A Forced Reduction in Consumption

It is possible that as part of the growth strategy the government intentionally takes steps to limit consumption (i.e. increase the saving rate). This could be achieved by a reduction in the public sector deficit, a tax on consumption, or controls on imports of consumer goods. In order to investigate the impact of reduced consumption on debt accumulation, the scenario with 6 percent growth was re-estimated with a 10 percent lower marginal rate of consumption.

Under this scenario, consumption is substantially lower than in the base case when growth is 6 percent. At the end of the projection period consumption is reduced over $250 million per year. The lower rate of consumption, in turn, reduces, aggregate demand for imported consumer goods. As can be seen in equation (3.3.7) the reduction in aggregate consumer demand will result in lower imports. With lower imports, adequate reserve coverage can be achieved with fewer reserve holdings. The combination of less reserve building and lower imports reduces the need for external financing. Initially the savings in debt is moderate. In 1982, the

Table 4.8

Honduras: Marginal Propensity to Consume Reduced by 10%

Real GDP Growth = 6 %

	Consum.	Imports	Reserves	Debt	Probability	Spreads
1982	1,230	1,030	44	1,735	.7449	0
1983	1,309	994	24	1,983	.7647	0
1984	1,392	1,115	47	2,358	.7729	0
1985	1,481	1,253	117	2,871	.7818	0.4
1986	1,575	1,397	203	3,491	.7929	1.3
1987	1,674	1,581	261	4,211	.8044	1.8
1988	1,780	1,788	275	5,032	.8145	2.6
1989	1,891	2,052	263	6,027	.8234	3.1
1990	2,010	2,365	302	7,274	.8320	3.8
1991	2,136	2,730	283	8,845	.8402	4.3

debt is only 5 percent lower than in the base scenario. However, the reduced servicing requirement associated with the lower debt also leads to less reliance on external borrowing. Consequently, the reduction in debt becomes substantial by the end of the period. The debt only reaches about $8 billion, about 80 percent of the $10.2 billion accumulated in the base case. The spread would remain below 4 percent until the last year of the projection period so this growth scenario is more

consistent with financing constraints. However, borrowing would become limited at the end of the period.

The country may decide that the savings on debt can be enhanced by channeling the reduced expenditures on consumption into the investment sector. Higher domestic investment should reduce the need to import capital. The government might pursue this policy totally within the public sector by reducing recurrent expenditures while increasing capital investments.

If Honduras channels resources from consumption to investment, the overall demand for domestic output remains unchanged. Imports, however, still decline since fewer capital imports are required to sustain the rate of GDP growth. Consequently, debt is lower than in the base case with 6 percent growth. The spread would remain well below 4 percent during the entire projection period. What is more interesting is that at the lower rate of consumption, debt is lower when the savings is forced into domestic investment. This reflects the fact that the two capital stocks while not perfect are close substitutes. Thus, over a large range foreign capital can be substituted for domestic capital without a substantial loss of output. However, if the marginal product of imported capital begins to substantially exceed the

Table 4.9
Honduras: Consumption Reduced by 10% and Investment Increased by 10%
Real GDP Growth = 6%

	Consumption	Imports	Reserves	Debt	Probability Index
1982	1,230	1,030	44	1,735	.7449
1983	1,309	855	24	1,843	.7678
1984	1,392	963	41	2,062	.7677
1985	1,481	1,079	100	2,389	.7705
1986	1,575	1,190	172	2,788	.7774
1987	1,674	1,325	219	3,240	.7860
1988	1,780	1,468	225	3,733	.7937
1989	1,891	1,641	207	4,309	.8002
1990	2,010	1,830	196	5,012	.8067
1991	2,136	2,025	219	5,866	.8123

	Spread	Domestic Capital	Imported Capital
1982	0	1,604	1,495
1983	0	1,892	1,523
1984	0	2,202	1,564
1985	0.2	2,518	1,641
1986	0.8	2,840	1,736
1987	1.2	3,170	1,859
1988	1.8	3,510	2,002
1989	2.3	3,861	2,178
1990	2.9	4,225	2,382
1991	3.3	4,604	2,606

marginal product of domestic capital the situation would be reversed and the reduction of outputs would exceed the increase in reduction of interest payments. Thus, the optimal strategy will depend on the relative sizes of the two capital stocks (for an endogenous projection of relative capital stocks, see p. 104 below).

Sensitivity of Projections to World Trade

In order to determine the sensitivity of the projections to changes in world trade, trade was assumed to grow annually at only 5 percent. The results of this experiment when target growth is 6 percent is shown in the following table.

Exports are reduced over $10 million by the end of the period. Several other variables in the model are also effected. Reserve building is moderated which somewhat counters the impact of the decline in exports on the level of debt. Both debt and the probability index increases. But, the impact on the index is not large, (less than 1 percent) so, overall, the projections are not very sensitive to changes in world trade. The impact on the debt level is also not large, it is only 5 percent larger than in the base case at the end of the projection period. Consequently, the impact on spreads is small until the last projection year.

Table 4.10
Honduras: Impact of Only 5% Growth In World Trade
Real GDP Growth = 6%

	Imports	Exports	Reserve	Debt	Probability	Spread
1982	1,116	683	44	1,821	.7440	0
1983	1,093	717	25	2,178	.7692	0
1984	1,230	752	52	2,684	.7818	0
1985	1,392	790	128	3,362	.7940	0.6
1986	1,568	829	218	4,164	.8075	1.5
1987	1,796	871	273	5,170	.8209	2.3
1988	2,064	915	285	6,331	.8325	3.4
1989	2,416	962	273	7,772	.8429	4.6
1990	2,856	1,012	277	9,619	.8528	5.8
1991	3,400	1,064	323	12,000	.8622	7.3

Substitution between capital stocks

In the simulations it has been assumed that the mix of capital was not sensitive to the relative values of domestic and foreign interest rates. As spreads on foreign borrowing increased, there was no voluntary shifting of investment from foreign into domestic capital. The shift only occurs in the cases where foreign creditors limited the country's access to credits. Economic theory suggests that as the cost of foreign capital increases the country would normally tend to shift into other sources of

capital. In fact, maximization of output requires that the ratios of marginal product to marginal cost for all types of capital be equal.

$$(4.25) \quad \frac{\partial Q/\partial KD}{P_{KD}} = \frac{\partial Q/\partial KM}{P_{KM}}$$

where P_{KD} and P_{KM} are the marginal prices of domestic and foreign capital respectively. An alternative model will be utlized in which growth will be endogenous and capital investment will be roughly determined by equation (4.25).

The marginal products of the two capital stocks can be easily determine by utilizing equations (4.12) and (4.16). From equation (4.12) it can be calculated that

$$(4.26) \quad \partial K/\partial KD = \frac{.47(.47KD^{.38} + .58KM^{.38})^{1.64}}{KD^{.62}}$$

and

$$(4.27) \quad \partial K/\partial KM = \frac{.53(.47KD^{.38} + .53KM^{.38})^{1.64}}{KM^{.62}}$$

Equation (4.16) indicates that

$$(4.28) \quad \partial Q/\partial K = .3(L/K)^{.77}$$

Utilizing the chain rule yields

$$(4.29.1)\quad \frac{\partial Q}{\partial K}\frac{\partial K}{\partial KD} = \frac{\partial Q}{\partial KD} = \frac{.14(.47KD^{-.38} + .53KM^{-.38})^{1.64}}{KD^{.62}}\left[\frac{L}{K}\right]^{.77}$$

$$(4.29.2)\quad \frac{\partial Q}{\partial K}\frac{\partial K}{\partial KM} = \frac{\partial Q}{\partial KM} = \frac{.16(.47KD^{-.38} + .53KM^{-.38})^{1.64}}{KD^{.62}}\left[\frac{L}{K}\right]^{.77}$$

Thus, equation (4.25) can only hold if

$$(4.30.1)\quad \frac{.14(.47KD^{-.38} + .53KM^{-.38})^{1.64}}{P_{KD}KD^{.62}}\left[\frac{L}{K}\right]^{.77}$$

$$= \frac{.16(.47KD^{-.38} + .53KM^{-.38})^{1.64}}{P_{KM}KM^{.62}}\left[\frac{L}{K}\right]^{.77}$$

or

$$(4.30.2)\quad \frac{P_{KD}KD^{.62}}{.14} = \frac{P_{KM}KM^{.62}}{.14}$$

It is assumed that domestic investors try to vary domestic capital given the existing capital stock index, so as to equate marginal product with marginal cost. Equation (4.29.1) can be rewritten as

$$(4.31)\quad \frac{\partial Q}{\partial KD} = \frac{.14K^{.62}}{KD^{.62}} \left[\frac{L}{K}\right]^{.77} = P_{KD}$$

Solving for KD yields

$$KD = \left|\frac{.14\ L^{.77}}{P_{KD}K^{.15}}\right|^{1.61}$$

Solving for KM yields

$$(4.32)\quad KM = \left|\frac{1.14P_{KD}KD^{.62}}{P_{KM}}\right|^{1.61}$$

A method for deriving the cost of capital is outlined by Corcoran and Sahling (1982). They claim that the real cost of capital is the interest rate which equates the expected total capital income with the current market value of the assets. Let $E_i(t)$ denote the expected income from capital of type i at time t, and let V be the current market value of this capital asset. Then the real cost of the capital, p_i is the solution to the following expression

$$(4.33)\quad V_i = \int_0^{\infty} E_i(t)\ e^{-p_i t}dt$$

This measure of the cost of capital shows the minimum rate of return at which it is profitable to purchase additional

capital of this type. Whenever p_i is greater than the market rate of interest, it will be profitable to make the capital investment. Thus it will be assumed that for the marginal investment, the cost of capital is just equal to the market rate. In this case then, P_{KD} and P_{KM} in equation (4.3) can be approximated by the market rates of interest, r_t and r_t^b respectively. Thus, 4.30 and 4.31 can now be expressed as

$$(4.34) \qquad KD = \left| \frac{.14L^{.77}}{r_t K^{.15}} \right|^{1.61} \qquad KM = \left| \frac{1.14 r_t KD^{.62}}{r_t^b} \right|^{1.61}$$

Several additional assumptions will be made for the projection period. Since KM and r^b are simultaneously determined, investors will not know r_t^b with certainty when they make their investment decisions. Instead of utilizing r_t^b in equation (4.34), the lagged value of r^b will be used. The rate of growth will now be determined endogenously.

In the initial projection years, when the spreads are very low, the stock of imported capital grows very quickly. Consequently real GDP growth is high, at over 7 percent, between 1982 and 1984. However, the need to finance these higher imports in turn leads to a

substantial increase in debt. The level of debt nearly doubles between 1982 and 1985 reaching over $5 billion. The increased level of debt leads to an increase in the spread so as the projection period progresses the optimal stock of foreign capital begins to decline.

The capital stock begins to decline since imports are less than depreciation. GDP growth falls to only 3 percent in 1985. It averages only 3 1/2 percent for the remainder of the projection period. Nevertheless, external debt continues to rise. This reflect a sharp jump in debt service payments since the higher spreads are applied to maturing external debt as well as any new debt.

In fact, with this scenario, debt at the end of the projection period is higher than the debt level when growth is kept constant at 6 percent. Yet, the endogenous growth rate averages only about 5 percent during the projection period. Since average growth is lower, consumption at the end of the period is also lower than if growth had remained constant at 6 percent.

The reason that the economy performs so poorly in the endogenous growth case is because equation (4.31) is only a function of current interest rates. Consequently, early in the period, when interest is low there is a strong incentive to borrow to finance capital imports.

Table 4.11: Endogenous GDP Growth
Average real GDP growth = 4.4%
(millions of 1975 dollars)

	GDP	Domestic Cap.	Imported Cap.	Consumption	Spread
1982	1,683	1,604	2,430	1,379	0
1983	1,835	1,775	3,256	1,565	0
1984	1,909	1,792	3,287	1,713	1.6
1985	1,964	1,898	3,958	1,787	3.6
1986	2,027	2,035	2,662	1,841	4.8
1987	2,091	2,177	2,396	1,902	5.5
1988	2,160	2,329	2,157	1,965	6.4
1989	2,231	2,488	1,941	2,032	7.4
1990	2,305	2,658	1,747	2,101	8.6
1991	2,390	2,839	1,597	2,175	8.8

	Imports	Exports	Reserves	Debt	Probability Index
1982	2,192	615	44	2,896	.7332
1983	2,029	683	58	4,185	.7994
1984	1,508	753	150	4,982	.8275
1985	1,393	804	283	5,661	.8378
1986	1,628	846	381	6,503	.8439
1987	1,867	884	401	7,463	.8515
1988	2,518	927	368	8,613	.8583
1989	2,994	973	343	10,083	.8645
1990	2,994	1,077	379	12,035	.8707
1991	3,550	1,135	480	14,552	.8762

Later, as interest rates rise the optimal foreign capital stock begins to decline. But, the country is still carrying the debt borrowed earlier and must now service it at an increasing interest rate.

Conclusions

External borrowing is an integral part of the development process. Less developed countries need to import production inputs to fill the gap between demand and domestic supply but also to provide critical inputs which cannot be produced domestically. Unless developing countries have access to foreign capital then their ability to finance these imports is limited by the growth of export earnings.

The control model developed in Chapter II indicates that under certain circumstances it is optimal for developing countries to accumulate external debt. The necessary condition for foreign borrowing to be optimal is that the rate of return from the foreign investment be in excess of the servicing costs. This is a requirement which probably holds true for most LDCs, since imports play a key role in production processes. In fact, most LDCs have become increasingly dependent on access to foreign credit over the last two decades.

The control model also suggests that external debt will eventually tend to decline. Currently, the external debt of developing countries is rising rapidly both in nominal and real terms. However, it is quite possible that eventually this trend will reverse itself.

The major shortcomings of the control model is that it does not reflect institutional rigidities that may exist in a country which prevent the unrestrained flow of productive factors. In other words, it may be the case that increased output cannot be utilized to make service payments on external debt. The control model also does not adequately reflect some of the uncertainties that exist in the real world.

The empirical model indicated several patterns between external debt and real growth. In the case of Honduras, a decision to finance higher economic growth with external debt will eventually result in a higher probability of incurring problems servicing the debt. This is even true at low rates of growth. It follows from this relationship that at any level of growth, Honduras can reduce both its debt and potential servicing problems by increasing the domestic rate of savings. A policy of forcing domestic savings into production of domestic capital will further reduce the debt burden if the marginal product of imported capital is relatively low.

The projection studies also suggest that myopia on the part of either Honduras or the creditors is likely to increase the likelihood of eventual debt servicing problems. Higher GDP growth is generally associated with

a higher debt servicing burden. However, if Honduras were to adopt a high growth strategy, initially while debt is still low, it may appear that Honduras is not in a high-risk situation. Thus unless creditors focus on the potential time path of external debt, they may extend loans which will be regretted in future years. If Honduras adopts the high growth strategy and banks are anxious to lend, then myopia on the part of Honduras will also increase the probability of debt servicing difficulties. Since banks perceive the risk to be small, the spreads they offer will be relatively low. Honduras may be tempted then to borrow heavily. However, in future years they may find that the debt must be refinanced at ever increasing rates. This may accelerate the growth of debt to an unsustainable level.

Finally, the danger of debt servicing problems appears to be greatest when there is a shift in the creditors perceived risk. When creditors decide to limit Honduras' access to credit it eventually reduces the debt service burden and risks. However, initially the probability of debt servicing problems increases.

-FOOTNOTES-

1. The definition of LDCs used in this paper corresponds to the IMF definition except that European countries (including Turkey) are excluded.

2. Gasser and Roberts (1982), p. 24.

3. Ibid, p. 4

4. Roberts (1981), p. 36.

5. Bitterman (1973) presents case studies of debt reschedulings of several countries. Specifically: Argentina pp. 109-118; Brazil pp. 118-128; Peru pp. 179-184; Chile pp. 128-136. For the history of arrearages in Zaire see Table 1.1.

6. Mikesell (1968), p. 121.

7. Frank (1970), p. 26.

8. For an introduction to optimal country theory, the reader is referred to Arrow, K. and Kurz, M. Public Investment, The Rate of Return, and Optimal Fiscal Policy, Baltimore, 1970.

9. Effective labor simply implies that the growth rate reflects any exogenous impacts on labor productivity.

10. A positive rate of depreciation would not significantly influence the results. Assume the average rate of depreciation equals . If were defined as n + , then if n were replaced by in all subsequent equations the equilibrium results would reflect the rate of depreciation. However, this would in no way alter the conclusions derived from the model (see Arrow and Kurz (1970), p. 85).

11. The interest rate on most international commercial credits is based on a floating spread over LIBOR (London inter-bank offer rate). LIBOR itself is independent of any individual country's decision to borrow. Feder and Just however have shown that the spread is sensitive to relative indebtedness (i.e. debt service ratio and debt to GNP) and the level of national income.

12. The current valued Hamiltonian was used so that the results will be consistant with earlier studies. As long as the discount rate is a positive function, the instruments chosen to maximize the Hamiltonian and the current valued Hamiltonian will be the same. By definition, the current valued Hamiltonian is being discounted by some function a(t). Arrow and Kurz, [(1970), p. 47] show that if the discount rate is positive, then the first order conditions for the Hamiltonian, H, will also be relevant for the current valued Hamiltonian, a(t)H. If H(t) is the Hamiltonian constraint then the current valued Hamiltonian is also optimized when the variables u_i satisfy the equations (2.13.c).

13. According to the IMF's International Financing Statistics, Honduras' exports of bananas, coffee, wool, and beef totaled $500 million compared with total merchandise exports of $800 million in 1981.

14. National Agrarian Institute, Resumen de Datos Generales del Sector Reformado, Dec. 1978.

15. The IMF's International Financial Statistics, provides a history of both volume and price levels for coffee and bananas.

16. Central Bank of Honduras' Annual Report provides a sectoral breakdown on GDP and employment.

17. IMF, op. cit.

18. Federal Financial Institutions Examination Council, Country Exposure Lending Survey. This report indicates that U.S. bank claims on Honduras have remained at about $300 million since end-1979. The Bank of International Settlements' Quarterly Report on Bank Claims indicates that total bank claims on Honduras have remained at about $350 million.

19. Numbers in parenthesis are t-statistics. An asterik (*) denotes significance at the .05 level. When necessary, an adjustment for first-order autocorrelation was made in the estimation procedure using the Cochran-Orcutt method.

20. Central Bank of Honruas' Annual Report indicates that wages and salaries in 1978 were 1.4 million lempiras and GDP was 1.8 million lempiras.

21. Central Bank of Honduras, Bulletin Mensual.

22. Based on the IMF's International Financial Statistics, global reserves fell from 26 percent of imports in 1971 to 14 percent in 1981.

APPENDIX A

Debt Path with Variable Cononsumption

Equation (2.23) indicated that consumption is determined by

$$(A.1) \qquad c^*(t) = U'^{-1}(-u_3(0)e^{(p + n - G(d))t})$$

Therefore, the differential of c* with respect to time is

$$(A.2) \qquad c^* = \frac{dc^*}{dt} =$$

$$-u_3(0)(p + n - G(d))^{(p + n - G(d))t}(U'^{-1})1_{(\cdot)}$$

$(U'^{-1})'$ can be expressed in Leibnitz notation as

$$(A.3) \qquad dU'^{-1}(\cdot) = = \frac{1}{dU'(\cdot)} = -\frac{U''(\cdot)}{U'(\cdot)^2}$$

Thus, since $U''(\cdot) > 0$, $(U'^{-1})' < 0$. So A.2 can be respecified as

$$(A.4) \qquad c^* = - \Gamma(t)$$

where $\Gamma(t) \geq 0$ for all t.

Equation (2.24) will now be specified as

$$(A.5) \qquad km\partial c^*/\partial km + k\partial c^*/\partial k + d\partial c^*/\partial d = c^* = -\Gamma(t)$$

Substituting from equation (2.27) yields

$$(A.6) \qquad d = km + k + \frac{\Gamma(t)}{p}$$

Since $\Gamma(t)/p$ is non-negative for all t the result that debt accumulates as long as the economy is growing will still hold. Moreover, equation (2.18) indicates that in steady state $p + n = G(d)$. If this condition holds then equation (A.2) indicates that $\Gamma(t) = 0$. Thus, over time the impact of $\Gamma(t)$ on debt growth will decline.

The determination of the debt path with constrained consimption is also not fundamentally different if optimal consumption is variable. Equation (2.38) becomes

$$(A.7) \qquad d = k + \frac{u_2(t)}{u_1(t)}\, km + \frac{\Gamma(t)}{p}$$

Debt will still continue to grow when capital is accumulated. Growth will moderate over time since $u_2(t)/u_1(t)$ and $\Gamma(t)$ both get smaller as the economy approaches a steady state.

APPENDIX B

Construction of the Capital Stock

Aggregating the flow equations on imported and domestic capital, required an arbitrary assumption on the average rate of depreciation. In the text it was assumed that the average rate of depreciation was 10 years. The capital stocks based on this assumption are presented on a table on page 72.

Testing the sensitivity of the estimate of the capital index to different depreciation rates requires that capital stocks be constructed with varying depreciation rates. The table below shows estimates of Honduran capital with the alternative assumptions of an eight-year and a twelve-year depreciation rate.

Table B.1
Honduras' Capital Stock
With Alternative Depreciation Assumptions
(Millions of 1975 U.S. dollars)

	8-year Average Depreciation Rate		12-year Average Depreciation Rate	
	Domestic Capital	Imported Capital	Domestic Capital	Imported Capital
1957	309.3	349.1	*	*
1958	314.1	353.9	*	*
1959	318.0	357.8	*	*
1960	319.1	358.9	*	*
1961	307.2	347.0	453.3	539.7
1962	317.9	357.7	469.6	562.8
1963	324.5	364.3	485.1	690.0
1964	333.5	373.3	501.3	592.6
1965	341.7	381.5	504.9	611.7
1966	364.1	403.9	526.5	649.8
1967	419.8	459.6	577.2	691.6
1968	485.9	525.7	637.2	722.5
1969	552.5	592.3	696.5	754.9
1970	595.0	634.8	750.5	811.2
1971	644.9	684.7	812.0	846.4
1972	684.2	724.0	866.4	866.7
1973	735.1	774.9	932.8	926.7
1974	778.6	818.4	987.2	994.9

Table B.1 (continued)
Honduras' Capital Stock
With Alternative Depreciation Assumptions
(Millions of 1975 U.S. dollars)

	8-year Average Depreciation Rate		12-year Average Depreciation Rate	
	Domestic Capital	Imported Capital	Domestic Capital	Imported Capital
1975	816.6	856.4	1,069.3	1,039.2
1976	845.5	885.2	1,149.1	1,102.4
1977	895.8	935.6	1,250.6	1,184.0
1978	1,019.5	1,059.3	1,405.9	1,263.9
1979	1,157.5	1,197.3	1,549.7	1,345.9
1980	1,303.9	1,343.7	1,684.4	1,432.7

The capital-stocks was used to estimate a capital stock index. To derive estimates of the parameters, the following equation was estimated

$$\text{(B.1)} \qquad \log k_t = a' + b' \log k_{t-1} + c' \log p_t$$

where k and p were the capital stock and price ratios, respectively. The results of estimating this equation with the original capital stock was

$$\text{(B.2)} \qquad \log k_t = \underset{(1.52)}{-.022} + \underset{(3.26)*}{.64} \log k_{t-1} + \underset{(2.78)*}{.58} \log p_t$$

The standard error for the coefficients are

(B.3) $S_{a'} = .13 \qquad S_{b'} = .08 \qquad S_{c'} = .10$

Thus, the confidence intervals at the .05 significance level are

(B.4) $-.15 < a' < .13$

$.59 < b' < .69$

$.48 < c' < .68$

The result of estimating equation (B.1) with the capital stock derived when the depreciation rate is eight years is

(B.4) $\log k_t = .16 + .65 \log k_{t-1} + .53 \log p$

$(5.16)^* \quad (14.65)^* \qquad (2.52)^*$

Similarly, if the depreciation rate is assumed to be twelve years the result is

(B.5) $\log k_t = .05 + .68 \log k_{t-1} + .58 \log p_t$

$(1.62) \quad (4.27)^* \qquad (2.82)^*$

Except for the constant term in the eight-year case, both estimates remain within the confidence interval of the original estimates. In fact, even this case estimate is within the .01 percent confidence interval. Thus it is reasonable to assume that the assumption on depreciation does not significantly affect the results of estimating the model.

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