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A Rationing Model of Imports and the Balance of Payments in Developing Countries: Theoretical Framework and an Application to the Philippine Economy

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Summary

This paper provides a framework for addressing the issue of balance of payments adjustments when there are quantitative restrictions on imports. A major objective is to contribute to an understanding of how two key government policy instruments--domestic credit and import restrictions--interact in the determination of the balance of payments in developing countries. In the model that is specified and estimated, government economic policy is included not as an exogenous factor but as an endogenous response to developments in the private and foreign sectors. The government's decision-making on the supply of domestic credit and imports is described by a reaction function derived from minimization of a loss function. Another important feature of the model is the symmetric treatment of the demand and supply functions in the imports market. The estimation technique makes it possible to estimate a model for data in which some of the observations for consumer imports are on the domestic authorities' import supply function and some observations on the private sectors demand function for imports. Empirical data from the Philippines were chosen as an illustration, because the Phillippine experience was regarded as representative of mechanisms and events that are characteristic of a large number of developing economies.

The framework for model building in developing countries that is presented in this study is capable of addressing several important policy issues. For instance, the model provides useful information with regard to the extent of import rationing in the economy. It also provides consistent estimates of price elasticities of imports; such estimates can make an important contribution to policy discussions relating to currency depreciation and macroeconomic adjustment.

I. Introduction

The major purpose of this paper is to clarify the policy issues raised by the use of quantitative import restrictions by developing countries to ameliorate pressures on their balance of payments position. To this end, a model is developed, and its theoretical and empirical inferences tested. In the model, a quadratic loss function for the government policymakers is minimized to determine how their response to external imbalances is divided between increased import restrictions, the use of net foreign assets, and tighter domestic credit policy. It needs to be emphasized, however, that this analysis is not intended to imply that quantitative import restrictions are an appropriate policy: determining the optimality of import restrictions would have to take account of the long-run costs that arise from resulting distortions in the allocation of resources. Short-run macroeconomic analysis, of the sort presented in this study, is not suited to this purpose. Nevertheless, it is hoped that the novel properties of the model throw new light on the impact of import restrictions as well as on matters of traditional interest in macroeconomic analysis of developing economies.

There are three special features of the model. First, there is an emphasis on government economic policy as an endogenous response to developments in the private and foreign sectors. Second, there is a concern about the multidimensional character of stabilization policy in open, developing economies: targets include the rate of growth of output, inflation, and the balance of payments (or the level of foreign exchange reserves). Third, there is a stress on the application of symmetric treatment of demand and supply to the imports market.

With regard to the latter point, developing countries are conventionally viewed as supply-constrained economies or systems of persistent excess demand, with demand regarded as having little effect on production. However, even if all markets are normally in excess demand, macro-models for the developing countries should consider the demand side, because disequilibrium might affect real variables (e.g., capital accumulation, savings, labor supply) and concern over such effects might in turn influence the authorities' allocation policies. To allow for either excess demand or excess supply and to quantify disequilibria and their effects on the private sector's and government's behavior, a macro-model for the developing countries must treat demand and supply symmetrically.

Furthermore, to test the hypothesis that there has been chronic excess demand for imports, neither the model nor the empirical technique used for testing it can assume anything about the actual relation between aggregate demand and aggregate supply on the market for imported goods. For instance, a model that assumes equilibrium obviously cannot be used for such a test, which requires techniques for dealing with markets in disequilibrium, where supply and demand are not always equal and the short side of the market determines the quantity transacted. 1/ To consider the case of the import market, the appropriate model must allow that either the importers encounter quantity constraints such as import quotas and what is observed is the government policymakers' import supply function, or that there is no quantity rationing and what is observed is the import demand function of the private sector. For these reasons, in this paper an application of the symmetric treatment of demand and supply to the import market is provided by using disequilibrium macroeconomic theory and related econometric techniques.

Section II presents the structure of the model and a description of the behavioral equations. Section III provides a historical background of the Philippine economy, in order to demonstrate the suitability of the rationing model for that economy. Section IV presents the results of the estimation of the rationing model using Philippine data. Section V presents some concluding observations and suggestions for future research. Appendix I contains the mathematical solution of the model, and Appendix II contains a description of the estimation technique.

1/ Fair and Jaffee (1972), Maddala and Nelson (1974), Goldfeld and Quandt (1975), and Goldfeld, Jaffee and Quandt (1980).

II. Model Specification

This section formulates a simultaneous equations model to analyze the adjustment processes of imports and the balance of payments in developing countries. In the model, the government faced with balance of payments disequilibria is assumed to respond by making adjustments in imports, net foreign assets of the banking system and domestic credit. For example, to finance balance of payments deficits, the government could either allow a decrease (or forego a normal increase) in the net foreign assets of the banking system or intensify its efforts to restrain imports. 1/ The government tries to combine these various measures in such a way as to minimize costs arising from the imbalances. In the model, the instruments for controlling imports are quantitative restrictions on imports and domestic credit.

The government's decision-making on the supply of domestic credit and imports follows from a reaction function derived from minimization of a loss function. The quadratic loss function has the form:

$$(1) \qquad V_t = (cqm_t - cqm_t^*)^2 + a_1(kqm_t - kqm_t^*)^2 + a_2(rv_t - rv_t^*)^2$$

where

cqm_t = volume of consumption imports;

kqm_t = volume of capital and intermediate goods imports;

rv_t = real stock of net foreign assets of the banking system;

1/ It is useful to distinguish external equilibrium from the external balance target. When the figures are ex post, then from the balance of payments identity $(X - M) + F + \Delta R = 0$; where X is nominal exports, M is nominal imports, F is net capital inflows, and R is the stock of international reserves. External equilibrium can be defined as the situation where autonomous payments are equal to autonomous receipts ($B = X - M + F = 0$); in stating equilibrium in the form ($X - M + F = 0$), X, M and F are being treated as ex ante and not ex post variables. But this external equilibrium is not the same as the external balance target. If the authorities prefer a surplus or deficit, then the desired external position may very well be $B^* \neq 0$. But when the external balance target is set at anything other than zero, forces will exist in the system to establish equilibrium in the long run. Since $B = -\Delta R$, then $B^* \neq 0$ will imply a change in the country's international reserve position, and this in turn will set in motion stock adjustments. If $B^* \neq 0$, then it is more appropriately expressed in terms of the desired change in the reserve position. This accords with the short-run features that reserves serve as a buffer stock to finance temporary balance of payments imbalances.

and asterisks denote the government targets for the variables. V_t is social disutility and a_1 and a_2 are constants indicating the relative weights given the various terms of the quadratic loss function. (See Table 1 for a summary list of definitions of symbols.) The coefficient for the disutility term for realized consumption imports deviating from the private sector's desired level is set equal to unity for normalization purposes. The first term indicates that disutility rises if consumption imports are above or below their target level. The authorities' target level of consumption imports is set equal to the private sector's demand for consumption imports. The second term indicates that disutility occurs when capital imports either exceed or are less than the desired level which is set by the government taking account of the requirements of economic stabilization and growth. The last term indicates the disutility consequences of the stock of net foreign assets deviating from the authorities' desired levels.

The internal and external policy objectives of the government are reflected in the loss function. The costs associated with the imbalances in consumption imports and in net foreign assets are due to the inability of the policymakers to achieve the external target; actual consumption imports and net foreign assets are not equal to the policymakers' desired amounts. The internal policy objective is incorporated in the deviations of realized capital imports from the target capital imports. By assuming a fixed coefficient production function between domestic and imported capital and intermediate goods, the output growth target can be expressed in terms of the requirements for capital imports. When realized capital imports are not equal to the target capital imports, then the domestic output target will not be met.

The quadratic loss function specified in equation (1) does not have interaction terms and the costs of imbalances are assumed to change symmetrically with respect to positive and negative imbalances. When the deviations from desired levels increase, their disutitity consequences are assumed to become increasingly serious. The total cost is decomposed into costs of imbalances in consumption imports, capital imports, and net foreign assets. The government sets the volume of consumption imports and domestic credit so as to minimize the costs defined in equation (1) subject to the four behavioral equations of the model and the balance of payments constraint and the money supply identity.

Target capital goods imports are determined as follows:

$$(2) \qquad kqm_t^* = b_1 + b_2\overline{kqm}_t + \varepsilon_{1t}$$

where $\overline{kqm}_t$ is the second-order exponential time trend fit to the observed values of kqm_t.

Table 1. Definition of Major Variables

Variables	Description
cqm_t^*	Demand for real consumption imports by private sector.
kqm_t^*	Target real capital and intermediate goods imports of the policymakers.
ae_t	Real aggregate expenditures.
rv_t	Net foreign assets deflated by import price index.
y_t	Real gross national product.
Pm_t	Import price index.
Pd_t	GNP deflator.
rp_t	Import price index divided by the GNP deflator.
x_t	Net foreign exchange receipts that are exogenous in relation to the balance of payments policies of the domestic authorities divided by the import price index. This series is derived from the balance of payments identity, and is made up of all flows except for imports and the change in net foreign assets.
m_t	Broad money (currency in circulation, plus demand deposits, plus time and savings deposits) divided by the GNP deflator.
dcr_t	Domestic credit of the consolidated banking system divided by the GNP deflator.

The equation for the demand for capital imports is specified as follows:

$$(3) \qquad kqm_t = c_1 + c_2 dcr_t + c_3 \bar{y}_t + \varepsilon_{2t}$$

where kqm_t is the volume of capital imports and dcr_t is real domestic credit. The trend output variable is included to capture the fact that when output is increasing, the demand for capital imports (including intermediate goods) also goes up, because maintenance imports and intermediate goods are necessary to keep existing capacity fully utilized. This import requirement constitutes the well-known factor proportion problem in developing countrries, where there is limited substitutability between domestic factors and imported inputs. In equation (3), the output variable appears in level form, rather than in percentage change terms as is done in investment demand functions based on the accelerator model, because the time series for capital imports includes both capital goods and intermediate goods.

Domestic credit is also included as an explanatory variable in equation (3) in order to capture the effects of credit rationing on the demand for capital imports. In many developing countries, the accumulation of financial assets occurs at a slower pace than the accumulation of nonfinancial wealth or total output and, in some of these countries, governments impose controls or ceilings on interest rates; as a result, there often arises excess demand for credit, which must be resolved by credit rationing. 1/ In the present model, when the quantity of real domestic credit is increased, firms are able to increase their volume of capital imports as is specified in the equation.

The target volume of consumption imports (cqm_t^*) is determined by the import demand function of the private sector that has, as explanatory variables, the relative price (rp_t) and real aggregate expenditures (ae_t):

$$(4) \qquad cqm_t^* = d_1 + d_2 ae_t - d_3 rp_t + \varepsilon_{3t}$$

The demand for consumption imports is generally specified to be a positive function of domestic income. There is the issue, however, of whether domestic demand for foreign goods (imports) should properly be related to domestic demand for all goods (expenditure) or rather to the sum of domestic

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1/ Furthermore, the public holds few primary securities and investment is financed primarily from retained earnings and commercial bank credit.

demand for domestic goods and the foreign demand for domestic goods (exports), i.e., to income. In the empirical literature, real expenditure has been favored in the monetary-oriented models, because it can be related to the difference between actual and real money balances, thereby assuring a direct role for money in trade and balance of payments adjustment. 1/ In equation (4) above, consumer imports are postulated to be positively related to aggregate expenditure and negatively to the ratio of import prices to domestic prices (rp_t).

The equation for real aggregate expenditures can be specified as follows:

$$(5) \qquad ae_t = e_1 + e_2\bar{y}_t + e_3(m_t - h_1\bar{y}_t) + \varepsilon_{4t}$$

where ae_t is real aggregate expenditure, $\bar{y}_t$ is the trend level of output, and m_t is the real stock of money. The trend level of output is taken as a proxy for permanent income. A simple expenditure function (ignoring time lags) can be written as $ae = \alpha_o + \alpha_1\bar{y} - \alpha_3 i$ and a linear approximation of the money demand function is $m = \beta_o + \beta_1\bar{y} - \beta_2 i$. Substituting for i, the interest rate, from the money demand function into the expenditure function, and combining terms, results in the form of equation (5). 1/

Underlying this model is the assumption that the authorities know the error terms (ε_i) in the behavioral equations and in the definition of kqm_t^*, and therefore the quantity-setting decision is deterministic. From the standpoint of the econometrician, the equations are stochastic. If the errors were not assumed known by the policymakers, reduced-form solutions for the optimal values of the instruments could be derived by minimizing the expected loss function. See Goldfeld, Jaffee, and Quandt (1980). But given the well-known limitations of the developing country data, the easier specification in which the quantity setting decision is deterministic is assumed.

The authorities' desired stock of net foreign assets (rv_t^*) are taken to be the values in the current period of a second-order exponential time trend fitted to the observed values of these variables. It would have been a more conventional procedure to estimate a reserve demand equation with imports, variability in export receipts and certain other explanatory variables. Such an equation would make the model even more complex and it was therefore not estimated for the present study.

1/ See Goldstein and Khan (1982) for a discussion of these issues.
2/ See Rhomberg (1977), p. 177 for a similar derivation.

For deriving a balance of payments equation, international flows are categorized into exogenous and endogenous variables as follows. Nominal net foreign exchange receipts (X) are defined as the sum of flows that are exogenous in relation to the balance of payments policies of the domestic authorities; this is assumed to include exports and net capital inflows. For the developed countries, the above categorization would not be very promising, because for these countries almost all international flows are substantially endogenous; in particular, capital flows are highly sensitive to domestic monetary policy. For the developing countries, however, the above categorization seems broadly appropriate. Since it can be argued that the exports of many developing countries, at least in the short run, are not sensitive to domestic policies, and that capital flows are not sensitive to domestic interest rates. Imports are disaggregated into consumption imports and capital imports (including intermediate goods), and are considered endogenous.

The balance of payments constraint can thus be expressed in real terms as:

$$(6) \qquad \Delta rv_t = x_t - cqm_t - kqm_t$$

where Δrv_t is the change in the real stock of net foreign assets of the banking system, and x_t is the sum of the volume of exports and net real capital inflows. 1/

The change in the stock of money in an economy is equal to the changes in the stocks of net foreign assets and domestic credit of the consolidated banking system. Identity (7) below relates the increase in the stock of real money balances (m_t) to the increase in the stock of real net foreign assets (rv_t) and real domestic credit (dcr_t), where use is made of identity (6) to substitute out net foreign assets. Pm_t and Pd_t are the import and domestic price deflators, respectively. 2/

$$(7) \quad m_t = dcr_t - (Pm_t/Pd_t)cqm_t - (Pm_t/Pd_t)kqm_t + (Pm_t/Pd_t)x_t - dcr_{t-1} + m_{t-1}$$

1/ The identity (6) can be derived from the balance of payments constraint expressed in nominal terms: $\Delta RV = EXP + NCA - PM(cqm) - PM(kqm)$ if divided through by import prices (PM), where EXP and NCA are exports and net capital inflows in current prices.

2/ In the derivation of identity (7), use is made of the following definitions:

$$\Delta RV = EXP + NCA - PM(cqm) - PM(kqm);$$

$$\Delta rv_t = x_t - cqm_t - kqm_t; \text{ and}$$

$$\Delta m_t = \Delta dcr_t + \Delta rv_t.$$

The policymakers' reaction function is the solution to the problem of choosing cqm_t and dcr_t to minimize the quadratic loss function (1) subject to the equations (2), (3), (4), and (5) and the identities (6) and (7). The government policymakers are not assumed to have the power to set cqm_t above cqm_t^*, since this would imply that undesired consumption imports are forced upon the population. The minimization of the loss function is thus constrained by:

$$(8) \qquad cqm_t \leq cqm_t^*$$

The solution is determined by forming the Lagrangean

$$\begin{aligned}(9) \qquad L = {} & (cqm_t - d_1 - d_2 ae_t + d_3 rp_t - \varepsilon_{3t})^2 \\ & + a_1(c_1 + c_2 dcr_t + c_3 \bar{y}_t + \varepsilon_{2t} - b_1 - b_2 \overline{kqm}_t - \varepsilon_{1t})^2 \\ & + a_2(x_t - cqm_t - kqm_t + rv_{t-1} - rv_t^*)^2 \\ & + \lambda(cqm_t - d_1 - d_2 ae_t + d_3 rp_t - \varepsilon_{3t})\end{aligned}$$

The minimum of the disutility function with respect to the policy instrument variables is found by equating the first derivative of the Lagrangean to zero. The Kuhn-Tucker conditions that are necessary and sufficient for the solution are derived in Appendix I.

The model operates in two distinct modes, a rationing mode with $cqm_t < cqm_t^*$, and a nonrationing mode with $cqm_t = cqm_t^*$. In the rationing mode, the desired consumption imports of the private sector are greater than the actual imports permitted by the authorities. In this mode, there are strong import restrictions on consumption imports and the quantity of imports that is observed is not the private sector's import demand, but rather the supply of imports allowed by the authorities. Conversely, in the nonrationing mode, actual imports are equal to the desired imports of the private sector; i.e., the quantitative restrictions, if any, do not prevent the private sector from importing the desired volume of consumer goods.

Exchange rate policy as an instrument for balance of payments adjustment is given only a sketchy treatment in this model. Exchange rate changes affect the relative price term in the import equation and they affect domestic prices, so that there is also a real balance effect in the model. But there is no policy reaction function for the exchange rate. Perhaps the most important reason for this omission is that when the exchange rate has been used as a policy instrument in developing countries, the changes involved have generally been discrete and large;

usually exchange rate changes are long-delayed and infrequent. In this respect, it is not clear that an exchange rate policy reaction function for the authorities could be estimated without encountering serious econometric problems. Furthermore, specification problems in the exchange rate equation would be transmitted into the other equations, since the estimation technique employed is full information maximum likelihood.

The consumption import equation and the domestic credit equation are different under the two modes, and this presents a complication in the derivation of the likelihood function. The structure of the likelihood function and the description of the estimation technique is provided in Appendix II.

III. Application of the Model to the Philippine Economy

Empirical data from the Philippines were used as an illustration of applying the model, since the Philippine experience may be regarded as representative of mechanisms and events that are characteristic of a large number of developing economies. 1/ In particular, the Philippines belongs to the group of developing countries whose growth is based to a considerable extent on a sustained and rapid expansion of manufacturing exports. It is highly dependent on oil imports and was severely hit by the 1973 and 1979 oil price increases. The Philippine economy has generally experienced rapid growth but it has also had several years of slow and uneven development, largely associated with domestic and external financial imbalance.

Over the last two decades, the Philippines has had a succession of standby arrangements with the IMF, which has entailed drawings under the Fund's regular facilities as well as under the oil facilities of 1974 and 1975, the compensatory financing facility, and the extended Fund facility. The broad objectives of the programs with the IMF have been to strengthen the capacity of the economy for self-sustaining growth with internal and external balance, while containing inflation and ensuring moderate growth during the adjustment phase. The main instrument of adjustment was demand management, but measures were also taken to reduce tariffs, liberalize import restrictions, improve the tax system, eliminate interest rate ceilings and improve the exchange and payments system.

In this section, we provide a brief description of the development strategy of the Philippine authorities since the early 1950s. We also provide a brief description of the import restriction and exchange rate

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1/ The basic data were obtained from International Monetary Fund, International Financial Statistics, and National Economic and Development Authority, Philippine Statistical Yearbook.

systems, which were changed on several occasions over the sample period of estimation. This description should help convince the reader that the model presented above is particularly suited for the Philippine economy.

1. Development strategy of the Philippine authorities

The development strategy of the Philippine authorities since the early 1950s focused on import-substituting industrialization: controls were imposed on imports of consumer goods, relatively low tariffs were levied on capital goods and other industrial inputs, several fiscal incentives were provided for industrial activities, domestic interest rates were kept low, and an overvalued exchange rate was maintained for the purpose of protecting domestic industries. Exchange controls were imposed in response to a foreign exchange crisis in 1949, which was caused by expansionary credit policies and an unrealistically low price for foreign exchange. But once the 1949 exchange crisis had passed, policymakers decided to continue to employ exchange controls to support their import-substitution objectives.

> Not only did exchange controls gradually intensify in the 1950s, but they became increasingly used to promote industrialization via import substitution. Industrialization became an important goal in the country immediately after the establishment of Philippine independence in 1946. However, although special tax exemptions were granted to "new and necessary" industries as early as 1946, it was not until import and exchange controls were introduced that significant progress beyond restoring prewar manufacturing was made in substituting domestic manufacturing for imports of manufactures. Imports of consumption goods under the exchange-control system were, for example, reduced from 50 percent of total imports in 1950 to less than 15 percent by 1960. Thus, although exchange control was not deliberately introduced for the purpose of fostering import substitution, this goal soon served as the main rationale for continuing controls over foreign-exchange transactions. 1/

In the initial years of its implementation, the policy of industrialization based on import substitution met with success, as domestic production of finished consumer goods expanded to replace imports. Real GNP grew by 6.9 percent per year during 1950-59, and manufacturing production increased by 12.7 percent per year during the same period. Nevertheless, the industries which were established were highly dependent on imports. The emphasis on producing finished consumer goods provided little stimulus

1/ Baldwin (1975), p. 13.

for the domestic production of intermediate goods. Once the process of replacing imports of finished consumer goods by domestic production had been largely completed, the industries established within the protective framework were unable to sustain a significant expansion in output. Thus, real GNP grew by 5.3 percent in 1960-69, while manufacturing production increased by only 5.9 percent during the same period.

> We can see quite clearly at this early stage how the Philippines embarked upon an industrialization policy directed not only at import-substitution activities rather than export-promoting ones but also at the production of many nonessential consumption commodities. Instead of attempting to remove exchange controls once the 1949 crisis had passed, policymakers decided to continue to employ these controls to carry out their export-promoting and import-replacing goals. With a simplistic view of economic interrelationships, these leaders reasoned that the capital goods needed for expansion of export-oriented and basic import-replacing production would be more or less automatically imported once imports of consumption goods were forcibly curtailed. They also concluded that the most plausible criterion for restricting these consumption imports was their degree of essentiality in terms of basic nutritional and health needs. Thus, imports of so-called luxury items were sharply curtailed. They had overlooked the tendency of capital to flow into the most profitable industries and that the act of restricting imports of nonessential consumption goods would raise the domestic prices of these goods sharply and thereby make their production the most profitable opportunity available. Imports of luxury goods were restricted so severely that the production incentives brought about by this act dominated all the other policies aimed at encouraging the manufacturing sector. 1/

By the late 1960s, it had become clear that the limits of growth led by import substitution had been reached and new policies were needed to sustain satisfactory growth. The Philippine authorities adopted a new development strategy oriented toward export expansion, which included a series of measures to increase investment and provide impetus for exports. Among these were the Investment Incentives Act, introduced in 1967, to help stimulate investment for production of new products, and the Export Incentives Act, introduced in 1970, to provide additional incentives to export-oriented firms. Credit facilities for the export sector were also improved. The low interest rate policy followed until the late 1960s was

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1/ Baldwin (1975), p. 25.

modified, and interest rates were adjusted upward in 1974 and again in 1976. The devaluation of the peso in 1970, together with some realignment of tariffs in 1973, also tended to offset the biases against export-oriented and producer-goods industries inherent in the existing system of protection.

The policies to redirect manufacturing away from import substitution and toward exports improved the performance of the economy. As the growth of exports of nontraditional manufactures accelerated and the international boom in commodity prices brought a sharp rise in export volume and price, the current account improved from being roughly in balance during 1970-72 to a record surplus in 1973. However, the favorable prospects for the new development strategy were adversely affected by the sharp rise in oil prices in 1973-74 and the recession in the industrial countries in 1974-75. The large trade and current account surplus of 1973 was reversed in 1974. But even though foreign demand showed an uneven pattern with large increases in 1976 and 1979 and small declines in 1975 and 1978, the Philippine economy achieved a stable rate of growth during the period 1975-79, with real GNP rising at an average annual rate of about 6 percent.

2. The exchange and trade payments system of the Philippines 1/

During the 1950s, the exchange system of the Philippines was characterized by severe restrictions on payments. Exchange controls and import restrictions were first imposed in 1949 on certain luxury and nonessential commodities, and later expanded in 1950 to include all goods. The basic fact of the Philippine international position during the 1950-60 period was an excess demand for imports. Purchases of imports were kept within manageable limits only by the import licensing system. Exchange proceeds, including invisibles, had to be surrendered to an Authorized Agent of the Central Bank. Restrictions on imports were applied by privileged listing of commodities. Imports were classified as unrestricted, qualitatively restricted, and prohibited imports. Licenses were freely given for unrestricted imports, and quantitatively restricted imports were licensed only to the extent that exchange had been allocated by the exchange control office.

Although the restrictive system was geared to a given level of foreign exchange, the selective method of determining the category of imports also served non-balance of payments purposes. For example, in order to help the reconstruction of the local tobacco industry and to develop the cigar and cigarette industry, cigarettes and leaf tobacco were classified as nonessential imports. At the same time, in order to

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1/ The system is described in detail in the Annual Report on Exchange Arrangements and Exchange Restrictions, International Monetary Fund, various issues.

keep the local cigar and cigarette industry operating at peak capacity, cigarette paper and cigar wrappers were given a large allocation of foreign exchange. While this is only one specific example, similar examples may be cited: nails which were banned versus nail wire, automobiles versus automobile parts for assembling in the Philippines, etc. In general, imports of raw materials, capital equipment and spare parts received a more liberal treatment than the imports of consumer goods.

The import and exchange restrictions were increased in certain years in the 1950-60 period. Since export income in 1952 was smaller than in 1951 on account of lower export prices, the foreign exchange certified for imports was reduced. Then in 1955, because of a decline in foreign exchange reserves, the Central Bank introduced further cuts in import quota allocations. The tightening of the regulations on imports which was begun in 1955 continued through 1958. Exchange controls were tightened considerably from 1957 to 1958. The greatest cuts were in the imports of consumer goods, while imports of raw materials actually increased.

Beginning in 1960, the authorities adopted a four-year program for gradual decontrol of imports. The essence of the program was the gradual transfer of exchange payments and receipts from the official rate, which was overvalued, to a free market rate. With the more realistic exchange rate in the free market, and the accompanying measures of monetary and fiscal restraint, it was expected that freedom of payments would be achieved with a fixed, unitary exchange rate. During 1960-61, the Philippine peso was depreciated to more realistic levels and there was some liberalization of payments. In 1962, all remaining restrictions on trade and payments were removed, with the exception of the requirement to surrender 20 percent of the export proceeds at par value, the requirement of advance deposits for imports of less essential goods, and the prohibition of the import of some agricultural commodities for protective reasons. The requirement that 20 percent of export proceeds be surrendered to the Central Bank at the former par value was eliminated in 1965, while the requirements of special time deposits on specified categories of imports was eliminated in 1966.

The trade and payments system of the Philippines, however, became somewhat more restrictive in 1968. The major development with respect to trade was the introduction of advance deposit requirements for imports, and the establishment of voluntary quotas by certain importers. The purpose of these measures was to alleviate the pressures on the balance of payments and foreign exchange reserves. The continuing pressures on the balance of payments led the authorities to impose further restrictions on trade and payments so that by the end of 1969, the trade and payments system had become considerably more complex and restrictive than it had been a year earlier. Although export-oriented industries were permitted to satisfy all their import needs subject to Central Bank approval,

ceilings were imposed on the opening of letters of credit. The ceilings on letters of credit applied to four essential categories of imports, and other imports were not permitted.

The exchange and payments restrictions, which were introduced in 1967 and intensified in 1969 when pressures on external resources became critical, were largely removed in 1970. The exchange reform of 1970 established a free foreign exchange market with a fluctuating rate. During most of the 1970s, the authorities pursued the policy of phasing out exchange restrictions, especially those maintained for industrial protection. This policy was coordinated with the policy of reducing tariff protection. Liberalization was also implemented by a dual policy of shifting items from the banned to the freely importable list, and increasing the foreign exchange allocations for the restricted items. In 1980, import items were divided into ten categories according to the type of good and the degree of essentiality as determined by the authorities. Foreign exchange sales for importation of items under three categories--nonessential consumer goods, semi-unclassified consumer goods, and unclassified consumer goods-required prior approval by the Central Bank. Such approvals were granted on a case-by-case basis, and were generally tightly restricted. There were no other quantitative restrictions on imports (other than imports of gold).

IV. Estimation Results

The model that was developed in section II was estimated using Philippine annual data for the 1952-80 period. The model was estimated using a full information maximum likelihood estimator, which allowed for the appropriate cross-equation restrictions on parameters. The numerical optimizations were performed using the Davidon-Fletcher-Powell and the quadratic hill-climbing algorithms, using the GQOPT program based on Goldfeld, Quandt and Trotter (1966).

Estimates of the parameters obtained are reported in Table 2. Except for the anomalous estimate for e_3, all the estimates are reasonable with significant asymptotic t-values. Examining first the relative weights of the quadratic loss function, we note that a_1 (the coefficient for the disutility term when capital imports deviate from the authorities' target capital imports) is greater than a_2 (the coefficient for the disutility when net foreign assets are above or below the desired level). Thus, the authorities assign greater weight to deviations of capital imports than deviations of net foreign assets. This accords with the features that international reserves serve as a buffer stock to finance temporary payments imbalances, while imports of capital goods and raw materials are necessary to avoid under-utilization of existing resources because of the complementarity of domestic and imported inputs in the production

process. But a_1 is less than 1, which is the coefficient for the disutility term for realized consumption imports deviating from the private sector's desired level. 1/ This seems reasonable since the authorities had high tariffs on consumer goods and nonessential items were banned. In other words, the losses would be high if the private sector was unable to import the most essential consumer goods, which were already being taxed heavily.

Turning now to the capital imports equations, we note first a coefficient of 1 for the trend capital imports variable in the equation for target capital imports of the authorities; this result indicates that the authorities' target capital imports are not very different from trend capital imports. In the equation for demand for capital imports by the private sector, all of the coefficients conform to a priori expectations. In particular, the coefficient c_2 for the domestic credit variable is positive, showing that when the availability of credit increased, firms were able to import more capital goods and raw materials. Alternatively, in order to import more capital and intermediate goods, the firms need more credit, holding other things equal.

The estimated coefficients of the demand equation for consumption imports by the private sector are interesting. The coefficient d_2 for the expenditure variable is similar to the estimates of previous studies on import demand functions. The coefficient d_3 for the relative price variable, however, is on the low side; it implies a relative price elasticity for consumption imports, calculated at the sample mean, of -0.41. Nevertheless, this is not a surprising result, for two reasons. First, since there were stringent controls on consumer imports in effect during most of the sample period, so that only the essential consumer imports were allowed, the substitution possibilities for the permitted consumer imports and domestic substitutes were limited. Second, when there are quantitative import restrictions, then there will be specification error bias in the least squares estimation of the relative price elasticity. If increases in quantitative restrictions on imports are positively correlated with increases in import prices on account of higher tariffs or exchange rate changes, but there is no variable in the regression equation to capture the effect of quantitative restrictions, then there would be the problem of the omitted variable equation and the slope coefficient of the relative price

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1/ The reader will recall from Section II that for normalization purposes the coefficient for the disutility term for realized consumption imports deviating from the private sector's desired level was set equal to unity.

Table 2. Maximum Likelihood Estimates 1/

Relative weights of loss function			
Constant	a_1	0.551	(171.21)
Constant	a_2	0.135	(4.63)
Target capital imports of the authorities equation			
Constant	b_1	0.437	(4.09)
Trend capital imports	b_2	1.003	(40.90)
Variance of error term	σ^2_1	7.972	(306.90)
Demand for capital imports by private sector equation			
Constant	c_1	-0.943	(-2.06)
Real domestic credit	c_2	0.303	(11.08)
Trend output	c_3	0.079	(8.31)
Variance of error term	σ^2_2	5.523	(101.12)
Demand for consumption imports by private sector equation			
Constant	d_1	0.158	(1.87)
Real aggregate expenditure	d_2	0.045	(23.55)
Relative price	d_3	0.021	(5.90)
Variance of error term	σ^2_3	1.110	(5.39)
Desired real aggregate expenditure equation			
Constant	e_1	-4.603	(-5.46)
Trend output	e_2	1.044	(159.89)
Money market disequilibrium term	e_3	-0.011	(-10.34)
Variance of error term	σ^2_4	13.124	(56.13)
Log of likelihood function			
LogL		-169.95	

1/ The sample period is 1952-80; asymptotic t-values are in parentheses.

term would be biased upward. 1/ The present model takes account of quantitative restrictions on imports and this source of bias has been eliminated.

Finally, turning to the equation for real aggregate expenditure, we note that the estimate for the coefficient of the trend output variable is, as might be expected, close to unity. The coefficient h_1 of the proxy for the transaction variable in the money demand function was restricted to unity during the estimation. The coefficient of e_3 for the money market disequilibrium variable has the wrong sign, perhaps because of the extremely simple form in which this variable is expressed. The expected rate of inflation and the interest rate are not included in the money demand function. It would be useful, therefore, to try somewhat different specifications of the aggregate expenditure equation.

As discussed in Section II the model that was estimated operates in two distinct modes. In the rationing mode, ($cqm_t < cqm_t^*$) the desired consumption imports of the private sector are greater than the actual imports permitted by the authorities, while in the nonrationing mode ($cqm_t = cqm_t^*$), actual imports are equal to the desired imports of the private sector. The modes are determined by the values of λ, where

$$(22) \qquad \lambda = \frac{2a_2}{1 + d_2 e_3 (Pm_t/Pd_t)} (x_t - cqm_t - kqm_t + rv_{t-1} - rv_t^*)$$

The nonrationing mode occurs when the values of λ are greater than zero. We present the values of λ for all of the observations of the sample period in Table 3. The values of λ, and therefore the occurrence of the rationing and nonrationing modes, are generally in accord with the description of the Philippine exchange and trade restriction systems provided earlier. 2/ Our model predicts the rationing mode when exchange restrictions by the authorities were extensive or were being increased.

1/ The bias equals the true coefficient of the omitted variable times the regression coefficient of the excluded variable on the included variable. Further, the bias will not disappear as the sample size grows large, so that the omission of a variable from the true model yields inconsistent parameter estimates as well. The only case in which the bias and inconsistency will disappear occurs when the omitted variable is uncorrelated with the included independent variable, but this appears extremely unlikely in the case of import prices and quota restrictions.

2/ Given the construction of the Kuhn-Tucker problem in the present model, the values of λ should not be less than zero. Basically, the values presented are only estimates of λ because of the treatment of the error term. The negative values of λ are interpreted as zero.

Table 3. Determination of the Rationing and Nonrationing Modes of the Model 1/

Year	Values of λ	Exchange and trade payments system
		Exchange controls and import restrictions introduced in 1949 and expanded in 1950.
1952	0.29	Foreign exchange certified for imports
1953	0.29	reduced in 1952 because of declines in
1954	0.19	export prices and export earnings.
1955	-0.19	Further cuts in import quota allocations
1956	-0.06	during 1955-58, particularly in 1957-58.
1957	-0.81	because of a decline in foreign exchange
1958	-0.74	reserves.
1959	-0.32	
1960	0.02	A four-year program of gradual decontrol of imports implemented in 1960.
1961	-0.41	Some liberalization of payments restrictions in 1960-61.
1962	-0.15	All remaining restrictions on trade and
1963	-0.07	payments removed in 1962, except the
1964	-0.25	requirement to surrender 20 percent of
1965	0.16	export earnings at par value, the requirement of advance deposits for imports of less essential goods, and the prohibition of some agricultural commodities.
1966	0.51	The requirement of special time deposits on specified categories of imports removed in 1966.
1967	-0.08	On account of declining foreign exchange
1968	-0.32	reserves, certain restrictions on
1969	-0.95	imports imposed in 1967 and increased
1970	-0.51	in 1969.
1971	-0.53	A free foreign exchange market with a fluctuating exchange rate established in 1970.
1972	0.62	Exchange restrictions progressively lowered
1973	4.70	during the 1970s. Items shifted from the
1974	4.26	banned to the freely importable list.
1975	1.89	Foreign exchange allocations for restricted
1976	0.74	items also increased.
1977	0.72	
1978	-1.93	
1979	-4.27	
1980	-5.42	

1/ The nonrationing mode occurs when the values of λ are greater than zero.

There are also, however, a few years in the late 1970s, for which the model is predicting the rationing mode but gradual liberalization was occurring. A possible explanation for this result could be that although the import supply was not being reduced by the policymakers, the demand for imports by the private sector was increasing rapidly, and thus the excess demand regime is predicted by the model.

It is also encouraging to note that the results here are in agreement with those obtained by Baldwin in his study, Foreign Trade Regimes and Economic Development: The Philippines. 1/ Table 4 is taken from Baldwin's extensive survey of the exchange and payments policies pursued by the Philippine government between 1949 and 1971. It is presented in terms of the five phases of exchange control suggested by Bhagwati and Krueger. His identification of the chronological development of the Philippines external payments regime was based on an exhaustive study of the external and internal economic policies of the Philippine authorities. In comparing Tables 3 and 4, we note that not only are the values of λ in agreement with Baldwin's description of the exchange-control phases in the Philippines, but our model successfully captures the short period of complete liberalization in 1965-66.

V. Concluding Remarks

An aggregate disequilibrium model of imports and the balance of payments in developing countries was specified and estimated in this paper. The model was estimated using Philippine annual data for the post-World War II period. A major aim of this study has been to show how two key government policy instruments--domestic credit and import restrictions--interact in the determination of the balance of payments. In the disequilibrium model, government economic policy was included as an endogenous response to developments in the private and foreign sectors. Another important feature of the model was the symmetric treatment of demand and supply in the imports market. The estimation technique makes it possible to estimate a model for data in which some of the observations for consumer imports were on the authorities' supply function for imports and some observations on the private sector demand function for imports.

1/ Baldwin's study was one of a series resulting from the research project on exchange control, liberalization, and economic development sponsored by the National Bureau of Economic Research and co-directed by Bhagwati and Krueger. In that project a number of country studies were undertaken, focusing upon the quantification and analysis of individual developing countries' experiences with exchange control regimes and attempts at liberalizing those regimes.

Table 4. Exchange-Control Phases in the Philippines, 1949-71 1/

Dec. 1949-Sept. 1955	Phase I	Introduction and intensification of exchange controls
Sept. 1955-Apr. 1960	Phase II	Adoption of ad hoc measures to offset some of the unfavorable aspects of exchange controls
Apr. 1960-Jan. 1962	Phase III	Introduction of exchange-control liberalization
Jan. 1962-Nov. 1965	Phase IV	Continued liberalization of exchange controls
Nov. 1965-June 1967	Phase V	Period of complete liberalization
June 1967-Feb. 1970	Phase I	Return to moderate exchange controls
Feb. 1970-Dec. 1970	Phase III	Floating of peso and relaxation of some exchange controls
1971	Phase IV	Further relaxation of exchange controls

1/ This is Table 1-6 in Baldwin (1975), p. 12.

There are various extensions of the present analysis that need to be explored in future work. Simulation experiments with the model could be performed. Slightly different specifications of the model would be useful. For example, instead of using a time trend for the estimation of desired international reserves, a reserve demand equation with imports as an explanatory variable could be estimated. The author is also compiling data sets for application of the model to other developing countries. The present model could be taken as a starting point on which to build by incorporating particular institutional features present in individual countries so as to attain a greater degree of realism. The purpose of this study was to develop a framework for model building in developing countries, and it appears from the results that the disequilibrium approach is a useful one to take.

APPENDIX I

Solution of the Model

The solution of the model is derived by minimizing the policymakers quadratic loss function, V_t, with respect to the two policy instrument variables, cqm_t and dcr_t, subject to the identities and equations of the model. For ease of reference, the loss function, the two identities, and the four equations of the model that were described in the text are listed below.

$$(A.1) \quad V_t = (cqm_t - cqm_t^*)^2 + a_1 (kqm_t - kqm_t^*)^2 + a_2 (rv_t - rv_t^*)^2$$

$$(A.2) \quad rv_t = x_t - cqm_t - kqm_t + rv_{t-1}$$

$$(A.3) \quad m_t = dcr_t - (Pm_t/Pd_t)cqm_t - (Pm_t/Pd_t)kqm_t + (Pm_t/Pd_t)x_t - dcr_{t-1} + m_{t-1}$$

$$(A.4) \quad kqm_t^* = b_1 + b_2\overline{kqm} + \varepsilon_{1t}$$

$$(A.5) \quad kqm_t = c_1 + c_2 dcr_t + d_3\bar{y}_t + \varepsilon_{2t}$$

$$(A.6) \quad cqm_t^* = d_1 + d_2 ae_t - d_3 rp_t + \varepsilon_{3t}$$

$$(A.7) \quad ae_t = e_1 + e_2\bar{y}_t + e_3(m_t - h_1\bar{y}_t) + \varepsilon_{4t}$$

The government policymakers will not set cqm_t above cqm_t^* because this would force consumption imports on individuals that they do not want, and this appears impossible. The minimization of the loss function is thus contrained by:

$$(A.8) \quad cqm_t \leq cqm_t^*.$$

The policymakers' reaction function is the solution to the problem of choosing cqm_t and dcr_t to minimize (A.1) subject to the constraint (A.8), the identities (A.2) and (A.3), and the equations (A.4), (A.5), (A.6), and (A.7). The solution is determined by forming the Lagrangean

$$(A.9)\quad L = (cqm_t - d_1 - d_2 ae_t + d_3 rp_t - \varepsilon_{3t})^2 + a_1(c_1 + c_2 dcr_t + c_3 \bar{y}_t + \varepsilon_{2t} - b_1 - b_2 \overline{kqm}_t - \varepsilon_{1t})^2 + a_2(x_t - cqm_t - kqm_t + rv_{t-1} - rv_t^*)^2 + \lambda(cqm_t - d_1 - d_2 ae_t + d_3 rp_t - \varepsilon_{3t})$$

The minimum of the disutility function with respect to the instrument variables is found by equating the first derivative to zero. It is postulated that cmq_t and dcr_t are always positive. As a result, the following Kuhn-Tucker conditions are necessary and sufficient for the solution, i.e., equations (A.10), (A.11), and (A.12).

$$(A.10)\quad \frac{\partial L}{\partial cqm_t} = 2(cqm_t - d_1 - d_2 ae_t + d_3 rp_t - \varepsilon_{3t})(1 + d_2 e_3(Pm_t/Pd_t)) - 2a_2(x_t - cqm_t - kqm_t + rv_{t-1} - rv_t^*) + \lambda + \lambda d_2 e_3(Pm_t/Pd_t) = 0$$

$$(A.11)\quad \frac{\partial L}{\partial dcr_t} = 2(cqm_t - d_1 - d_2 ae_t + d_3 rp_t - \varepsilon_{3t})(d_2 e_3 c_2(Pm_t/Pd_t) - d_2 e_3) + 2a_1(c_1 + c_2 dcr_t + c_3 \bar{y}_t + \varepsilon_{2t} - b_1 - b_2 \overline{kqm}_t - \varepsilon_{1t})(c_2) + 2a_2(x_t - cqm_t - kqm_t + rv_{t-1} - rv_t^*)(-c_2) + \lambda d_2 e_3 c_2(Pm_t/Pd_t) - \lambda d_2 e_3 = 0$$

$$(A.12)\quad cqm_t^* \leq cqm_t \text{ and } (cqm_t^* - cqm_t)\lambda = 0$$

The full model consists of (A.2), (A.3), (A.4), (A.5), (A.6), (A.7), (A.10), (A.11), and (A.12). The model operates in two distinct modes, a rationing mode with $cqm_t^* < cqm_t$, and a nonrationing mode with $cqm_t^* = cqm_t$. In the rationing mode, the desired consumption imports of the private sector are greater than the actual imports permitted by the authorities. Thus, in the rationing mode there are strong quantitative restrictions on consumer imports and the quantity of imports that is observed is not the private sector's import demand, but rather the supply of imports allowed by the authorities. Conversely, in the nonrationing mode, actual imports are equal to the desired imports of the private sector; i.e., the quantitative restrictions, if any, are not strong and the private sector is able to import the desired levels of consumer goods.

Solution values for the endogenous variables for each mode can be written usefully as follows:

Nonrationing mode

(A.13a) $$\lambda = \frac{2a_2}{1 + d_2e_3(Pm_t/Pd_t)}(x_t - cqm_t - kqm_t + rv_{t-1} - rv_t^*) > 0$$

(from A.10 and A.12)

(A.13b) $$cqm_t^* = cqm_t = d_1 + d_2ae_t - d_3rp_t + \varepsilon_{3t}$$

(by definition of mode)

(A.13c) $$(a_1c_2^2)dcr_t = \left(\frac{a_2d_2e_3c_2(Pm_t/Pd_t) - d_2e_3a_2}{1 + d_2e_3(Pm_t/Pd_t)} - a_2c_2\right)cqm_t$$

$$+ \left(\frac{a_2d_2e_3c_2(Pm_t/Pd_t) - d_2e_3a_2}{1 + d_2e_3(Pm_t/Pd_t)} - a_2c_2\right)kqm_t$$

$$- (a_1c_2c_3)\bar{y}_t + (a_1c_2b_2)\overline{kqm}_t$$

$$- \left(\frac{(Pm_t/Pd_t)a_2d_2e_3c_2 - d_2e_3a_2}{1 + d_2e_3(Pm_t/Pd_t)} - a_2c_2\right)x_t$$

$$- \left(\frac{a_2d_2e_3c_2(Pm_t/Pd_t) - d_2e_3a_2)}{1 + d_2e_3(Pm_t/Pd_t)} - a_2c_2\right)rv_{t-1}$$

$$+ \left(\frac{a_2d_2e_3c_2(Pm_t/Pd_t) - d_2e_3a_2}{1 + d_2e_3(Pm_t/Pd_t)} - a_2c_2\right)rv_t^*$$

$$- (a_1c_2c_1 - a_1c_2b_1) - (a_1c_2\varepsilon_{2t} - a_1c_2\varepsilon_{1t})$$

(from A.11)

(A.13d) $$kqm_t = c_1 + c_2dcr_t + c_3y_t + \varepsilon_{2t}$$

(from A.5)

(A.13e) $$ae_t = e_1 + (e_2 - e_3h_1)\bar{y}_t + e_3dcr_t - e_3(Pm_t/Pd_t)cqm_t$$

$$-e_3(Pm_t/Pd_t)kqm_t + e_3(Pm_t/Pd_t)x_t - e_3dcr_{t-1} + e_3m_{t-1} + \varepsilon_{4t}$$

(from A.3 and A.7)

Rationing mode

(A.14a) $\lambda = 0$ (from A.10)

(A.14b) $(1 + d_2e_3(Pm_t/Pd_t) + a_2)cqm_t = (d_2 + d_2^2e_3(Pm_t/Pd_t))ae_t$
$- a_2kqm_t - (d_3 + d_2d_3e_3(Pm_t/Pd_t))rp_t + a_2x_t$
$+ a_2rv_{t-1} - a_2rv_t^* + (d_1 + d_1d_2e_3(Pm_t/Pd_t))$
$+ (1 + d_2e_3(Pm_t/Pd_t))\,\varepsilon_{3t}$
(from A.10)

(A.14c) $(a_1c_2^2)dcr_t = (d_2^2e_3c_2(Pm_t/Pd_t) - d_2^2e_3)ae_t$
$+ (d_2e_3 - d_2e_3c_2(Pm_t/Pd_t) - a_2c_2)cqm_t + (d_2d_3e_3 - d_2d_3e_3c_2)rp_t$
$- (a_1c_2c_3)\bar{y}_t - (a_2c_2)kqm_t + (a_2c_2)x_t$
$+ (a_1c_2b_2)\overline{kqm}_t + (a_2c_2)rv_{t-1} - (a_2c_2)rv_t^*$
$+ (d_1 + d_2e_3c_2(Pm_t/Pd_t) - d_1d_2e_3 - a_1c_1c_2 + a_1b_1c_2)$
$+ (d_2e_3c_2(Pm_t/Pd_t) - d_2e_3)\,\varepsilon_{3t} - a_1c_2\varepsilon_{2t} + a_1c_2\varepsilon_{1t}$
(from A.11)

(A.14d) $kqm_t = c_1 + c_2dcr_t + c_3\bar{y}_t + \varepsilon_{2t}$ (from A.5)

(A.14e) $ae_t = e_1 + (e_2 - e_3h_1)\bar{y}_t + e_3dcr_t - e_3(Pm_t/Pd_t)cqm_t$
$- e_3(Pm_t/Pd_t)kqm_t + e_3(Pm_t/Pd_t)x_t - e_3dcr_{t-1}$
$+ e_3m_{t-1} + \varepsilon_{4t}$
(from A.3 and A.7)

Estimation of the Model

The consumption imports equation and the domestic credit equation are different under the two modes, and this presents a complication in the derivation of the likelihood function. In what follows, the structure of the likelihood function is presented. For simplicity, the nonrationing version of the model can be rewritten as follows:

(i) $cqm = g_1(ae, Z_1) + \varepsilon_3$ if $(x - cqm - kqm + rv_{-1} - rv^*) > 0$

$dcr = g_2(cqm, kqm, Z_2) + \gamma_1\varepsilon_1 - \gamma_1\varepsilon_2$

(ii) if $(x - cqm - kqm + rv_{-1} - rv^*) > 0$

(iii) $kqm = g_3(dcr, Z_3) + \varepsilon_2$

(iv) $ae = g_4(dcr, cqm, kqm, Z_4) + \varepsilon_4$

Similarly, the rationing version can be rewritten as follows:

$cqm = h_1(ae, kqm, Z_5) + \gamma_2\varepsilon_3$

(i) if $(x - cqm - kqm + rv_{-1} - rv^*) < 0$

$dcr = h_2(ae, cqm, kqm, Z_6) + \gamma_3\varepsilon_3 - \gamma_1\varepsilon_2 + \gamma_1\varepsilon_1$

(ii) if $(x - cqm - kqm + rv_{-1} - rv^*) < 0$

(iii) $kqm = g_3(dcr, Z_3) + \varepsilon_2$

(iv) $ae = g_4(dcr, cqm, kqm, Z_4) + \varepsilon_4$

where the Z_i and ε_i represent predetermined variables and error terms, respectively, and γ_i are a composite of parameters. The likelihood function has the form

$$L = \left(\prod_{\delta>0} f_1(cqm, dcr, kqm, ae/\delta>0)\, pr(\delta>0) \prod_{\delta<0} f_2(cqm, dcr, kqm, ae/\delta<0)\, pr(\delta<0) \right)$$

where $f_1(cqm, dcr, kqm, ae/\ \delta \geq 0)$ is the joint density of the four endogenous variables conditional on $\delta \geq 0$ and $pr(\delta \geq 0)$ is the probability that $\delta \geq 0$, and $\delta = (x - cqm - kqm + rv_{-1} - rv^*)$, and f_2 is defined analogously. Expressions for these can be derived from the above set of equations and the resulting function maximized, giving the maximum likelihood estimates of the parameters in the model.

It is assumed that the error terms $\epsilon_{it}(i = 1,2,3,4)$ are distributed normally with mean zero and variance-covariance matrix:

$$\Sigma = \begin{bmatrix} \sigma_1^2 & 0 & 0 & 0 \\ 0 & \sigma_2^2 & 0 & 0 \\ 0 & 0 & \sigma_3^2 & 0 \\ 0 & 0 & 0 & \sigma_4^2 \end{bmatrix}$$

Given that the error terms are normally and independently distributed, it can be shown that the variance-covariance matrices of the error terms in the two modes are:

A. Nonrationing mode

$$\Sigma_1 = \begin{bmatrix} \sigma_3^2 & 0 & 0 & 0 \\ 0 & (a_1c_2)^2(\sigma_1^2+\sigma_2^2) & -a_1c_2\sigma_2^2 & 0 \\ 0 & -a_1c_2\sigma_2^2 & \sigma_2^2 & 0 \\ 0 & 0 & 0 & \sigma_4^2 \end{bmatrix}$$

B. Rationing mode

$$\Sigma_2 = \begin{bmatrix} A_1^2\sigma_3^2 & A_2\sigma_3^2 & 0 & 0 \\ A_2\sigma_3^2 & A_3^2\sigma_3^2+(a_1c_2)^2(\sigma_1^2+\sigma_2^2) & -a_1c_2\sigma_2^2 & 0 \\ 0 & -a_1c_2\sigma_2^2 & \sigma_2^2 & 0 \\ 0 & 0 & 0 & \sigma_4^2 \end{bmatrix}$$

where $A_1 = (1 + d_2e_3(Pm_t/Pd_t))$, $A_2 = (1 + d_2e_3(Pm_t/Pd_t))(d_2e_3c_2(Pm_t/Pd_t) - d_2e_3)$ and $A_3 = (d_2e_3c_2(Pm_t/Pd_t) - d_2e_3)$. Full-information maximum likelihood is the estimation technique; the derived restrictions on the parameters and the variance-covariance matrices of the error terms were imposed during the estimation of the model. The numerical optimizations were performed using the Davidon-Fletcher-Powell and the quadratic hill-climbing algorithms. The asymptotic standard errors of the estimates were computed by taking the square root of the diagonal elements of the negative inverse Hessian matrix of the loglikelihood function.

Bibliography

Baldwin, Robert E., Foreign Trade Regimes and Economic Development: The Philippines (New York: Columbia University Press for National Bureau of Economic Research, 1975).

Branson, W.H., "Monetarist and Keynesian Models of the Transmission of Inflation," American Economic Review, Vol. 65 (May 1975), pp. 115-119.

Chu, Ke-Young, E.C. Hwa and K. Krishnamurty, "Export Instability and Adjustments of Imports, Capital Inflows, and External Reserves: A Short-Run Dynamic Model," in Exchange Rate and Trade Instability: Causes, Consequences, and Remedies, ed. by D. Bigman and T. Taya, (Cambridge, Massachusetts: Ballinger Publishing Company, 1983), pp. 195-214.

Dornbusch, Rudiger, "Money, Devaluation and Nontraded Goods," American Economic Review, Vol. 63 (1973), pp. 871-880.

Fair, R.C., and D.M. Jaffee, "Methods of Estimation for Markets in Disequilibrium," Econometrica, Vol. 40 (May 1972), pp. 497-514.

_____, and H.H. Kelejian, "Methods of Estimation for Markets in Disequilibrium: A Further Study," Econometrica, Vol. 42 (1974), pp. 177-190.

Frenkel, J. and Harry G. Johnson (eds.), The Monetary Approach to the Balance of Payments (London: Allen and Unwin, 1976).

Goldfeld, S.M., and R.E. Quandt, Studies in Nonlinear Estimation, (Cambridge, Massachussets: Ballinger Publishing Company, 1976).

_____, "Estimation of a Disequilibrium Model and the Value of Information," Journal of Econometrics, Vol. 3 (1975), pp. 325-348.

_____, D.M. Jaffee, and R.E. Quandt, "A Model of FHLBB Advances: Rationing or Market Clearing?" Review of Economics and Statistics, Vol. LXII (February 1980), pp. 339-347.

_____, R.E. Quandt and Hale F. Trotter, "Maximization by Quadratic Hill Climbing," Econometrica, 34 (1966), pp. 541-551.

Goldstein, Morris, and Mohsin S. Khan, "Income and Price Effects in Foreign Trade," in Handbook of International Economics, ed. by P.B. Kenen and R.W. Jones (Amsterdam: North-Holland, 1984).

Grandmont, J.M., "Temporary General Equilibrium Theory," Econometrica, Vol. 45 (April 1977), pp. 535-72.

Hemphill, William L., "The Effects of Foreign Exchange Receipts on Imports of Less Developed Countries," International Monetary Fund, Staff Papers, Vol. 21 (November 1974), pp. 637-677.

Khan, Mohsin S., "The Determination of the Balance of Payments and Income in Developing Countries," in The Monetary Approach to the Balance of Payments (Washington: International Monetary Fund, 1977), pp. 243-74.

Lindbeck, Assar (ed.), Inflation and Employment in Open Economies, (Amsterdam: North-Holland, 1979).

Maddala, G.S., and F.D. Nelson, "Maximum Likelihood Methods for Models of Markets in Disequilibrium," Econometrica, Vol. 42 (1974), pp. 1013-1030.

Malinvaud, E., The Theory of Unemployment Reconsidered (Oxford: Basil Blackwell, 1977).

McKinnon, Ronald I., Money and Capital in Economic Development, (Washington: The Brookings Institution, 1973).

Quandt, R.E., "Tests of the Equilibrium Vs. Disequilibrium Hypothesis," International Economic Review, Vol. 19 (1978), pp. 435-452.

Rhomberg, Rudolf R., "Money, Income, and the Foreign Balance," in The Monetary Approach to the Balance of Payments (Washington: International Monetary Fund, 1977), pp. 163-84.