MACROECONOMIC MODELS FOR ADJUSTMENT IN DEVELOPING COUNTRIES

Edited by Mohsin S. Khan, Peter J. Montiel, and Nadeem U. Haque

International Monetary Fund

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The following symbols have been used throughout this paper:

... to indicate that data are not available;

— to indicate that the figure is zero or less than half the final digit shown, or that the item does not exist;

— between years or months (e.g., 1987–88 or January–June) to indicate the years or months covered, including the beginning and ending years or months;

/ between years (e.g., 1987/88) to indicate a crop or fiscal (financial) year.

"Billion" means a thousand million.

Minor discrepancies between constituent figures and totals are due to rounding.

The term "country," as used in this book, does not in all cases refer to a territorial entity that is a state as understood by international law and practice; the term also covers some territorial entities that are not states, but for which statistical data are maintained and provided internationally on a separate and independent basis.
The use of macroeconomic models for the design of adjustment programs has a long history in the IMF. The IMF’s approach to economic stabilization, generally referred to as “financial programming,” is based to a large extent on the models developed in the Fund during the 1950s and 1960s by, among others, J.J. Polak and E. Walter Robichek. The analytical foundation underpinning financial programming has come to be known in the literature as “the monetary approach to the balance of payments.” Financial programming essentially aims at ensuring consistency between the impact of proposed policy measures and a desired balance of payments outcome. This consistency reflects the interaction between a set of balance sheet and behavioral relationships linking the assets and liabilities of the banking system to the balance of payments.

The earlier IMF models are basically formalizations of the monetary approach to the balance of payments. They start from the proposition that in an open economy with a fixed exchange rate, the money supply is an endogenous variable reacting to surpluses and deficits in the balance of payments and not an exogenous policy instrument, as is customarily assumed in a closed economy. Though using somewhat different assumptions and structures, these models derive a formal relationship between changes in the domestic component of the money stock (domestic credit) and changes in international reserves, which can then be employed for setting policy. Specifically, the models allow one to obtain a value for the policy variable—domestic credit—that is consistent with a desired balance of payments position.

This volume contains a selection of the more recent models developed in the IMF dealing with adjustment and stabilization policies in developing countries. The macroeconomic models of the 1980s, while retaining the basic insights of the monetary approach to the balance of payments, have gone well beyond the simple structures outlined in the earlier formulations. For example, they now include objectives in addition to the balance of payments—principally output and inflation—as well as consideration of other policy instruments along with the rate of domestic credit expansion. Such developments were only to be expected, given the advancement of theoretical understanding of macroeconomic relationships, the refinement of econometric methods, and the dramatic improvement in computer technology which has greatly facilitated experimentation with alternative assumptions of macroeconomic behavior.
The newer generation of models included in this volume represents efforts by IMF staff to specify and estimate models that incorporate many of the key structural and institutional characteristics that make developing countries differ significantly from most developed economies. These features include the absence of well-developed equity and capital markets, the existence of credit and foreign exchange rationing that leads to the emergence of parallel markets and curb markets for credit, foreign financing constraints, and underdeveloped fiscal systems that result in frequent use of inflationary finance.

The new generation of models stresses the role, among others, of dynamics, expectations, relative prices, foreign debt issues, and exchange rate policy. The dynamic nature of economic relationships is an important consideration, since it permits an understanding of both the short- and the long-run costs and benefits of alternative policy measures, as well as the path of adjustment. To policymakers, the latter is often just as important as the initial and ultimate effects of a change in policy. By striving to capture expectations and lagged responses in one form or another, the models presented in this volume are capable of addressing dynamic issues. The role that relative prices play in affecting production and consumption decisions is now commonplace. Foreign debt issues, particularly those relating to optimal borrowing and to the effects of the debt stock and debt servicing on the level of economic activity and on the balance of payments, are routinely addressed in macroeconomic models. Since exchange rate policy has assumed much more importance in the adjustment process, it receives correspondingly greater attention than was given to it in the early formulations of the monetary approach to the balance of payments. The above examples are only a subset of the many advances that have been made. Basically, the overriding intention has been to bring a greater degree of realism into macroeconomic models, enabling better explanation of macroeconomic behavior and thereby an improvement in the quality of the input they can provide in the design and implementation of adjustment programs.

Nevertheless, the current macroeconomic models do not necessarily represent the last word. Model building is an evolutionary process that will continue to reflect new developments in economic theory, new econometric methods, and better understanding of the structure of developing economies. As such, the contributions contained in this volume may be viewed as a progress report of an ongoing research program aimed at improving economic policymaking in developing countries.

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Introduction

Mohsin S. Khan, Peter J. Montiel, and Nadeem U. Haque

Most developing countries at one time or another have faced the need for macroeconomic adjustment. Such a need typically arises when a country experiences a persisting imbalance between aggregate domestic demand and aggregate supply, reflected in a worsening of its external payments and an increase in inflation. While in certain cases external factors, such as an exogenous deterioration of the terms of trade or an increase in foreign interest rates, can be responsible for the emergence of the basic demand-supply imbalances, these imbalances can often be traced to inappropriate domestic policies that expand domestic demand too rapidly relative to the productive capacity of the economy. As long as adequate foreign financing is available, the relative expansion of domestic demand can be sustained for an extended period, albeit at the cost of a widening deficit in the current account of the balance of payments, a loss of international reserves, rising inflation, worsening international competitiveness, falling growth, and a heavier foreign debt burden. Eventually, however, the country would lose international creditworthiness, and as foreign credits ceased, adjustment would be necessary. This type of forced adjustment could prove to be very disruptive for the economy.

Adjustment programs are designed to eliminate the basic imbalances in the economy in a timely and orderly fashion. The first task is to stabilize the economy—lower the rate of inflation, restore international competitiveness, reduce the current account deficit, and check the loss of international reserves. Once macroeconomic stability is assured, policies to expand the productive capacity of the economy and to improve the efficiency with which resources are utilized are more likely to be successful. Experience and theory both suggest that to achieve a viable balance of payments in the context of price stability and a sustained rate of economic growth—the principal objectives of macroeconomic adjustment—macroeconomic adjustment and structural reform policies have to be effectively combined.
To achieve these goals requires a fairly comprehensive package of economic policies. With differences in emphasis, most economists would tend to subscribe to the inclusion of the following measures in a macroeconomic adjustment program:

- **Monetary restraint** aimed at reducing the growth of absorption and the rate of inflation.
- **Interest rate policies** aimed at keeping real interest rates positive but low.
- **Fiscal restraint** to reduce the fiscal deficit to a sustainable level and thereby restrain aggregate demand pressures.
- **Exchange rate action** to ensure a real exchange rate that improves international competitiveness and creates the incentive for expanding the production of internationally tradable goods.
- **External financing policies** to reduce the stock of external debt if it is perceived to be currently unsustainable, or to limit foreign borrowing if it is likely to become so in the future.
- **Structural reforms** (such as financial sector reforms, producer pricing policies, trade liberalization, and tax reforms) to make the economy flexible and efficient.

Because of the complex relationship between the various policies and objectives, formulating a package with such features turns out to be no easy task. A judicious blending of economic theory, informed judgment, and a thorough knowledge of the principal structural and institutional characteristics of the country in question is required.

In the end, however, a quantitative macroeconomic program cannot be formulated without a model, whether explicit or implicit. Formal models, by delineating the links between the principal macroeconomic variables of concern, allow both direct examination of the assumptions underlying the individual behavioral relationships and development of a synthesis of views on macroeconomic phenomena. Furthermore, macroeconomic models impose a discipline on the design of an adjustment program by requiring consistency among individual relationships and ensure that budget constraints and accounting identities are respected. Finally, the program's objectives, and the policies to attain them, have to be set quantitatively. Consequently, the policymaker needs to have information not only on the qualitative nature of the relationships between variables but also on the orders of magnitude of the relevant parameters. Empirical macroeconomic models in principle provide such information.

The papers in this volume are a representative sample of work on empirical macroeconomic models for developing countries carried out in the IMF during the 1980s. All of these models trace their roots back to
the work by Polak (1957) and Robichek (1967), which became the mainstay in the design of adjustment and stabilization programs supported by the IMF. Some of the models are applied to, and thus are relevant for, specific countries. Others relate to groups of developing countries and can thus be seen as applying to an “average” developing country. While the models are dissimilar in certain important respects, they all have one common characteristic that is worth highlighting: they are all “small.” This preference for highly aggregated structures and parsimonious depiction of macroeconomic relations can be considered a legacy of the earlier Polak (1957) and Robichek (1967) approaches undertaken in the IMF. Attempts to build large-scale models for developing countries are virtually nonexistent in the Fund. This partly reflects the view that, for the main purpose for which such models are developed—to assist in designing programs—elaborate or detailed structures are not necessary. Furthermore, from a more practical viewpoint, the availability of data in developing countries constrains the degree of disaggregation that can be undertaken. However, being small does not necessarily imply that important aspects of macroeconomic policymaking are left unaddressed. Indeed, since in all the models considerable care is taken to link policies and targets, it would be correct to label them policy-based models.

The first paper in the volume, by Carmen Reinhart (Chapter 2), outlines a model that can be viewed as a reference point for evaluating the more complex and elaborate models developed in the IMF. This simple model has two building blocks: the first, a monetary block, is very much in the spirit of the Polak (1957) specification, while the second is a variant of the standard neoclassical growth model relating growth to rates of investment and labor force growth and to (exogenous) technical progress. The result of combining the monetary model and the neoclassical model is a unified framework in which the domestic price level, output, and the balance of payments can be simultaneously determined. This merged model can be considered the simplest of macroeconomic models that can be usefully applied to analyze the effects of the main policies of adjustment programs. This simplicity is a virtue, as the model can be used operationally in countries where data are scarce. The empirical part of the paper presents estimates of the key parameters of the model for a sample of seven diverse developing countries and tests the validity of a subset of the theoretical assumptions. The estimated model is then

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1 Some of the papers on earlier models are contained in International Monetary Fund (1977). These earlier models are closely related to the monetary approach to the balance of payments; see Frenkel and Johnson (1976).

2 For a detailed analytical exposition of this model, see Khan, Montiel, and Haque (1990) and Khan and Montiel (1989).
used for a variety of comparative static exercises, including the effects of fiscal and monetary policy changes, and devaluation, on the principal macroeconomic objectives.

In Chapter 3, Mohsin Khan and Malcolm Knight formulate a structural version of the monetary model, which makes inflation and output endogenous along with the balance of payments. Monetary disequilibrium plays a key role in the behavior of macroeconomic variables, and careful attention is paid to expectations (which are assumed to be formed adaptively) and to the dynamics of adjustment. The model is tested using a pooled sample of data for 29 developing countries during 1968–75, and the results are broadly supportive of the chosen specification. To analyze the policy implications of the model, two sets of simulation experiments are conducted. The first set shows the effects of certain policy-induced shocks. For example, an increase in the supply of domestic credit simultaneously raises growth and the rate of inflation and worsens the balance of payments. The dynamics, however, are much more complicated than those emerging from the simple monetary model of the balance of payments (of the type outlined by Reinhart in Chapter 2). The second set of simulations utilizes the model in a programming mode and compares the path for domestic credit for two types of adjustment programs—a one-year program and a five-year program—both designed to achieve a specified improvement in the balance of payments. Because of the dynamics built into the model, the paths for domestic credit are not smooth, with more pronounced fluctuations for the shorter-run program. Although the balance of payments target is obviously attained faster in the shock program, the growth rate suffers in comparison to the more gradual program.

The next four papers describe macroeconomic models for individual countries and thus build more detail into the specifications. The paper by Bijan Aghevli and Cyrus Sassanpour (Chapter 4) develops a model designed to analyze the impact of an increase in world petroleum prices for the case of an oil producing country, namely, the Islamic Republic of Iran. The paper expounds the basic idea that the bulk of government revenues in such economies is derived from oil exports and is denominated in foreign exchange. The domestic spending of these revenues increases aggregate demand for both traded and nontraded goods, leading to an increase in domestic output, imports, and prices of nontraded goods. If the nominal exchange rate remains fixed, the real exchange rate appreciates, as expected from the well-known “Dutch disease” phenomenon. Monetary disequilibrium plays a critical role in the model, which comprises six behavioral equations and three identities. Fiscal policy, however, is also a very important adjustment instrument. The
Aghevli-Sassanpour model is among the first to make a distinction between the overall fiscal deficit and the "domestic" fiscal deficit (excluding oil revenues and government foreign expenditures), arguing that only the latter is relevant for the rate of monetary expansion. Estimates of the model for 1960–77 confirm the basic hypothesis that the domestic fiscal deficit and monetary factors are important in the determination of prices and in variations in private expenditures. Simulation experiments for different values of oil revenues, and thus levels of government spending, show a clear trade-off between higher growth and higher rates of inflation.

The paper by Reza Vaez-Zadeh (Chapter 5) also deals with an oil producer—Venezuela—but extends the framework by attempting to take into account the "confidence effect" that oil wealth might have on the behavior of economic agents. This effect arises from the impact of resource availability (oil) on future expected income, which in turn influences saving behavior, the pattern of expenditures, and the composition of asset portfolios. However, not only current oil wealth but also future wealth is important for the confidence effect. Oil is an exhaustible resource, and exhaustibility is likely to influence expectations about future income, thus inducing shifts in perceived wealth that alter the private sector's present behavior. The model incorporating this confidence effect is estimated for 1965–81, and the results are generally supportive of the theory. The confidence effect manifests itself particularly in private expenditures and in the demand for money, dampening the inflationary consequences of expansionary shocks but adversely affecting private saving and investment. The paper shows that a larger monetary intervention is required following exogenous disturbances to stabilize the economy in the presence of the confidence factor associated with resource availability. Furthermore, this factor also affects significantly the timing of needed monetary interventions.

The model for Singapore contained in Chapter 6 by Ichiro Otani and Cyrus Sassanpour analyzes the transmission processes and attempts to quantify the importance of alternative policy instruments—specifically monetary, exchange rate, and wage policies—influencing key macroeconomic variables, including output, prices, and foreign reserves. The model makes two notable advances: first, it introduces wage behavior and wage policies; and second, it explicitly incorporates an exchange rate reaction function. Both these additions are unusual for developing countries, but are clearly important for a country like Singapore. The model is estimated for 1979–86 on a quarterly basis, and the behavioral relationships are by and large well determined. The simulations show that a restrictive wage policy improves the balance of payments, lowers in-
flation, depreciates the exchange rate, and increases output, while an expansionary fiscal policy worsens the balance of payments, increases inflation, appreciates the exchange rate, and lowers output. The model thus suggests that flexibility in financial, exchange rate, and wage policies is crucial in achieving noninflationary growth with external payments viability. If trade-offs develop between outcomes from a particular policy, other instruments must be used. In the specific case of Singapore an appropriate wage policy is an important complement to exchange rate policy, but this result is generalizable to other developing countries.

The objective of the paper by Leslie Lipschitz (Chapter 7) is to provide some empirical generalizations regarding appropriate credit and exchange rate policies in a developing country, using Korea as a case study. A model is specified and estimated, and then simulations are used to determine policy responses to a variety of domestic (output and monetary) shocks, as well as to external terms of trade shocks. The model assigns a central role to monetary disequilibrium in determining trade flows, absorption, and prices. The importance of expectations is recognized, although formally expectations are taken to be static in nature. The estimates of the model containing four behavioral equations—for inflation, exports, imports, and real absorption—using quarterly data covering 1965–78 yield generally well-determined parameters. For simulation, the model is expanded to include reaction functions for domestic credit expansion and nominal exchange rate adjustment. The expanded model thus allows appropriate policy responses to different types of shocks to be determined. Four particular results stand out. First, exchange rate policy is a powerful instrument for adjustment even when estimated price elasticities of trade are small. Second, the source of the disturbance to the economy is often more important than the manifestation of the disturbance in determining the best policy response. Third, monetary conditions have a large and rapid effect on the balance of payments. Finally, the appropriate policy response to any disturbance depends on whether the shock is transitory or permanent.

The paper by Pierre-Richard Agénor (Chapter 8) is among those that introduce rational expectations (as opposed to static or adaptive expectations, which have been far more commonplace). This paper formulates and estimates a short-term monetary model for a small, open developing economy, using a sample consisting of annual time-series observations on a cross-section of eight countries. The model incorporates illegal trade transactions, foreign exchange rationing, currency substitution, and forward-looking rational expectations. Various simulation exercises are conducted to quantify the impact of alternative policies on major macroeconomic variables. Anticipated expansionary credit and fiscal policies
have a positive impact on real output and prices, a negative effect on net foreign reserves, and are associated with a depreciation of the parallel exchange rate. The analysis shows that the balance of payments adjustment process following a temporary shock is inversely related to the degree of rationing in the official market for foreign exchange. The higher the degree of rationing, the lower will be the offsetting effect on the money supply coming through the balance of payments, and the higher the rate of depreciation of the parallel exchange rate generated by an expansionary policy. A once-for-all devaluation of the official exchange rate is associated in the short run with a contraction in output, a rise in inflation, a fall in reserves, and a depreciation of the parallel rate. In the long run, devaluation results in a permanently higher price level and a more depreciated parallel exchange rate, but has no effect on the spread, as predicted by standard perfect-foresight currency substitution models.

The model outlined in the paper by Nadeem Haque, Kajal Lahiri, and Peter Montiel (Chapter 9) is in the same spirit as that of Agénor. However, although it too incorporates advances in modern macroeconomics, it no longer adheres closely to the monetary model. The model is more eclectic and is thus more in tune with conventional economic theory. Rational expectations are assumed, and at the same time developing country characteristics are explicitly incorporated. For example, the model allows the effectiveness of capital controls (which exist in many developing countries) to be empirically tested, and the foreign exchange constraint on imports (which many of these countries face) to be endogenously treated. An appropriate econometric procedure to estimate rational expectations models with pooled time-series data is developed and is then applied to a group of 31 developing countries (over the period 1963–87). The estimated parameters conform to standard economic theory and in many cases approximate those available in the literature. An interesting result to emerge from the empirical analysis is that barriers to capital mobility seem to be quite ineffective in developing countries. This result has important policy consequences, suggesting that effects of changes in credit policy on the balance of payments are substantial. The estimates also suggest that imports have tended to be restricted by the availability of foreign exchange. The interaction of perfect capital mobility, forward-looking behavior, and an endogenous foreign exchange constraint presents a novel framework in which to study the dynamic responses of developing economies to exogenous and policy shocks.

3This finding is a generalization of a similar conclusion reached by Edwards and Khan (1985).
In Chapter 10, Nadeem Haque and Peter Montiel utilize their model to study the economy's path of adjustment to several domestic policy shocks—devaluation, expansionary fiscal policy, and domestic credit expansion—as well as to changes in external demand and in foreign interest rates. The paper shows that the dynamic response of the principal macroeconomic variables to both policy and exogenous shocks depends critically on several features in developing countries (such as the degree of wage-price flexibility and the extent of capital mobility), about which no clear consensus exists among informed observers. This conclusion has important implications for both policy and research on developing country macroeconomics and the adjustment process. Regarding policy, the implication is that the state of knowledge for most developing countries suggests that real-time macroeconomic “fine-tuning” is likely to be very difficult, because the dynamic responses of the system to policy choices will, in most cases, be highly uncertain. Regarding research, the analysis identifies specific areas—such as wage-price formation and capital mobility—that merit particular attention in developing a greater understanding of macroeconomic adjustment in these economies.

The role of rational expectations is also highlighted in the final paper in this volume, by Nadeem Haque, Peter Montiel, and Steven Symansky (Chapter 11). These authors specify a general-equilibrium simulation model that relies on familiar analytical assumptions, such as a Mundell-Fleming two-good commodity structure, a permanent-income specification for private consumption, a neoclassical investment function, and rational expectations. In addition, several of the more distinct structural features of developing economies, such as the role of imported intermediate and capital goods, the absence of domestic equity or securities markets, and the existence of dual markets for foreign exchange, are also incorporated explicitly into the model. Although the model is not directly estimated, representative developing country parameters are used to perform a variety of simulations from which several useful insights are derived about the “average” developing economy’s general-equilibrium interactions, as well as the dynamics of the effects of various policy choices. For example, the dynamic response to a shock is fundamentally affected by the way expectations are modeled—rational expectations make a significant difference to the impact effect and to the adjustment path. Moreover, the impact effects of many policy choices turn out to be opposite to their medium-term effects. But it is reassuring to note certain familiar results, such as the expansionary effect on output and prices of increases in government spending and in the supply of credit to the private sector. Also, the current account is improved by a devaluation, although there may be a temporary contractionary effect on output.
In conclusion, it is evident from the collection of papers in this volume that empirical macroeconomic models for adjustment in developing countries have come a very long way from the earlier efforts in the IMF that are associated with the names of Polak and Robichek. Three basic factors account for the advances. First, the changed focus of adjustment programs—the balance of payments is no longer the sole objective. In programs of the 1970s and 1980s inflation and growth became equally important objectives, mainly because the balance of payments can be sustained only in an environment of price stability and satisfactory growth performance. Second, a deeper understanding of the economies of developing countries has emerged, along with a recognition that the structural and institutional characteristics need to be explicitly included if the models are to realistically represent macroeconomic behavior in these countries. Finally, the state of macroeconomic theory has changed considerably during the past two decades, and many of the analytical developments have been absorbed into the models. As evident from the papers in this volume, all these factors combine to make today's models quite different in both form and substance from those of yesterday.

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A Model of Adjustment and Growth
An Empirical Analysis

Carmen M. Reinhart*

The concept of "growth-oriented adjustment," or the notion that economic growth is essential for the achievement of the twin goals of a sustained reduction in inflation and a viable balance of payments, has recently received the attention of policymakers and academics alike. Indeed, growth-oriented adjustment is considered a key characteristic of the policy packages that make up Fund-supported programs. Examples of the blossoming literature on the subject of growth-oriented adjustment can be found in Bacha and Edwards (1988), Blejer and Chu (1989), and Corbo, Goldstein, and Khan (1987).

Any analysis of the effects of policies on the targets of growth, inflation, and the balance of payments requires a consistent and unified framework. Further, because this issue is particularly relevant for developing countries, it is desirable that the framework be both sufficiently simple to allow its application where data are limited, and general enough to ensure its applicability to a diverse set of countries. The model developed by Khan and Montiel (1989), which merges a variant of a neoclassical growth model frequently employed by the World Bank with the monetary approach to the balance of payments associated with the IMF, provides such an integrated framework.

However, the simplicity that makes a model more tractable from an operational standpoint may have several drawbacks as a result of the necessarily restrictive assumptions it employs. This paper assesses the

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1 See the references contained therein, particularly Michalopoulos. Khan (1987) also provides a broad survey of this literature.

2 For a more detailed discussion of the building blocks of this model, see Khan, Montiel, and Haque (1990).
usefulness of the Khan-Montiel model for policymaking by examining empirically the trade-off between its simplifying assumptions and its ability to fit reality. This trade-off can be assessed by applying the model to a variety of countries. For each country, the following questions are asked: (1) Are the key parameters of the model stable? (2) How sensitive are the policy multipliers to these parameter estimates—that is, how robust are the policy implications? and (3) Are some target variables more vulnerable to forecast errors than others?

This paper examines these three questions for a diverse sample of seven capital importing developing countries and attempts to reach some conclusions about the usefulness of the model to help in designing policy. The countries considered here are Chile, Ghana, Honduras, the Republic of Korea, Myanmar, Pakistan, and Tanzania. The sample thus includes low- and middle-income countries, manufacturing and primary exporters, as well as service and remittance countries, and one heavily indebted country. This diversity makes the sample reasonably representative of a large set of developing countries.

Section I briefly outlines the theoretical framework and examines its properties. Section II presents the estimates of the key parameters of the model and tests the stability of a subset of these parameters. Special attention is given to the adequacy of the model’s specification of output determination, the demand for money, and private savings behavior. Section III contains comparative static exercises dealing with a variety of exogenous and policy-induced shocks, given the estimated parameter values. The shocks are central to most adjustment programs: devaluation, changes in domestic credit, and changes in government spending.3 The section concludes with an analysis of the “robustness” of the policy implications of the model under varying parameter values. The final section reviews the key results, discusses the limitations of the approach followed in this paper, and highlights some of the directions in which the theoretical and empirical work could be extended.

I. Summary of the Theoretical Framework

The Key Relationships

The theoretical framework outlined in this section, which follows Khan and Montiel (1989), serves as a benchmark for the subsequent empirical application. The model merges a growth block similar to that employed by the World Bank (see Khan, Montiel, and Haque (1990)) and a mone-

3 See, for instance, Khan and Knight (1985).
ary block that is central to the monetary approach to the balance of payments associated with Fund-supported adjustment programs (see International Monetary Fund (1977, 1987)).

The framework describes a small open economy, representative of a developing country, that maintains a fixed exchange rate. Equations (1) through (7) define the basic identities of the model, as well as the budget constraints for the private and public sectors.

The private sector’s budget constraint:

\[ Y_t - T_t - C_t - S_{pt} = 0. \]  

(1)

The allocation of private savings:

\[ S_{pt} = P_{Dt} \, dk_t + dM^d_t - dD_{pt}. \]  

(2)

The government budget constraint:

\[ e_t dF_t + dD_{gi} \equiv G_t + i_t e_t F_t - T_t - T_{gi}. \]  

(3)

The sources of changes in the money stock:

\[ dM^d_t = e_{t-1} dR_t + dD_t. \]  

(4)

The composition of changes in domestic credit:

\[ dD_t = dD_{gi} + dD_{pr}. \]  

(5)

Interest earnings on foreign reserves transferred to the government:

\[ T_{gi} = i_t e_t R_t. \]  

(6)

Gross national product:

\[ \dot{Y}_t = Y_t - i_t e_t (F_t - R_t). \]  

(7)

In order of appearance, the variables are defined as:

- \( Y_t \): Gross domestic product
- \( T_t \): Taxes from the private sector
- \( C_t \): Private consumption
- \( S_{pt} \): Private savings
- \( P_{Dt} \): Price of domestic output
- \( dk_t \): Change in the capital stock (investment)
- \( dD_{pt} \): Change in domestic credit to the private sector
- \( dD_{gi} \): Change in domestic credit to the public sector
- \( G_t \): Government purchases of domestic output
- \( F_t \): Foreign currency value of government foreign debt
- \( i_t \): Interest rate on foreign debt
- \( e_t \): Nominal exchange rate—number of domestic currency units per unit of foreign currency
$dM$: Change in the money stock  
$R$: Foreign currency value of reserves held by the central bank  
$dD$: Change in total domestic credit  
$T_B$: Interest earnings on foreign reserves transferred to the government

The $d$'s denote changes from time $t - 1$ to time $t$, that is, $dx = x_t - x_{t-1}$.

The centerpiece of the growth block of the model is a neoclassical production function. Capacity, or potential growth, depends on increases in total factor productivity, changes in the size of the labor force, and changes in the capital stock. Combining productivity changes that are technologically driven and changes in labor supply into one exogenous variable, the production function takes the following form:

$$dy = \alpha_0 + \alpha_1 dk, \tag{8}$$

where the lowercase letters denote real magnitudes. The coefficient of investment, $\alpha_1$, is the marginal product of capital, and the constant term, $\alpha_0$, denotes the combined effects of total factor productivity and the change in the size of the labor force. This production function specification is a more generalized version of the "incremental capital output relationship" (ICOR).\(^4\)

The second behavioral relationship in the growth block describes private savings. It is assumed that real private savings is proportional to real disposable income:

$$s_p = s(y - t), \quad 0 < s < 1 \tag{9}$$

where $s$ is a constant representing both the marginal and average savings rate.

The third component of the growth block links savings identically to investment. Substituting the definition of the money stock, the government's budget constraint, and the savings function into equation (2), the following expression for the change in the capital stock is obtained:

$$dk = s(y - t) + \left[ t - g - ie \left( \frac{F - R}{P_{Dt}} \right) \right] + e \left( \frac{dF - dR}{P_{Dt}} \right) t, \tag{10}$$

where the first term represents real private savings, the second real public saving, and the third is the real current account deficit (real foreign savings).

\(^4\) They are combined for simplicity in the theoretical model (as in Khan and Montiel, 1989). This assumption is relaxed in the empirical work.

Since \( y_t = y_{t-1} + dy_t \), and \( P_{Dt} = P_{Dt-1} + dP_{Dt} \), capacity growth can be expressed as a function of domestic prices, reserves, and the exogenous variables and parameters:

\[
dy_t = (1 - s\alpha_t)^{-1}(\alpha_0 + \alpha_0(t - g)_t + (1 - g)_t + e(dF - dR - i[F - R])_t)
\]

The monetary block is also defined by three relationships, starting with the flow supply of money (equation (4)).

The second relationship is the flow demand for money, here simplified by the assumption that velocity is constant:

\[
dM^s_t = vP_t dy_t + vy_{t-1} dP_t,
\]

where \( P \) is the aggregate price level, defined below, and \( v \) is the inverse of the income velocity of money.

The last relationship in the monetary block describes money market equilibrium:

\[
dM_t = dM^s_t.
\]

Defining the change in the aggregate price level, \( dP_t \), as a weighted average of the change in the price of importables, \( dP^*_t \), and the change in the price of domestic output, \( dP^0_{Dt} \), with weights \( \theta \) and \( (1 - \theta) \), respectively, it can be written

\[
dP_t = \theta dP^*_t + (1 - \theta)dP_{Dt}.
\]

Assuming that \( \theta \) and the foreign currency price of importables are constant, initial conditions are set so that \( e_0 = P^*_0 = P^0_0 = 1 \) and that the law of one price holds, the following is obtained

\[
dP^*_t = P^*_0 de_t = de_t.
\]

Using equations (14) and (15), and the definitions of flow money demand and supply, and substituting them into the money market equilibrium condition (equation (13)), an expression for the change in domestic prices as a function of output, reserves, the exogenous variables, and the parameters of the system is obtained

\[
dP_{Dt} = \{\nu(1 - \theta)[y_{t-1} + dy_t]^{-1}[dR_t - \nu dy_t - \nu \theta y_{t-1} - \nu de_t
\]

\[
- \nu \theta de_t, dy_t + dD_t}\}.
\]


7 The underlying specification \( M^d_t = \nu P^*_y \) assumes a constant interest rate. This type of restrictive assumption is not essential to the model, as the analysis carries through with a more general specification.
The Merged Model

Combining the growth block (equation (10)) with the monetary block (equation (16)) does not close the system, as there are two equations in three unknowns, \(dy,\ dP_0,\ \) and \(dR,\). The additional relationship that enables this system to be fully determined is the balance of payments identity:

\[
dR, = X, - Z, - i(F - R), + dF, ,
\]

where \(X,\) and \(Z,\) are the foreign currency value of exports and imports. Defining the trade balance in foreign currency terms, \(B, = Z, - X,\), it is assumed that

\[
B, = B_0 - a(e,/P_D, - 1) + bdy, ,
\]

where \(a\) and \(b\) are positive constants and \(B_0\) is a constant whose sign is undetermined. Equation (18) implies that the trade balance improves in foreign currency terms when the real exchange rate depreciates \((e/P_D > 1)\) or when real output falls.\(^8\) Recalling that \(F, = F,-, + dF,\) and, similarly for \(R,\), equations (17) and (18) yield an expression for the change in reserves:

\[
dR, = (dF, - B_0') + a'(e,/P_D, - 1) - b'dy, - i'(F,-, - R,-, - 1),
\]

where \(a' = a/(1 - i),\ b' = b/(1 - i),\ i' = i/(1 - i),\) and \(B_0' = B_0/(1 - i).\)

Having obtained an expression for reserves (equation (19)), the system can be solved in terms of equation (10), which summarizes the growth block, and equation (16), which summarizes the monetary block.

The substitution of equation (19) into equation (10) yields

\[
(dy, = [1 - s\alpha_1 - \alpha_1 sbe,/P_D,]^{-1} \{ \alpha_0 + \alpha_1 \\
\[s(y,-, - t,) + (t - g,) + \frac{e_r}{P_D,} [B_0 - a(e,/P_D, - 1)] \}).
\]

Graphically, the growth block traces out the locus in Chart 1 that has been labeled GG. Its slope, evaluated at \(dy, = dP_D, = 0,\) is

\[
\left. \frac{(dP_D)}{(dy,} \right|_{\eta} = -\beta/\alpha_1 \eta,
\]

where,

\[
\eta = B_0 - a
\]

and

\[
\beta = 1 - \alpha_1 (s + b) > 0.
\]

\(^8\) Because imports (Z) decline in the latter case.
If $\eta$ is negative, the $GG$ schedule is upwardly sloped as depicted in Chart 1.

Similarly, substituting reserves in the equation representing the monetary block (equation (16)) yields

$$dP_{Di} = [\nu(1 - \theta)(y_{1-1} + dy_{1})]^{-1}[[dF_r - B_0' - i'(F_{1-1} - R_{1-1})$$

$$+ dD_r] - (b' + \nu)dy_r - \nu(y_{1-1}de_r - \nu de_d dy_r$$

$$+ a'(e_i/P_{Di} - 1)]].$$

Equation (21) traces a negatively sloped locus, labeled $MM$ in Chart 1. The slope at $dy_r = dP_{Di} = 0$ is given by

$$\left.\frac{(dP_D)}{(dy)}\right|_{MM} = -(b' + \nu)/\gamma < 0,$$

where $\gamma = a' + \nu(1 - \theta)y_0 > 0$. 

**Chart 1. Macroeconomic Equilibrium**

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The intersection of the $GG$ and $MM$ schedules in Chart 1 depicts the equilibrium values of output changes and domestic inflation.

**Parameters to Be Estimated**

The model outlined above is applied to a sample of seven countries. Table 1 lists the parameters that must be estimated to make it operational.

**II. Estimating the Parameters of the System and Testing the Underlying Assumptions**

**General Comments**

To test the empirical validity of the model outlined above, the model is applied to a set of seven diverse developing countries: Chile (1976-87), Ghana (1969-87), Honduras (1969-87), Korea (1969-87), Myanmar (1969-87), Pakistan (1976-87), and Tanzania (1969-87).

The common approach to evaluating a model's empirical performance involves a two-step process: the first is the estimation of the model as a system; the second uses the estimated system to generate either in-sample forecasts, out-of-sample forecasts, or possibly both; and the final judgment is based on a comparison between the “fitted” values and the actual values—the forecast errors.

One problem with this approach is that it generally provides little or no direct information about what particular assumptions of the model are inappropriate, or what equations were misspecified. The approach followed here, although similar to the one outlined above, varies in some important ways. The first step is to obtain estimates for the seven parameters that characterize the system. However, this was accomplished by estimating each behavioral equation separately, using either ordinary

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_0$</td>
<td>Captures total factor productivity and changes in the size of the labor force</td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>The marginal product of capital</td>
</tr>
<tr>
<td>$s$</td>
<td>The private savings rate</td>
</tr>
<tr>
<td>$\nu$</td>
<td>The inverse of income velocity</td>
</tr>
<tr>
<td>$\theta$</td>
<td>The share of importables in the aggregate price level</td>
</tr>
<tr>
<td>$a$</td>
<td>The sensitivity of the trade balance with respect to the real exchange rate</td>
</tr>
<tr>
<td>$b$</td>
<td>The sensitivity of the trade balance with respect to changes in output</td>
</tr>
</tbody>
</table>
least squares (OLS) or generalized least squares (GLS), as dictated by the data. The individual equation approach was preferred over the alternative approach—estimating the model as a system—as it allowed more efficient use of the limited data, particularly in cases where the available time series for the same country had uneven starting points. The sample period covered by the empirical work for the individual equations was the maximum allowed by the availability of the data.

To assess not just the general fit of the model but to be able to pinpoint where the specification weaknesses lie, an intermediate step was added to the evaluation process: the validity of a subset of the individual theoretical assumptions was tested. Particular attention was devoted to specifying output growth, savings behavior, and money demand, as the parameters in these equations are central to the analysis.

Finally, since the model was not estimated as a system, and because it was desired to highlight the effects of certain policies, the methodology adopted in this paper does not involve a direct comparison of the actual and fitted values of the endogenous variables. Instead, the estimated parameter values are used to construct reduced-form policy multipliers for each of the endogenous variables. The range of values these multipliers take, as the parameter values are allowed to vary, provide useful information on the robustness of the model’s policy implications. Except for the production function, which includes a proxy for the labor force, the empirical work uses only those explanatory variables dictated by the theoretical model. In general, the specifications of the estimation equations allowed these explanatory variables to appear with a richer lag structure than that suggested by the theoretical model. In each case the data determined the relevant lag pattern for the explanatory variables. Details for each equation and each country are outlined in the remainder of this section.

**How Well Can a Production Function Explain Output Growth?**

To obtain estimates for the marginal product of capital, \( \alpha_1 \), and the combined effects of changes in the size of labor and total factor productivity, \( \alpha_0 \), a simple growth model was estimated that is derived from an aggregate neoclassical production function. As in Robinson (1971), International Monetary Fund (1988), and Khan and Reinhart (1990), the growth function estimated takes the form

\[
Dy_t = \alpha_0 + \alpha_1 (dk_t / y_{t-1}) + \alpha_2 DL_t,
\]

where the uppercase \( D \)'s indicate rates of change and \( L \) denotes the labor force, here proxied by population. Because the data were allowed to
Table 2. Production Functions: How Well Can These Explain Output Growth?

<table>
<thead>
<tr>
<th></th>
<th>Tanzania</th>
<th>Ghana</th>
<th>Pakistan</th>
<th>Korea</th>
<th>Myanmar</th>
<th>Honduras</th>
<th>Chile</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_0$</td>
<td>-0.07</td>
<td>-0.04</td>
<td>-0.07</td>
<td>0.08</td>
<td>-0.02</td>
<td>-0.05</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>(-2.25)</td>
<td>(-1.06)</td>
<td>(-1.35)</td>
<td>(6.94)</td>
<td>(-0.66)</td>
<td>(-2.10)</td>
<td>(-2.61)</td>
</tr>
<tr>
<td>$a_1$</td>
<td>0.28</td>
<td>0.12</td>
<td>0.62</td>
<td>0.08</td>
<td>0.23</td>
<td>0.28</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>(2.60)</td>
<td>(1.79)</td>
<td>(5.01)</td>
<td>(2.58)</td>
<td>(2.61)</td>
<td>(2.01)</td>
<td>(6.08)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.28</td>
<td>0.14</td>
<td>0.71</td>
<td>0.34</td>
<td>0.17</td>
<td>0.13</td>
<td>0.79</td>
</tr>
<tr>
<td>DW</td>
<td>1.81</td>
<td>1.40</td>
<td>1.51</td>
<td>1.12</td>
<td>1.38</td>
<td>1.27</td>
<td>2.83</td>
</tr>
</tbody>
</table>

Notes: Figures in parentheses are the t-statistics. $R^2$ is the coefficient of determination, and DW denotes the Durbin-Watson statistic.

The investment-output ratio has been detrended.

To determine the lag pattern for the investment-output ratio, the particular form that equation (8a) assumed for each country is presented in Appendix II. The estimates presented in Table 2 were obtained by applying ordinary least squares to a form such as equation (8a) and imposing constant returns to scale, so that $a_2 = (1 - a_1)$.

This exercise has a twofold purpose: first, it yields the relevant parameter estimates; second, it serves as a "test" of the usefulness of an aggregate production function in explaining actual output growth. As Table 2 indicates, the estimates for the marginal product of capital are reasonable in sign and magnitude across countries, averaging about 0.29 (these are the parameter values used in the subsequent comparative static exercises). Unfortunately, however, a neoclassical production function does not explain much of the variation in actual output. A large proportion of output variation remains unexplained, perhaps reflecting that the specification traces a production possibility frontier when in reality, a significant number of countries, particularly developing countries, are not operating at full capacity. As such, a host of macroeconomic and microeconomic factors, not embodied in the production function, can push actual output growth toward or away from its potential. While this variation of the incremental capital output relationship meets the criteria of simplicity, which makes it applicable even in countries with limited data, it has the considerable drawback of being unstable over time. Projections of output growth based on variants of a production function are routinely subject to large and variable errors, and yet a neoclassical

---

9 This average is higher than the 0.2 value obtained by Khan and Reinhart (1990) for a cross-section sample of 24 developing countries, but is in line with Tyler (1981), who obtained a value of 0.25. Balassa (1978) found the marginal product to be about 0.16.
production function is one of the key relationships of the growth block of the theoretical framework.

Given the empirical inadequacy of the "full capacity" assumption, one possible route for future research would be to incorporate persistent excess capacity (present in varying degrees in most developing countries). The theoretical model would then allow domestic and foreign "demand" variables to play a greater role in output determination. Empirically, this extension should help reduce the share of output fluctuations that remains unexplained.

Savings Behavior—Is the Savings Rate Constant?

The second behavioral relationship in the model's growth block is the specification of the personal savings rate. The theoretical model assumes that real private savings is proportional to real disposable income. Variables that proxy the private sector's rate of time preference are not included in this specification. Similarly, other scale variables, such as wealth, are also omitted. 10

Negative levels of private savings for some countries in the sample for a subset of the years in which the data are available precluded estimating a log linear savings function. Furthermore, the problem of heteroskedastic errors makes the use of levels inappropriate. 11

Equation (9), however, implies that the marginal and average savings rates are equal. The average private savings rate, reported in Table 3, is used as the measure of \( s \). 12 While this average provides numerical values for the savings parameter, it says nothing about the adequacy of assuming a constant stable savings rate. To assess the properties of savings behavior, in particular its stability, given these obstacles, consumption behavior was examined. Table 3 reports the results of an equation of the form:

\[
De_t = c_0 + c_1 D(y - t),
\]  

(21)

where \( c \) represents real private consumption, \( c_0 \) is a constant term, \( c_1 \) is the average propensity to consume, and the \( D \)'s indicate rates of change. The results of equation (21) were used to test the assumption of a constant savings rate. If the savings rate is constant, the null hypothesis of \( c_0 = 0 \) and \( c_1 = 1 \) should hold in the data. In other words, to maintain the savings rate constant, income and consumption would have to increase at equal

10 For example, the role of wealth in consumption is emphasized in Haque and Montiel (1989).
11 White's test for the presence of heteroskedastic errors was applied to the versions of the savings and consumption functions that were specified in levels.
12 The construction of this variable is explained in Appendix I.
Table 3. The Savings Rate\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>Tanzania</th>
<th>Ghana</th>
<th>Pakistan</th>
<th>Korea</th>
<th>Myanmar</th>
<th>Honduras</th>
<th>Chile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>0.03</td>
<td>-0.25</td>
<td>0.07</td>
<td>0.31</td>
<td>0.16</td>
<td>0.21</td>
<td>-0.06</td>
</tr>
</tbody>
</table>

**Is the Savings Rate Constant?**

Unconstrained Equation

\[
\begin{align*}
c_0 & = 0.02, & 0.04, & 0.01, & 0.03, & -0.01, & 0.04, & -0.04 \\
(0.49) & (1.02) & (0.08) & (0.94) & (-0.52) & (2.78) & (-1.73) \\
c_t & = 0.76, & 0.79, & 1.02, & 0.82, & 1.06, & 0.61, & 1.07 \\
(3.01) & (8.41) & (10.70) & (5.40) & (14.86) & (4.15) & (31.82) \\
R^2 & = 0.32, & 0.79, & 0.86, & 0.60, & 0.92, & 0.48, & 0.99 \\
DW & = 1.42, & 1.98, & 1.94, & 1.34, & 1.87, & 1.31, & 1.78 \\
\end{align*}
\]

Unconstrained

- SSE: 0.152, 0.211, 0.017, 0.043, 0.020, 0.015, 0.023

Constrained

- SSE: 0.166, 0.284, 0.017, 0.047, 0.021, 0.022, 0.033
- F-stat: 0.62, 3.08, 0.21, 0.91, 0.26, 3.72, 1.98

Note: Figures in parentheses are the t-statistics, \( R^2 \) is the coefficient of determination, and DW denotes the Durbin-Watson statistic. SSE is the sum of squared residuals of the estimated equation, and the F-statistic tests for the significance of the difference between the unconstrained and the constrained versions of the equations.

\(^1\) The sample period is 1963-86, except for Chile in which a 1973-86 sample is used.

rates. This test of stability was preferred over the more traditional approaches, such as the Chow test, because in many instances splitting the sample was not advisable, given the limited number of observations available.

The results of an \( F \)-test comparing the residuals of the unconstrained (equation (21)) and the constrained equations indicate that in only one of the seven countries in the sample was the savings rate variable, making the assumption of a constant and stable savings rate reasonable for most instances. In effect, the constrained equation imposes the condition that the savings rate is stable while the unconstrained does not. If the savings rate is indeed unstable, then imposing the constraints would generate large errors relative to the errors of an unconstrained specification, and this would be apparent in the \( F \)-tests that compare the two versions of equation (21). The drawback of this test is that, even if the savings rate is found to be unstable, as for Honduras, this result could stem from misspecification—in particular the omission of the real rate of interest—and not from behavioral instability. If the interest rate belongs in the savings function, as several studies suggest (see, for example, Rossi (1988)), the constant term in a specification such as equation (21) could simply be picking up the systematic influence of the omitted variable.
Money Demand—Is Velocity Constant?

After obtaining estimates for the three parameters describing the growth block of the model and after evaluating the relative merits of the assumptions underscoring that portion of the merged model, the same test is performed for the monetary sector. The key behavioral relationship is the specification of money demand. As equation (14) indicates, it is assumed that since opportunity cost variables do not affect the demand for money, the income velocity of money is constant.13

As with the savings parameter, the historical averages of the ratio of money to income are used to approximate $v$, the inverse of the income velocity of money, and are reported for both narrow and broad definitions of money in Table 4.

To “test” the validity of the constant velocity assumption, a generalized version of equation (14) is taken, which (a) includes a constant term (which under the null hypothesis of constant velocity should be insignificantly different from zero); and (b) does not restrict the coefficients of output and prices to be identical, allowing for economies of scale in cash balances. This generalized specification is

$$DM_t = d_0 + d_1Dy_t + d_2DP_t,$$

where $d_0$ is a constant term that represents $D(1/v)$, the rate of change in income velocity. This equation was estimated over the seven countries in the sample (using both narrow and broad definitions of money) both imposing and not imposing the restriction that $d_1 = d_2$. The results are presented in Table 4. At one end of the spectrum are Korea and Chile, with an insignificant constant term in all specifications, indicating that the null of no change in velocity cannot be rejected. At the other end, for Ghana and Pakistan, all specifications indicate that velocity is not constant. More generally, it is easier to reject the null hypothesis of constant velocity for broad definitions of money (five out of seven countries) than for narrowly defined money (only two out of seven).14 The almost uniform poor fit of equation (14a) is another indication of the variability of velocity changes, since, where the rate of change in velocity is constant, equation (14a) would be an identity.

As with the savings rate, these results must be interpreted with care. They do not imply widespread instability in the demand for money, but rather suggest that a specification such as equation (14) is likely to be too restrictive. In particular, it seems reasonable to expect that a developing country, becoming increasingly monetized over time, would show secular

---

13 This assumption is, of course, extreme.
14 When both restricted and unrestricted versions coincide, they are rejected.

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### Table 4. Velocity Behavior

<table>
<thead>
<tr>
<th>Money plus Quasi Money</th>
<th>Tanzania</th>
<th>Ghana</th>
<th>Pakistan</th>
<th>Korea</th>
<th>Myanmar</th>
<th>Honduras</th>
<th>Chile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>0.31</td>
<td>0.25</td>
<td>0.37</td>
<td>0.31</td>
<td>0.29</td>
<td>0.21</td>
<td>0.22</td>
</tr>
</tbody>
</table>

| Narrow Money          |          |       |          |       |         |          |       |
| Average               | 0.24     | 0.19  | 0.25     | 0.10  | 0.25    | 0.11     | 0.07  |
| Is Velocity Constant?|          |       |          |       |         |          |       |

| Money plus Quasi Money |          |       |          |       |         |          |       |
| Unrestricted           |          |       |          |       |         |          |       |
| \(d_0\)                | 0.11     | 0.14  | 0.14     | 0.11  | 0.06    | 0.12     | 0.17  |
| \(d_1\)                | 0.77     | 0.39  | 0.53     | 0.70  | 0.29    | 0.57     | 0.09  |
| \(d_2\)                | 0.25     | 0.41  | -0.32    | 0.57  | 0.32    | -0.13    | 0.84  |
| \(d_3\)                | (-1.07)  | (-3.87)| (-1.50)  | (1.62)| (-1.61)| (-0.68)  | (7.83)|
| \(R^2\)               | 0.10     | 0.42  | 0.16     | 0.17  | 0.12    | 0.13     | 0.88  |
| DW                    | 2.10     | 1.57  | 2.02     | 0.91  | 1.18    | 1.78     | 1.46  |

| Restricted \((d_1 = d_3)\) |          |       |          |       |         |          |       |
| \(d_0\)                | 0.13     | 0.14  | 0.16     | 0.11  | 0.06    | 0.13     | 0.15  |
| \(d_1\)                | 0.23     | 0.41  | -0.13    | 0.60  | 0.32    | -0.03    | 0.86  |
| \(d_2\)                | (-0.98)  | (-3.96)| (-0.66)  | (2.10)| (1.72)  | (-0.16)  | (8.15)|
| \(R^2\)               | 0.05     | 0.42  | 0.02     | 0.17  | 0.12    | 0.00     | 0.87  |
| DW                    | 1.99     | 1.57  | 1.92     | 0.90  | 1.20    | 1.77     | 1.86  |

| Narrow Money          |          |       |          |       |         |          |       |
| Unrestricted           |          |       |          |       |         |          |       |
| \(d_0\)                | 0.07     | 0.11  | 0.14     | 0.10  | 0.03    | 0.08     | 0.08  |
| \(d_1\)                | 1.06     | 0.38  | 0.69     | 0.48  | 0.26    | 0.74     | 0.20  |
| \(d_2\)                | 0.37     | 0.50  | -0.40    | 0.47  | 0.62    | 0.07     | 0.82  |
| \(d_3\)                | (-1.20)  | (-4.22)| (-1.86)  | (1.54)| (2.54)  | (0.35)   | (8.15)|
| \(R^2\)               | 0.11     | 0.46  | 0.23     | 0.14  | 0.25    | 0.14     | 0.91  |
| DW                    | 2.06     | 1.62  | 1.29     | 1.78  | 1.71    | 2.05     | 1.73  |

| Restricted \((d_1 = d_3)\) |          |       |          |       |         |          |       |
| \(d_0\)                | 0.10     | 0.11  | 0.15     | 0.10  | 0.02    | 0.09     | 0.07  |
| \(d_1\)                | 0.33     | 0.50  | -0.15    | 0.48  | 0.57    | 0.17     | 0.84  |
| \(d_2\)                | (1.11)   | (4.31) | (-0.73)  | (1.89)| (2.52)  | (0.82)   | (9.18)|
| \(R^2\)               | 0.06     | 0.46  | 0.02     | 0.14  | 0.23    | 0.03     | 0.89  |
| DW                    | 1.95     | 1.65  | 1.74     | 1.78  | 1.81    | 2.01     | 2.27  |

*Note: Figures in parentheses are the t-statistics. \(R^2\) is the coefficient of determination, and DW denotes the Durbin-Watson statistic.*
changes in the income velocity of money. The significance of the constant term in many of the specifications presented in Table 5 may well arise as much from such institutional changes as from omitting other explanatory variables such as the nominal interest rate, inflationary expectations, and exchange rate changes. However, the results indicate that future extensions to the theoretical and empirical work should include more comprehensive specifications of money demand. In summary, the assumption of constant velocity, like the assumption of fully employed resources in the growth block, appears to be a weak link in the merged model.

The remaining parameter in the monetary component of the model is \( \theta \), the weight of import prices in the general price level. This parameter was approximated by average share of imports in total (public plus private) consumption and is reported in Table 5.

### Trade Balance

Two external sector relationships close the system: the balance of payments identity (equation (17)) and the trade balance responses to output and real exchange rate changes (equation (18)). These two remaining parameters (in the trade balance equation) to be estimated link the "real" and "monetary" sectors. The remainder of this section outlines how estimates for the parameters \( a \) and \( b \) were obtained. Because the trade balance changes in sign across countries and across time, a log-linear version of equation (18) cannot be estimated. Also, to avoid the problem of heteroskedastic errors, levels were not used. Instead, the trade balance was decomposed into its components—exports and imports. The relative price and income elasticities of import demand and export supplies were estimated using some variant of:

\[
\log(z_t) = \delta_0 + \delta_1 \log(y_t) + \delta_2 \log(P_{zt}/P_{Dt})
\]

(22)

for imports; and

\[
\log(x_t) = \varepsilon_0 + \varepsilon_1 \log(y_{f_t}) + \varepsilon_2 \log(P_{xt}/P_{Dt})
\]

(23)

for exports.\(^{15}\) For export demand, \( y_f \) denotes real GDP of the industrial

\(^{15}\)The use of the relative price of exports, \( P_{xt}/P_{Dt} \), in this specification, in lieu of the real exchange rate, \( P_r/P_{Dt} \), is justified by the assumption of constant terms of trade in the theoretical model.
countries. The specific form that equations (22) and (23) assume for each country varies according to the lag pattern the data reveal. These details are in Appendix II.

Proxies for $a$ and $b$ were constructed by weighting the “disaggregated” parameter estimates (obtained by applying generalized least squares to the above equations) by the sample period averages of imports and exports, respectively. The results of the estimation of import demand and export supply as well as the derivation of the relevant weights are reported in Appendix II, while the “weighted” estimates for $a$ and $b$ are reported in Table 6. In all seven countries, the real exchange rate elasticity, $-a$, has the correct sign (negative), and an increase in domestic income worsens the trade balance—that is, $b$ is positive.

### III. Comparative Statics and Sensitivity Analysis

**Summary of Findings in the Cross-Country Comparisons**

Parametrizing the model is useful in comparing its ability to fit diverse circumstances but is only an intermediate step in evaluating its usefulness for policymaking. The purpose of this section is to construct the policy multipliers associated with the estimated parameter values and to address two related issues. First, the sensitivity of these multipliers to varying parameter values is examined—the policy robustness question—and second, the relative precision of the forecasts for the target variables is assessed.

Table 7 summarizes the point estimates of the parameters of interest, and these values generate the “core” set of policy multipliers. However, as Table 8 shows, only limited confidence can be placed in these point
estimates, since some of the parameters are unstable. Even in the instances in which the hypothesis of stability cannot be rejected, the precision of these point estimates tends to be quite low (that is, the standard errors tend to be large). For any analytical purposes, a band of parameter values must be considered. The upper and lower bounds of such a band were calculated by respectively adding to and subtracting from the point estimates one half of a standard error.

Chart 2 illustrates the configuration of the real and monetary sectors that the averages from the sample suggest. The actual numerical values of the slopes of the \( GG \) and \( MM \) schedules (and the range defined by the parameter band) are presented in Table 9 for the sample countries. The remainder of this section considers three policy exercises: an increase in domestic credit; an increase in government spending; and a devaluation. Since the model is static, the effects of policy are evaluated by comparing the pre-shock and post-shock steady states—that is, the relevant policy multipliers are calculated.

In all cases considered, the sensitivity of these multipliers to changing parameter values is assessed. The policy implications of the model are said to be robust if the range of values assumed by the multiplier remains narrow despite changes in the parameters. This section concludes with a discussion of the relative predictability of the target variables.

### Table 7. Cross-Country Comparison of the Key Parameters

<table>
<thead>
<tr>
<th></th>
<th>Tanzania</th>
<th>Ghana</th>
<th>Pakistan</th>
<th>Korea</th>
<th>Myanmar</th>
<th>Honduras</th>
<th>Chile</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha_0 )</td>
<td>-0.07</td>
<td>-0.04</td>
<td>-0.07</td>
<td>0.08</td>
<td>-0.02</td>
<td>-0.05</td>
<td>-0.07</td>
<td>-0.03</td>
</tr>
<tr>
<td>( \alpha_1 )</td>
<td>0.28</td>
<td>0.12</td>
<td>0.62</td>
<td>0.08</td>
<td>0.23</td>
<td>0.28</td>
<td>0.50</td>
<td>0.29</td>
</tr>
<tr>
<td>( s )</td>
<td>0.03</td>
<td>-0.25</td>
<td>0.07</td>
<td>0.31</td>
<td>0.16</td>
<td>0.21</td>
<td>-0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>( u )</td>
<td>0.31</td>
<td>0.25</td>
<td>0.37</td>
<td>0.31</td>
<td>0.29</td>
<td>0.21</td>
<td>0.22</td>
<td>0.28</td>
</tr>
<tr>
<td>( \theta )</td>
<td>0.25</td>
<td>0.11</td>
<td>0.16</td>
<td>0.18</td>
<td>0.10</td>
<td>0.31</td>
<td>0.20</td>
<td>0.19</td>
</tr>
<tr>
<td>( v )</td>
<td>-0.37</td>
<td>-0.08</td>
<td>-0.21</td>
<td>-0.83</td>
<td>-0.40</td>
<td>-0.12</td>
<td>-0.59</td>
<td>-0.37</td>
</tr>
<tr>
<td>( b )</td>
<td>0.69</td>
<td>1.20</td>
<td>1.00</td>
<td>0.64</td>
<td>0.62</td>
<td>1.28</td>
<td>1.81</td>
<td>1.03</td>
</tr>
</tbody>
</table>

1 Uses the broad definition of money: money plus quasi-money.

### Table 8. Testing the Assumptions of the Model

<table>
<thead>
<tr>
<th></th>
<th>Tanzania</th>
<th>Ghana</th>
<th>Pakistan</th>
<th>Korea</th>
<th>Myanmar</th>
<th>Honduras</th>
<th>Chile</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Con ) constant velocity be rejected? \</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>( Narrow ) constant velocity be rejected? \</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>( Con a constant savings rate be rejected? \</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>What percentage of output variation is explained by a production function?</td>
<td>22</td>
<td>28</td>
<td>74</td>
<td>34</td>
<td>20</td>
<td>9</td>
<td>91</td>
</tr>
</tbody>
</table>
**Chart 2. Parametrized System**

![Chart 2](chart.png)

**Increase in Domestic Credit**

An increase in the rate of domestic credit expansion (assumed to go entirely to the private sector) creates a flow excess supply of money on impact. In Chart 2, the \( MM \) schedule shifts upward. At the initial level of output, this shift induces an increase in the price level which, in turn,

<table>
<thead>
<tr>
<th>Table 9. Graphics of the Empirical Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanzania</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Slope of the ( GG ) schedule</td>
</tr>
<tr>
<td>Point estimate</td>
</tr>
<tr>
<td>Lower bound</td>
</tr>
<tr>
<td>Upper bound</td>
</tr>
<tr>
<td>Slope of the ( MM ) schedule</td>
</tr>
<tr>
<td>Point estimate</td>
</tr>
<tr>
<td>Lower bound</td>
</tr>
<tr>
<td>Upper bound</td>
</tr>
</tbody>
</table>
increases money demand. However, for a given level of import prices, the domestic price rise also produces a real exchange rate appreciation and a worsening in the current account deficit. The latter is mirrored by an increase in foreign savings and an increase in investment and output growth. Ultimately, inflation rises, output growth increases, and the balance of payments worsens.\(^{16}\)

More formally, the increase in inflation is given by

\[
\frac{\partial (dPD)}{\partial (dD)} = (\Omega \gamma)^{-1} > 0
\]

\[
\Omega = 1 - \frac{\alpha_1 \eta(b' + \nu)}{\beta \gamma} > 0
\]

and, as before,

\[
\beta = 1 - \alpha_1 (s + b) > 0
\]

\[
\eta = B_0 - a.
\]

The change in output growth is

\[
\frac{\partial (dy)}{\partial (dD)} = -\frac{\eta \alpha_1}{\beta} (\Omega \gamma)^{-1} > 0,
\]

and the change in the balance of payments is

\[
\frac{\partial (dR)}{\partial (dD)} = \left(\frac{b' \alpha_1 \eta}{\beta} - a'\right) (\Omega \gamma)^{-1} < 0.
\]

Using the estimated parameter values and the corresponding parameter bands, the multipliers for the three target variables are reported in Table 10. As an example, in the sample average case, a 10 percent increase in the rate of growth of credit increases inflation by about 15 percent (the range is 12–19 percent), increases output growth by 2 percent, and worsens the balance of payments by 6 percent.

Note the large discrepancy between the inflation multipliers, which are highly variable in most instances, and the relatively close values for multipliers for growth and the balance of payments. This suggests that the usefulness of the model, and/or the desirability of using credit as a policy instrument, will depend, to a large degree, on the form of the policymaker’s objective function. If the primary objective of policy is to meet an inflation target, then this framework of analysis, given the underlying parameter values, may not be the best to employ. If, however, the primary policy objective is a balance of payments or growth target, the model is more useful.

\(^{16}\)See Khan and Montiel (1989) for a detailed discussion.
Table 10. A 10 Percent Increase in Domestic Credit

<table>
<thead>
<tr>
<th>Inflation multiplier$^2$</th>
<th>Tanzania</th>
<th>Ghana</th>
<th>Pakistan</th>
<th>Korea</th>
<th>Myanmar</th>
<th>Honduras</th>
<th>Chile</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point estimate</td>
<td>13.5</td>
<td>31.3</td>
<td>9.7</td>
<td>8.8</td>
<td>13.1</td>
<td>28.7</td>
<td>1.8</td>
<td>15.3</td>
</tr>
<tr>
<td>Lower bound</td>
<td>15.3</td>
<td>37.8</td>
<td>12.8</td>
<td>9.2</td>
<td>14.1</td>
<td>36.3</td>
<td>4.8</td>
<td>18.6</td>
</tr>
<tr>
<td>Upper bound</td>
<td>17.7</td>
<td>26.4</td>
<td>5.9</td>
<td>8.4</td>
<td>12.1</td>
<td>20.2</td>
<td>0.8</td>
<td>11.8</td>
</tr>
</tbody>
</table>

| Output multiplier$^3$     |          |        |          |       |         |          |       |         |
| Point estimate            | 1.7      | 0.4    | 3.6      | 0.5   | 1.4     | 1.5      | 4.2   | 1.9     |
| Lower bound               | 1.4      | 0.5    | 2.8      | 0.6   | 1.4     | 1.1      | 3.5   | 1.6     |
| Upper bound               | 2.1      | 0.4    | 4.6      | 0.5   | 1.4     | 2.2      | 5.2   | 2.3     |

| Balance of payments multiplier$^4$ |          |        |          |       |         |          |       |         |
| Point estimate            | -6.2     | -3.0   | -5.6     | -7.6  | -6.1    | -5.4     | -8.7  | -6.1    |
| Lower bound               | -6.4     | -3.4   | -5.3     | -8.0  | -6.3    | -5.5     | -8.6  | -6.1    |
| Upper bound               | -6.1     | -2.7   | -6.2     | -7.3  | -6.0    | -5.8     | -9.1  | -6.2    |

$^1$The upper and lower bounds refer to adding to and subtracting from (respectively) the underlying structural parameters—not the multipliers themselves—one half of a standard deviation.

$^2\frac{\partial(dPD)}{\partial(dO)}$.

$^3\frac{\partial(dy)}{\partial(dO)}$.

$^4\frac{\partial(dR)}{\partial(dO)}$.

Increase in Government Spending

An increase in government spending, maintaining taxes and the rate of change in domestic credit at initial levels, shifts the $GG$ schedule in Chart 2 to the left. The rise in fiscal spending translates into a higher deficit and, therefore, less public savings. The decline in savings reduces capital accumulation and output growth. As output growth falls, reducing the flow demand for money and creating an excess supply, inflation must rise to ensure that the money market clears. With output falling and prices rising, the impact of the fiscal expansion on the balance of payments is theoretically ambiguous and must be determined by the data. The effects of a change in real government spending on inflation growth and the balance of payments are listed below, while Table 11 summarizes the relevant set of policy multipliers.

\[
\frac{\partial(dP_D)}{\partial g} = \frac{\Omega^{-1} \alpha_1 (b' + \nu)}{\beta \gamma} > 0,
\]

\[
\frac{\partial(dy)}{\partial g} = -\Omega^{-1} \frac{\alpha_1}{\beta} < 0,
\]

and

\[
\frac{\partial(dR)}{\partial g} = \frac{\alpha_1}{\beta} \Omega^{-1} [b' - a'(b' + \nu) \gamma] \leq 0.
\]
### Table II. A 10 Percent Increase in Government Spending

(In percent)

<table>
<thead>
<tr>
<th></th>
<th>Tanzania</th>
<th>Ghana</th>
<th>Pakistan</th>
<th>Korea</th>
<th>Myanmar</th>
<th>Honduras</th>
<th>Chile</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inflation multiplier</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point estimate</td>
<td>4.8</td>
<td>6.1</td>
<td>24.4</td>
<td>0.7</td>
<td>3.3</td>
<td>20.6</td>
<td>14.6</td>
<td>10.7</td>
</tr>
<tr>
<td>Lower bound</td>
<td>3.3</td>
<td>5.0</td>
<td>18.0</td>
<td>0.7</td>
<td>2.6</td>
<td>11.8</td>
<td>10.9</td>
<td>7.5</td>
</tr>
<tr>
<td>Upper bound</td>
<td>6.8</td>
<td>7.2</td>
<td>33.4</td>
<td>0.8</td>
<td>4.1</td>
<td>35.0</td>
<td>19.4</td>
<td>15.2</td>
</tr>
<tr>
<td><strong>Output multiplier</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point estimate</td>
<td>-2.9</td>
<td>-1.3</td>
<td>-9.3</td>
<td>-0.8</td>
<td>-2.4</td>
<td>-3.7</td>
<td>-5.5</td>
<td>-3.7</td>
</tr>
<tr>
<td>Lower bound</td>
<td>-2.2</td>
<td>-1.2</td>
<td>-7.0</td>
<td>-0.8</td>
<td>-2.4</td>
<td>-2.4</td>
<td>-4.3</td>
<td>-2.9</td>
</tr>
<tr>
<td>Upper bound</td>
<td>-3.7</td>
<td>-1.4</td>
<td>12.7</td>
<td>-0.8</td>
<td>-2.5</td>
<td>-5.8</td>
<td>-7.0</td>
<td>-4.8</td>
</tr>
<tr>
<td><strong>Balance of payments multiplier</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point estimate</td>
<td>0.2</td>
<td>1.0</td>
<td>4.2</td>
<td>-0.1</td>
<td>0.2</td>
<td>2.3</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Lower bound</td>
<td>0.1</td>
<td>0.6</td>
<td>2.7</td>
<td>-0.1</td>
<td>-0.1</td>
<td>1.0</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Upper bound</td>
<td>0.6</td>
<td>1.5</td>
<td>6.5</td>
<td>-0.1</td>
<td>0.4</td>
<td>4.9</td>
<td>2.2</td>
<td>2.3</td>
</tr>
</tbody>
</table>

1. The upper and lower bounds refer to adding to and subtracting from (respectively) the underlying structural parameters—not the multipliers themselves—one half of a standard deviation.
2. $\frac{\partial (d_P)}{\partial (g)}$.
3. $\frac{\partial (d_Y)}{\partial (g)}$.
4. $\frac{\partial (d_R)}{\partial (g)}$.

Once again, the fiscal multipliers for output and the balance of payments are bounded by a fairly narrow range. In the case of a change in credit—a monetary shock—the bulk of the adjustment falls on the nominal variable (inflation), with output growth and the balance of payments remaining relatively unaffected. This result is not surprising, given the very steep $GG$ schedules that the estimated parameter values trace. What is more surprising is that a change in government spending—a real shock—also has a greater (and more variable) impact on inflation than on the real variables. For all seven countries, the balance of payments improved after the shock, indicating that the contractionary output effect dominated the relative price effect.

### Devaluation

A devaluation is both a real and a nominal shock, and consequently shifts both schedules in Chart 2. At the initial price of domestic goods, a devaluation increases the aggregate price level through an increase in the price of imports. This increases the flow demand for money. At the same time, the shift in relative prices induces lower consumption of the importable and higher production of the domestic good, leading to an improvement in the balance of payments and an expansion in the flow
supply of money. If substitution effects are dominant, then the increase in the flow supply of money more than accommodates the rise in demand, and the MM schedule shifts to the right—this effect is expansionary. In the “real” sector the foreign component of savings is lower, owing to the improvement in the balance of payments; this reduces capital formation, shifting the GG schedule to the left—a contractionary effect. As shown in Khan and Montiel (1989), the latter effect dominates, and output falls. Table 12 presents numerical multipliers of a devaluation; the partial derivatives are listed below:

\[
\frac{\partial (dP_Y)}{\partial (de)} = (\Omega \gamma)^{-1} [a' - \nu Y_0 \theta - \alpha_1 \eta (b' + \nu) / \beta] > 0
\]

for growth:

\[
\frac{\partial (dy)}{\partial (de)} = \frac{\alpha_1 \eta}{\beta} (\Omega \gamma)^{-1} \nu Y_0 < 0
\]

and the balance of payments:

\[
\frac{\partial (dR)}{\partial (de)} = \left( a' - b' \alpha_1 \eta \right) (\Omega \gamma)^{-1} \nu Y_0 > 0.
\]

<table>
<thead>
<tr>
<th>Table 12. A 10 Percent Devaluation¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>(In percent)</td>
</tr>
<tr>
<td>Tanzania</td>
</tr>
<tr>
<td>Inflation multiplier²</td>
</tr>
<tr>
<td>Point estimate</td>
</tr>
<tr>
<td>Lower bound</td>
</tr>
<tr>
<td>Upper bound</td>
</tr>
<tr>
<td>Output multiplier³</td>
</tr>
<tr>
<td>Point estimate</td>
</tr>
<tr>
<td>Lower bound</td>
</tr>
<tr>
<td>Upper bound</td>
</tr>
<tr>
<td>Balance of payments multiplier⁴</td>
</tr>
<tr>
<td>Point estimate</td>
</tr>
<tr>
<td>Lower bound</td>
</tr>
<tr>
<td>Upper bound</td>
</tr>
</tbody>
</table>

¹ The upper and lower bounds refer to adding to and subtracting from (respectively) the underlying structural parameters—not the multipliers themselves—one half of a standard deviation.

² \( \frac{\partial (dP_Y)}{\partial (de)} \).

³ \( \frac{\partial (dy)}{\partial (de)} \).

⁴ \( \frac{\partial (dR)}{\partial (de)} \).
Two general characteristics are worth noting. First, the multipliers of a devaluation are relatively low when compared with those associated with credit and fiscal changes, suggesting it takes large devaluations to affect the target variables in any meaningful way. Second, as with monetary and fiscal policy—although not quite as pronounced—the effects of a devaluation on inflation are greater than those of output or the balance of payments, indicating that the desirability of either employing this framework, using devaluation as a policy tool, or both, depends on the relative importance to policymakers of the inflation target.

IV. Conclusions

The objective of this paper was to apply to a diverse group of developing countries a model that in principle is simple enough to be used operationally in countries where data are limited and is comprehensive enough to enable a useful analysis and evaluation of growth-oriented policies to be undertaken.

The first step of this evaluation was to estimate the model and test its underlying assumptions. The estimated parameter values were in accordance with the theoretical priors, but two weak building blocks in the framework were identified: that output is assumed to expand at a rate determined by technology and endowment, and that the income velocity of money is assumed to be constant. The low explanatory power of a neoclassical production function suggests that future extensions to this framework should attempt to incorporate excess capacity, which characterizes most developing countries. Similarly, the empirical variability in velocity indicates the need for a less restrictive specification of money demand that allows for the secular effects of monetization in developing economies as well as for the impact of a variety of opportunity cost variables. Finally, the model is static and consequently does not incorporate the possibility of slow adjustment and the role of expectations in the analysis. The second part of the evaluation used the estimated parameter values to construct reduced-form multipliers and to analyze the effects of a variety of policy exercises. The robustness of the model's policy implications were found to depend heavily on two factors.

First, robustness varies with the target variable considered. For output growth and the balance of payments, the range for multipliers is narrow, despite sizable variation in parameter values. For inflation, the range of values the policy multipliers assumed are quite broad. This suggests that the forecast errors are likely to be large if this model is employed to forecast the effects of policy changes on inflation. In effect, the usefulness of this model for policymaking (given the parameter values) depends
crucially on the policymaker's objective function. In general, the model is less useful if the primary objective of policy is to meet an inflation target, whereas if the balance of payments or growth are the principal targets, then the projected outcomes suggested by this model are more useful.

Second, the reliability of the policy implications depends on the policy instrument being considered. Based on the multipliers calculated in this paper, the effects of a devaluation (on all target variables) are less sensitive to parameter changes than the multipliers of changes in credit or fiscal policies.

While some possible extensions to the theoretical framework have already been mentioned, there are a number of ways in which the empirical work can be enriched. In particular, when maintaining a consistent methodology across countries is not a binding constraint, as it was in this paper, more efficient use can be made of the greater data availability in some countries. This would allow for more rigorous tests of parameter instability and would enable the estimation of the model as a system and a more formal assessment of forecasting errors.

In conclusion, the present model is a useful starting point for the design of growth-oriented policies, although its usefulness across countries is by no means uniform. There are countries where none of the theoretical assumptions appear to be adequate—Honduras—and where, consequently, the effects of macroeconomic policies suggested by the model are subject to much uncertainty. There are countries where the assumptions appear to have greater empirical validity—Korea and Chile—and the policy implications are relatively more robust. In general, analysis indicates that a reasonable next step in enhancing the operational usefulness of the basic model would be to relax some of the more rigid assumptions while attempting to keep the added degree of complexity to a minimum.

APPENDIX I

Data Definitions and Sources

Source A: International Monetary Fund, International Financial Statistics; and Source B: International Monetary Fund, World Economic Outlook.

The definition of the variables used in the estimations are, in order of appearance:

\[ y_t = \text{real GDP (Source B).} \]
\[ d_{k_t}/y_{t-1} = \text{investment-output ratio (Source B).} \]
\[ L_t = \text{population (Source B).} \]
\[ s = \text{average private savings rate—constructed by subtracting government savings from gross savings (Sources A and B).} \]
The specification of equation (18a) for Tanzania and Honduras took the form of

\[ Dy = \alpha_0 + \alpha_1 (dk/y_{-1}) + (1 - \alpha_1) DL \]

(18a)
For the other countries, lagged values of the investment-output ratio were included along the lines outlined below:

\[
D_y = \alpha_0 + \sum_{i=1}^{n} \alpha_i [(dk/y)_{-i}] + \left(1 - \sum_{i=0}^{n} \alpha_i\right) DL.
\]  
(18a-4)

For Myanmar and Chile; \(n\), the number of lags included equals one.
For Korea; \(n = 2\).
For Ghana and Pakistan; \(n = 3\).

**Import and Export Demand Specifications**

The generalized version of the estimated import demand equation is given by

\[
\log(z) = \delta_0 + \delta_1 \log(y) + \delta_2 \log[(P_z/P_D)_{-1}].
\]  
(22)

For Pakistan, Korea, and Chile; \(i = 0\) -- no lag.
For Honduras; \(i = 1\).
For Myanmar; \(i = 2\).
For Tanzania and Ghana; \(i = 3\).

The generalized version of the estimated export supply equation is given by

\[
\log(x) = \epsilon_0 + \epsilon_1 \log(yf) + \epsilon_2 \log[(P_x/P_D)_{-1}].
\]  
(23)

For Honduras and Chile; \(i = 0\).
For Ghana and Pakistan; \(i = 1\).
For Tanzania, Korea, and Myanmar; \(i = 2\).
Equation (23) also includes a time trend for Tanzania.

**Deriving the Weights**

To construct the price and income elasticities of the trade balance, \(B\), from the estimates obtained by estimating import demand and export demand individually:

\[
\text{Since } dB = z \frac{dz}{z} - x \frac{dx}{x} , \quad d[\log(z)] = \frac{dz}{z} , \quad d[\log(x)] = \frac{dx}{x} ,
\]

and recalling that the terms of trade, \(P_x/P_z\), is assumed constant in the theoretical model (and equal to one at \(t = 0\)) yields

\[
dB = z \delta_1 \frac{dy}{y} - x \epsilon_1 \frac{dyf}{yf} - [z \delta_2 + x \epsilon_2] \frac{d(P_z/P_D)}{(P_z/P_D)}.
\]

As usual the estimated elasticities are unit free, but the relevant weights, \(z\) and \(x\), are not. To make these weighted elasticities comparable across countries the above was divided by the sum of imports and exports, \(z + x\).

\[
\frac{dB}{z + x} = \frac{z}{z + x} \delta_1 \frac{dy}{y} - \frac{x}{z + x} \epsilon_1 \frac{dyf}{yf} - \left[\frac{z}{z + x} \delta_2 + \frac{x}{z + x} \epsilon_2\right] \frac{d(P_z/P_D)}{(P_z/P_D)}.
\]
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Stabilization Programs in Developing Countries: A Formal Framework

Mohsin S. Khan and Malcolm D. Knight*

Most developing countries have at one time or another faced the twin problems of a high domestic rate of inflation and a deficit in the balance of payments. The cause of these problems can often be traced to a situation of government fiscal deficits that result in excessive monetary expansion and feed domestic demand. Stabilization programs are typically put into effect to reduce these pressures. Policymakers have long recognized that the implementation of a stabilization program will have simultaneous effects on output, inflation, and the balance of payments. While practitioners generally attempt to make allowances for these effects in qualitative terms, relatively little is known about the precise quantitative nature of the relationships among these major economic aggregates in the context of developing countries. This lack of knowledge, of course, creates considerable problems when one wishes to assess the effects of a particular policy initiative—say, for example, a change in monetary policy—on important macroeconomic variables, and, conversely, to derive the appropriate policy to achieve specific stabilization objectives.

Most economists would probably accept the general proposition that monetary expansion will not only create inflationary pressures and cause the balance of payments to deteriorate but also, particularly when it is unanticipated, increase real income. However, the actual operation of the transmission mechanism in developing countries, and the relative size and timing of the effects of a change in policy, are a matter of considerable doubt. There is now an extensive literature on some of the more important individual relationships. For example, substantial work has been done on the links between monetary growth and inflation, and

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between money and the balance of payments. A relatively smaller number of empirical studies have also been made of the relationship between money and growth. Systematic analysis of these various relationships across developing countries, however, is very limited. Models have been specified and estimated for some individual countries—for example, by Aghevli (1977) for Indonesia, Khan (1976) for Venezuela, and Otani and Park (1976) for Korea—but it is difficult to generalize these results to other countries because of differences in model specification, estimation methods, and periods of estimation.

Furthermore, there has been only limited formal analysis of the effects that a stabilization program may have on a developing economy. This, of course, has considerable implications for the Fund’s lending operations, since the relationships just mentioned figure prominently in the stabilization programs that are established by member countries in connection with stand-by arrangements. Broadly defined, a stabilization (or financial) program is a package of policies designed to eliminate disequilibrium between aggregate demand and supply in the economy, which typically manifests itself in balance of payments deficits and rising prices. Thus, the fundamental objective of a financial program is to find “a suitable relationship between resource availabilities and needs that causes minimum strain on the internal price level and produces a desired balance of payments result.”

While no single theoretical model underlies all financial programs, a broad framework within which most of them are formulated has evolved in the IMF over the years. In this framework there is a fairly well-defined relationship between money, the balance of payments, and domestic prices, in which the supply of and demand for money play a central linking role. The effects of policies on the real sector are treated less explicitly. When feedbacks from real output are taken into consideration, the analysis is made on a more informal case-by-case basis rather than in the context of an explicit and consistent general methodology. Because of this, it is difficult to say a priori whether a given financial program will have undesirable consequences for growth and employment, something that has worried policymakers and academic economists alike.

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2 See the papers contained in Frenkel and Johnson (1976) and International Monetary Fund (1977). Magee (1976) also provides a useful survey of this topic.
3 See, for example, Blejer and Fernandez (1980).
4 One previous study, by Aghevli and Khan (1980), does try to generalize by using the same model for eight developing countries.
5 Robichek (1967), pp. 1–2.
6 See Polak (1957), Robichek (1967; 1971), and International Monetary Fund (1977).
7 See, for example, Williamson (1980).
pie, as Robichek (1967, p. 4) has observed, in implementing a financial program one has to be aware of "the need to frame programs that are compatible with aspirations for rapid economic growth."

Generally, treating output as independent of monetary or credit factors has been rationalized on the grounds that the typical program is essentially short term and that in the short run one can assume that the domestic supply of resources is effectively fixed. This assumption has apparently been supported by some empirical evidence. For example, Reichmann and Stillson (1978), after examining a number of Fund stand-by arrangements over the period 1963-72, conclude (p. 304) that "one cannot observe a systematic relationship between the introduction or implementation of programs and rates of growth in the short run." This conclusion, however, does not distinguish between the rate of growth of capacity output and the rate of capacity utilization, and the latter could be affected even in the short run. Furthermore, in view of the extension of the time span of stand-by arrangements that has occurred in more recent times, this rationale can no longer be relied upon, and anyone engaged in setting up a financial program has to face the growth problem directly.

While the principal objectives of a stabilization program may be to reduce the inflation rate and improve the country's external payments position, the policies followed will have repercussions on the other variables in the economy, some of which may be desirable and some not. Yet these other effects are clearly of interest to the policymaker. For example, a restrictive monetary policy may involve an unwanted temporary loss of output, even though eventually such a policy would reduce inflation and improve the balance of payments. The size of this loss of output, and the period over which it occurs, is often of overriding importance to the authorities in developing countries from both economic and social perspectives. One can easily conjure up a scenario in which a deflationary policy initially has little effect on prices, perhaps because they are "sticky" in the short run, but causes a substantial slowdown in the growth of real income and employment. Such a scenario would depend on the relative sizes of the various parameters in the system and the time lags involved in the response of variables to policy changes. The question that arises is whether there are combinations of private sector behavior and government policy that could potentially give rise to this result, and how likely it is to occur.

Handling this type of problem would naturally require a dynamic model that could simultaneously capture the major relations between prices, the balance of payments, and output. The purpose of this paper

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8 Such stickiness could arise from the existence of prior contracts, or simply because inflation is driven by expectations that are slow to be revised.
is to propose a formal framework for examining these interrelations, and, more important, to use this framework to analyze the effects of policy changes on all these variables. In a sense, the model can be viewed as providing one particular interpretation of the basic theoretical paradigm underlying the financial programming exercises of the Fund. Within the context of the simple dynamic model developed here, questions regarding the effect of stabilization programs on resource utilization in both the short run and the long run can be handled. Such an analysis is important, since the time path that the variables follow during the course of a stabilization program is often just as crucial as the positions they ultimately reach.

The model proposed here, although highly aggregated and simple in structure, is nevertheless able to meet this main requirement. It stresses the crucial role played by the demand for money and monetary disequilibrium in the behavior of such major macroeconomic variables as prices, output, and the balance of payments. Thus, the analysis can be considered a generalization of the models developed in the context of the monetary approach to the balance of payments, and is also consistent with the philosophy underlying the financial programming approaches followed in the Fund. Nevertheless, while monetary factors are assigned a dominant role, it is explicitly recognized that the money supply is not necessarily under the close control of the authorities. The domestic money stock definitionally equals the net foreign assets of the consolidated banking system plus bank credit to the government and the private sector, and it is by now well established that in a small open economy operating under a system of fixed exchange rates (a description that would fit most developing countries), changes in the money supply can be brought about through the balance of payments. Furthermore, in countries that lack a developed capital market, the growth of domestic credit may be closely linked to the government's borrowing requirements and hence to its fiscal policy. In this model, monetary (cum fiscal) policy is the relevant means by which the authorities seek to achieve their objectives, and it is the domestic component of the money stock that is the instrument to be used to this end.

This stress on monetary factors and short-run dynamics obviously gives an unmistakably demand-oriented flavor to the model. No account is taken of wealth and capital accumulation and their role in affecting the long-run growth path of the economy. Essentially, the model attempts to

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9See Frenkel and Johnson (1976) and International Monetary Fund (1977). Such generalizations have been made by Blejer (1977) for Mexico, Knight and Wymer (1978) for the United Kingdom, and Knight and Mathieson (1983) for Canada.

10See Polak (1957) and Robichek (1967). For a view of the Fund approach from the outside, see Williamson (1980).
capture only short-term deviations of real income from its long-run trend, which is here assumed to be exogenously determined. However, the analysis could be extended by specifying the determinants of capacity output.

As the focus of the exercise is to derive meaningful policy conclusions, the model is estimated using a systems method in order to provide parameters that can be used to quantify the various relationships. Through the use of pooled time-series cross-sectional data covering 29 developing countries, an attempt is made to achieve sufficient generalization that the estimated parameters can be taken as representative of a broad class of developing countries. Finally, and this is perhaps the most important part of the paper, a set of simulation experiments is conducted using the estimated version of the model. In the first simulations, the effects of certain shocks are traced, including a change in monetary policy and an exogenous increase in capacity output. The results of these simulations are compared with those obtained from a model that does not allow for simultaneous interaction between output, inflation, and the balance of payments to highlight the differences that emerge when such interaction is taken into account. In the second set of simulations, an attempt is made to derive the appropriate financial policy to achieve a specified improvement in the balance of payments. This type of simulation is, of course, similar to the typical financial programming exercise. Indeed, one of the objectives of this part of the paper is to compare the price and output consequences of two types of stabilization program: a standard short-term program, and a longer-run or “extended” program.

Section I describes the structure of the model. The results from estimating the model, and certain of its overall empirical characteristics, are discussed in Section II. The various simulation experiments are considered in Section III, and a summary of the findings of the study is presented in Section IV.

I. Specification of the Model

The model contains nine equations, of which six are behavioral. Such simplicity was dictated mainly by a desire to focus on the general aspects of the issues considered here and to develop an analysis that is applicable to a variety of developing countries. Any greater detail would necessitate consideration of the institutional characteristics of individual countries, and thus make it difficult to generalize from the results. Furthermore,

11 Careful study of the individual characteristics of a specific country would obviously be required before a stabilization program could be tailored to its particular circumstances.
any attempt to construct a more disaggregated model for developing
countries immediately runs into the constraints of the limited availability
of data. Essentially, this model describes an economy that is small relative
to the rest of the world. It is open to international trade and financial
flows, and maintains a pegged exchange rate.\(^\text{12}\) It is assumed that the
domestic financial sector is relatively underdeveloped. This specifically
implies that the number of financial assets that could substitute for money
holdings is very limited, and/or that the authorities control the interest
rates on those assets that are available.\(^\text{13}\) Naturally, not all developing
countries would fit exactly into the framework given by these assump­tions, but it is argued that these features seem to be characteristic of most
developing countries.

The stochastic equations of the model explain inflation, the overall
balance of payments, the fiscal budget (that is, government expenditure
and revenues), and output. Identities for the supply of money and its
domestic component (domestic credit) are used to close the system.

**Inflation**

The specification for price changes is an extension of the monetary
disequilibrium model of Goldman (1972) to an open economy. The
domestic rate of inflation, relative to the foreign rate, is assumed to be
positively related to the excess supply of real money balances, and a
negative function of the deviation of domestic prices from their equi­
librium (purchasing power parity) level. Formally, the specification is
written as follows:

\[
\Delta \log P_t = \gamma_1 [\log m_{t-1} - \log m^*_t] \\
- \gamma_2 [\log P_{t-1} - \log (\epsilon_{t-1} \cdot P_{t-1}) - \beta_0] \\
+ \gamma_3 \Delta \log (\epsilon_{t} \cdot P_{t}) + \lambda_1
\]

\(^{12}\)This does not mean that the exchange rate cannot be altered, but only that
it is policy determined. Indeed, an exchange rate change may well be one of the
policy actions included in a stabilization package. It is recognized that a few
developing countries have a floating exchange rate, and that a larger number
follow some variation of a crawling-peg system. The present model explicitly
allows an exchange rate change to affect domestic prices, and it could easily be
extended to a crawling-peg regime.

\(^{13}\)Financial reform policies in recent years in some Latin American and Asian
countries have resulted in a fairly rapid development of domestic capital and
financial markets. See, for example, Mathieson (1979). For such countries, it is
possible that this model would involve some misspecification. However, the
experience of these countries is quite recent and not representative of developing
countries in general.
where

\[ P = \text{domestic price level} \]
\[ \epsilon = \text{exchange rate, in units of domestic currency per unit of foreign currency} \]
\[ P_f = \text{foreign price level} \]
\[ m = \text{stock of real money balances, that is, the nominal stock of money, } M, \text{ deflated by the domestic price level} \]
\[ \lambda_1 = \text{constant (reflecting the steady-state properties of the system).} \]

The superscript \( d \) denotes demand, and \( \Delta \) is a difference operator, so that \( \Delta \log P \) is the domestic rate of inflation, and \( \Delta \log \epsilon \) and \( \Delta \log P_f \) are the proportionate rates of change in the exchange rate and the foreign price level, respectively.

On the simplifying assumption that a country's equilibrium real exchange rate is not changing secularly, \( \beta_0 \) may be taken as a parameter rather than varying over time. If there is no excess demand for real money balances and domestic prices are equal to their equilibrium level \( \beta_0 \), then, with the exchange rate fixed, domestic inflation will be equal to the rate of inflation prevailing in the rest of the world. In other words, domestic price setters always attempt to keep their prices in line with those charged in foreign markets. Divergences from this equilibrium relationship can arise from two sources. First, any expansion of the money stock that results in an excess supply of real money balances will (in the next period) create inflationary pressures that tend to eliminate the disequilibrium in the money market. Second, if domestic prices are pushed away from their equilibrium level, for whatever reason, they will move in the direction that restores the relationship. In a sense, this second term in equation (1) represents a type of "catch-up" effect to any erosion that may occur in a country's international competitiveness. While the preceding interpretation of the inflation equation is somewhat heuristic, it is possible to derive it from a theoretical model involving traded and nontraded goods. This derivation is shown in Appendix II.

Feeding into equation (1) is the stock demand for real money balances.

\[ \text{In the steady state, } \lambda_1 = \gamma_1 \gamma_4 g, \text{ where } \gamma_4 \text{ is the income elasticity of the demand for money and } g \neq 0 \text{ is the rate of growth of capacity output. This ensures that domestic prices are at their equilibrium level relative to foreign prices.} \]

\[ \text{Here, } \beta_0 \text{ represents the equilibrium ratio of domestic prices to prices in the rest of the world. This ratio depends on such factors as domestic and foreign tastes and levels of productivity.} \]

\[ \text{This assumption of } \gamma_3 = 1 \text{ is, of course, one of the main features of the monetary approach to the balance of payments.} \]

\[ \text{For a discussion of the role of this variable in the inflationary process, see Knight and Mathieson (1983).} \]
Here we follow the standard literature in relating money demand to real income \((y)\) and to the expected rate of inflation \((\Pi)\).

\[
\log m_t^d = \beta_1 + \gamma_2 \log y_t - \gamma_3 \Pi_t,
\]

(2)

where both parameters are expected to be positive.

This formulation, which is typically used for developing countries, differs from theoretical models in excluding the rates of interest on other financial assets from affecting money demand. This follows directly from the assumption above regarding the paucity of financial alternatives to money in developing countries. The relevant substitution in such countries is therefore between money and goods, or real assets, with the opportunity cost being the expected rate of inflation.

Substituting equation (2) in equation (1), one obtains

\[
\Delta \log P_t = (\gamma_2 \beta_1 - \gamma_1 \beta_1) + \gamma_1 [\log m_{t-1} - \log y_t + \gamma_3 \Pi_t] \\
- \gamma_2 [\log P_{t-1} - \log e_{t-1} - \log P_{f_{t-1}}] \\
+ \gamma_3 [\Delta \log e_t + \Delta \log P_{f_t}] + \lambda_t.
\]

(3)

**Balance of Payments**

The overall balance of payments, as represented by the proportionate change in the stock of international reserves (in terms of domestic currency), is specified as a positive function of the excess demand for nominal money balances and a negative function of the deviation of the domestic price level from its purchasing power parity equilibrium

\[
\Delta \log R_t - \Delta \log e_t = \gamma_6 [\log M_t^d - \log M_{t-1}] \\
- \gamma_7 [\log P_{t-1} - \log (e_{t-1} \cdot P_{f_{t-1}}) - \beta_0],
\]

(4)

where

- \(R\) = net stock of international reserves, and
- \(M\) = nominal stock of money.

The other variables are defined as before.

In equation (4), variations in the domestic currency value of foreign exchange reserves that are due solely to exchange rate movements are

\[\text{18 See Khan (1980).}\]
\[\text{19 For a survey of money demand functions, see Laidler (1977; 1980).}\]
\[\text{20 Furthermore, because of controls imposed by the authorities, the interest rates that are available show very little variation over time. This makes it difficult to detect empirically any systematic relationship between money holdings and interest rates. For a discussion of the interest rate data that are available for some developing countries, see White (1980).}\]
eliminated by subtracting the percentage change in the exchange rate from the left-hand side of the equation.\footnote{This has to be done because such valuation changes do not affect the domestic money stock or the excess demand for money. If $F$ is the stock of reserves valued in foreign currency, then $R = cF$. It is $\Delta \log F$ that is related to the excess demand for money, and $\Delta \log R = \Delta \log F - \Delta \log c$.} Equation (4) is a dynamic version of models in the tradition of the monetary approach to the balance of payments and, following that literature, it does not distinguish between the current and capital accounts of the balance of payments. It makes no prediction as to whether domestic residents rid themselves of excess money balances by increasing expenditure (that is, absorption) relative to output, or by purchasing financial assets abroad. Laidler and O'Shea (1980) note that even the second term, which says that the balance of payments will deteriorate when domestic prices rise relative to foreign prices, does not reflect current account factors alone, since such a decline in a country's competitive position may induce domestic asset holders to export capital on the expectation that the probability of a future devaluation of the (fixed) exchange rate has increased. Thus, the present treatment of the overall balance of payments in a single equation is consistent with our neglect of domestic financial markets. Furthermore, since many developing countries impose various restrictions on current and capital transactions, it would be difficult to deal empirically with this distinction in a cross-country framework without taking a large number of country-specific factors into account. The balance of payments adjustment equation, therefore, has the virtue of simplicity as well as generality.

Most empirical applications of the monetary approach to the balance of payments assume that the change in a country's international reserves is exactly equal to the difference between the flow demand for money and the flow supply of domestically created money. This standard assumption does not seem very realistic in the context of developing countries, where the degree of international mobility of goods and assets may not be sufficient to allow an excess supply of money to be offset fully and instantaneously by balance of payments leakages. The equation that is specified here for international reserves is consistent with the broad framework of the monetary approach, but it includes a degree of dynamic adjustment as measured by the parameter $\gamma_6$. Thus, it allows for inertia in the response of reserve flows to monetary disequilibrium in the short run, while still retaining the feature that the effect of an expansion in domestic credit on the money stock is completely offset in the long run.
Substituting for the nominal demand for money gives

\[ \Delta \log R_t = \gamma_6[\beta_1 + \gamma_4 \log v_t - \gamma_5 \Pi_t + \log P_t - \log M_{t-1}] - \gamma_7[\log P_{t-1} - \log e_{t-1} - \log P'_{t-1} - \beta_0] + \Delta \log e_t. \]  

(5)

**Government Sector**

Fiscal policy and the government’s budgetary position are modeled explicitly because of the crucial role that they play in the money supply process and in overall economic activity in developing countries. In most cases, excess demand in the economy can be traced back to the deficits of the public sector, and consequently stabilization programs often contain requirements to reduce or eliminate fiscal deficits. The causes of these deficits, and their impact on the economy, are therefore important questions that need to be handled in any analysis where one must make recommendations about desirable changes in domestic credit policy.

The model of the government sector that we utilize is taken from Aghevli and Khan (1978), where it is argued that nominal government expenditure adjusts proportionally to the difference between the authorities’ target spending and the actual level of expenditure in the previous period

\[ \Delta \log G_t = \gamma_8[\log G^*_t - \log G_{t-1}], \]  

(6)

where \( G \) and \( G^* \) are the actual and desired levels of nominal government expenditure, respectively, and \( \gamma_8 \) is the coefficient of adjustment, \( 0 \leq \gamma_8 \leq 1 \). The desired level of expenditure is simply related to the level of nominal income\(^{24}\)

\[ \log G^*_t = \beta_2 + \gamma_9[\log y_t + \log P_t]. \]  

(7)

It is probably reasonable to assume that in the long run the government would wish to increase its expenditure in line with the growth of nominal income, and therefore one would expect a priori that the income elasticity, \( \gamma_9 \), would be equal or close to unity. Such a restriction would normally also be required to ensure that the overall model has a steady-state

\(^{22}\)The demand for nominal money balances is simply \( \log M^d = \log m^d + \log P \).

\(^{23}\)See also Olivera (1967), Dutton (1971), Aghevli and Khan (1977), and Tanzi (1978).

\(^{24}\)The Aghevli-Khan expenditure function is cast in real terms, that is, desired real expenditure is related to the level of real income. In combination with a nominal revenue formulation, this implies asymmetric behavior in the components of the deficit. In the model here, both expenditure and revenues are written in nominal terms.
solution when capacity income and foreign prices, or the exchange rate, are allowed to change over time. This constraint is not imposed on the model during estimation, since there is no reason to suppose that it has held during the sample period across our group of countries.

Substituting equation (7) in equation (6) and solving for the (logarithmic) level of government expenditure, one obtains

\[ \log G_t = \gamma_s \beta_2 + \gamma_s \gamma_f [\log y_t + \log P_t] + (1 - \gamma_s) \log G_{t-1}. \] (8)

As with expenditure, nominal government revenues \( (T) \) adjust to the difference between planned revenues \( (T^*) \) and the actual revenues obtained in the previous period

\[ \Delta \log T_t = \gamma_{10} [\log T^*_t - \log T_{t-1}] \quad 0 \leq \gamma_{10} \leq 1. \] (9)

Desired nominal revenues are specified as a function of nominal income

\[ \log T^*_t = \beta_3 + \gamma_t \log y_t + \log P_t. \] (10)

Substituting from this equation for \( T^* \) in equation (9) gives

\[ \log T_t = \gamma_{10} \beta_3 + \gamma_t \gamma_{10} [\log y_t + \log P_t] + (1 - \gamma_{10}) \log T_{t-1}. \] (11)

**Real Income**

Reflecting the short-term perspective of a stabilization program, this model focuses on determining the deviations of actual output from its full capacity level, rather than on capacity output itself. Since capacity output is treated as exogenous to the model, such factors as capital accumulation, population growth, and technical progress are not considered here. However, because this model distinguishes clearly between capacity output and current output, it would not be difficult to extend it to allow for endogenous capacity growth if a more detailed analysis of the supply side of the economy were desired, for example, in the context of programs designed for purposes of structural adjustment.26

Basically, it is argued that the rate of growth of output is positively related to the excess stock of real money balances, and to the so-called

\[ \text{If government expenditure and revenues both grow at the same rate as nominal income in the long run, then it would imply that } \gamma_s = \gamma_{11} = 1. \] Starting from an equilibrium position, this would ensure a balanced budget in the steady state. In the short run, however, even with the condition being satisfied that the income elasticities equal unity, one could observe a divergence between expenditure and revenues that would result from differences in the values of the adjustment parameters \( \gamma_s \) and \( \gamma_{10} \).

26 See Knight and Wymer (1978) for an example of such a model. In a recent paper, Keller (1980) also examines theoretically the relationship between monetary factors and the supply side of the economy in developing countries.
output gap, represented here by the difference between normal capacity output and actual output of the previous period:  
\[ \Delta \log y_t = \gamma_{12} [\log m_{t-1} - \log m_t] + \gamma_{13} [\log y^*_t - \log y_{t-1}] + \lambda_2, \]  
(12)

where \( \Delta \log y \) is the growth of real income, and \( y^* \) is the normal (or cyclically adjusted) level of output. This latter variable is simply proxied by the trend level of real income, that is,

\[ y^*_t = y^*_0 e^{gt}, \]  
(13)

where \( y^*_0 \) represents the base level, and \( g \) the trend growth rate, of real income.

This formulation, which is very close to that outlined by Laidler and O'Shea (1980), states that any disequilibrium in the money market will result in a temporary expansion of real income, and, of course conversely, any tightening of monetary policy that results in a fall in real money balances will have output consequences through hoarding effects on the level of real expenditure. The degree to which this occurs is measured by the parameter \( \gamma_{12} \). While there are no strong theoretical priors on the

\[ \text{In principle, one would also like to include the effects of changes in fiscal policy and relative prices on the flows of real aggregate demand and output. To determine the direct impact on output of a change in the relation between domestic and foreign prices, the term } -[\log P_t - 1 - \log P_{t-1} - \log P_{t-1} - \beta_n] \text{ was introduced into equation (12), but the estimate of the coefficient was insignificant and had the wrong sign. This result is perhaps unsurprising, given that many developing countries are commodity producers, while the prices included in the model are consumer price indices.}

To catch the stimulative effect of an increase in real government spending on output, \([\log G_t - \log P_{t-1} - \log h_t^*]\) was added to equation (12). The variable \( h_t^* \) was derived from a trend analogous to equation (13) and was taken to be the anticipated level of government spending. This term therefore specifies that an "unanticipated" increase in real government spending will stimulate output. Because it is in percentage deviation form, this particular specification avoids a potential empirical problem arising from the fact that the ratio of government spending to output varies widely across the countries of the pooled sample. However, the coefficient also proved to be insignificant and contrary to its expected sign. This counterintuitive result suggests that the relation between real government spending and the rate of capacity utilization in developing countries is more complicated than standard Keynesian macrotheory suggests. What seems to be needed here is a more intensive investigation of the link between government spending, net investment, and the growth of capacity output; but such an investigation is beyond the scope of the present study. It is important to note, therefore, that the inability to estimate a significant direct impact of fiscal policy on real output means that the conclusions of this model, which follow, are based on the linkage between fiscal policy and the rate of monetary expansion.

\[ \text{In a growing economy where } g \neq 0, \lambda_2 \text{ must be equal to } (1 + \gamma_{12} - \gamma_{13}) g \text{ for current output to increase at the same rate as capacity output in the steady state.}

See Dornbusch (1973), Clements (1980), and Aghevli and Khan (1980).}
size of this parameter, conventional wisdom would probably tend to argue that it would be small. However, this is clearly an empirical question, and one would wish to remain agnostic about the extent to which monetary changes affect real income pending the estimation results.

Equation (12) also hypothesizes that when the actual level of real income is below its normal capacity level, current output will tend to expand. If it were argued that there is a one-for-one relationship between growth and this gap, that is, \( \gamma_{13} = 1 \), then equation (12) would simply say that current real income would deviate from capacity only when there was monetary disequilibrium. In other words, equation (12) could then be written as

\[
\log(y/y^*) = \gamma_{12}[\log m_{t-1} - \log m^d_t] + \gamma_4 \gamma_{12} \delta.
\]

(14)

This constraint was not imposed on the structure, however, and the parameter, \( \gamma_{13} \), was left to be freely determined. Substituting for \( m^d \) in equation (12) gives

\[
\Delta \log y_i = \gamma_{12}[-\beta_1 + \log (m_{i-1} - \gamma_4 \log y + \gamma_5 \Pi)]
+ \gamma_{13} \log y_i^* - \log y_{i-1} + \lambda_2
\]

(15)

or, in terms of the level of real income

\[
(1 + \gamma_{12} \gamma_4) \log y_i = \gamma_{12}[-\beta_1 + \log (m_{i-1} + \gamma_5 \Pi)]
+ \gamma_{13} \log y_i^* + (1 - \gamma_{13}) \log y_{i-1} + \lambda_2.
\]

(16)

**Expected Inflation**

Expectations of inflation, \( \Pi \), are assumed to be generated by the adaptive-expectations model of Cagan (1956), in which these expectations are revised proportionally to the difference between the actual rate of inflation in the previous period and the rate that was expected to prevail in that period

\[
\Delta \Pi_i = \gamma_{14} \Delta \log P_{t-1} - \Pi_{t-1},
\]

(17)

where \( \gamma_{14} \) measures the extent to which the revision of expectations responds to the error, and \( 0 \leq \gamma_{14} \leq 1 \).

This expectations mechanism has certain theoretical problems,\(^{30}\) and does not fit easily into the currently popular rational-expectations framework developed by Sargent and Wallace (1973) and Barro (1977; 1978), among others; but it is still the most commonly used because of its

\(^{30}\) A discussion of some of these is contained in Khan (1977).
inherent simplicity, a property that is of considerable importance given the limited availability of data for developing countries. For this reason, we have also used this approach to modeling expectations.

**Domestic Credit and Money Supply**

Generally speaking, in an open economy the domestic component of the money stock—namely, the net level of domestic credit extended by the banking system—is taken to be the basic monetary tool. However, any model for a developing country must recognize the linkage that exists between government fiscal operations and the supply of money. For this reason, domestic credit is allowed to be determined endogenously in the following manner. Changes in domestic credit ($\Delta DC$) can take place through changes in the banking system's claims on the government ($\Delta CG$) and on the private sector ($\Delta CP$), that is,

$$\Delta DC_t = \Delta CG_t + \Delta CP_t,$$

or,

$$DC_t = \Delta CG_t + \Delta CP_t + DC_{t-1}.$$  

If all changes in claims on the government are a reflection of the fiscal deficit of the government, then equation (19) can be written as

$$DC_t = G_t - T_t + \Delta CP_t + DC_{t-1}.$$  

In this formulation, any expansion of the fiscal deficit results in an equivalent increase in the stock of domestic credit. This implicitly assumes that the government finances its deficit by borrowing from the banking system, using its cash balances held with banks, or by borrowing abroad and converting the proceeds into domestic currency. Only if the government were able to borrow domestically from the nonbank sector—say, by selling bonds or bills—would this identity break down. It is obvious that here the assumption of the lack of a sufficiently developed domestic market for securities, government or otherwise, becomes crucial. Despite recent progress in the development of these markets, the scope for such borrowing is fairly limited in developing countries, thereby confirming the appropriateness of definition (20).

The supply of money—broadly defined to include currency, demand deposits, and time and savings deposits—is identically equal to the net stock of international reserves (in domestic currency terms) and the level of net domestic credit extended by the banking system

$$M_t = R_t + DC_t.$$
Complete Model

The full structural model, along with definitions of the relevant variables, is shown in Table 1. Generally speaking, in this model it is expected that a once-and-for-all expansion in domestic credit will, through increasing the nominal supply of money, simultaneously raise the rate of inflation and real income and worsen the balance of payments. Both the increase in domestic prices and the leakage through the balance of payments will tend to lower the real stock of money, thereby reversing the process. Because of the rise in real income, real demand for money will also rise and thus support the movement of the system toward equilibrium. Eventually, if the system is stable, long-run domestic inflation will be equal to foreign inflation, and the level of real income will be determined by capacity output. The relative sizes of the various effects, and the lags in adjustment involved, obviously depend on the particular values of the parameters in the system.

II. Estimation Results

The model described in the previous section was estimated using a pooled sample of time-series cross-sectional data for 29 developing countries. For each country, eight annual observations were obtained on the relevant variables. While allowance was made for country differences arising from, say, size, etc., through the use of country dummies, the estimation procedure basically assumes that behavioral parameters are the same across countries. Since the same money demand parameters appear in three different equations, the criterion of efficient estimation requires the imposition of appropriate across-equation restrictions. This is accomplished by employing a full-information maximum-likelihood...
Table 1. Specification of the Model

**Inflation**
\[ \Delta \log P_t = (\gamma_3 \beta_3 - \gamma_1 \beta_1) + \gamma_1 \log m_{t-1} + \gamma_1 \Pi_t + \gamma_1 (\Delta \log e_t + \Delta \log P_{t-1}) + \lambda_1 \]

**Balance of Payments**
\[ \Delta \log R_t = \gamma_4 [\beta_4 + \gamma_4 \log y_t - \gamma_1 \Pi_t - \log M_{t-1} + \log P_t] + \gamma_1 [\log P_{t-1} - \log (e_{t-1} \cdot P_{t-1}) - \beta_2] + \Delta \log e_t \]

**Government Sector**

**Expenditure**
\[ \log G_t = \gamma_8 \beta_2 + \gamma_8 \gamma_4 [\log y_t + \log P_t] + \gamma_8 (1 - \gamma_8) \log G_{t-1} \]

**Revenues**
\[ \log T_t = \gamma_1 \beta_3 + \gamma_1 \gamma_4 [\log y_t + \log P_t] + \gamma_1 (1 - \gamma_1) \log T_{t-1} \]

**Real Income**
\[ (1 + \gamma_3 \gamma_4) \log y_t = \gamma_3 [-\beta_3 + \log m_{t-1} + \gamma_3 \Pi_t] + \gamma_3 \log y^*_t + (1 - \gamma_3) \log y_{t-1} + \lambda_3 \]

**Expected Inflation**
\[ \Delta \Pi_t = \gamma_4 (\Delta \log P_{t-1} - \Pi_{t-1}) \]

**Domestic Credit**
\[ DC_t = G_t - T_t + \Delta CP_t + DC_{t-1} \]

**Money Supply**
\[ M_t = R_t + DC_t \]

**Real Money Balances**
\[ m_t = M_t / P_t \]

**Definition of Variables**

**Endogenous**
- \( \Delta \log P \) = rate of inflation
- \( \Delta \log R \) = growth of international reserves
- \( G \) = nominal government expenditure
- \( T \) = nominal government revenues
- \( y \) = real income
- \( \Pi \) = expected rate of inflation
- \( DC \) = domestic credit of the consolidated banking system
- \( M \) = nominal stock of money
- \( m \) = real money balances

**Exogenous**
- \( \epsilon \) = exchange rate, index of units of domestic currency per unit of foreign currency
- \( P_t \) = foreign price index
- \( y^* \) = trend value of real income
- \( \Delta CP \) = change in net claims of the banking system on the domestic private sector, and other items (net) in the banks’ consolidated balance sheet
(FIML) estimator that allows nonlinear constraints to be placed on parameters both within and across equations.34

The FIML estimation method that is used does, however, require that the model be linear in (the logarithms of) the variables, while the model as specified is nonlinear, owing to the identities defining domestic credit and the nominal supply of money. For estimation purposes, and for analyzing questions of the dynamic stability of the model, these two identities have been approximated by relationships that are linear in the logarithms of the variables. For domestic credit, the equation used is

\[ \log DC_t = \gamma_{15}\log G_t - \gamma_{16}\log T_t + \gamma_{17}\log \Delta CP_t + \gamma_{18}\log DC_{t-1} + \beta_4 \]  

(22)

and for the money supply35

\[ \gamma_{19}\log M_t = \log M_{t-1} + \gamma_{20}[\log \epsilon_t + \log R_t] - \gamma_{21}[\log \epsilon_{t-1} + \log R_{t-1}] + \gamma_{22}\log DC_t - \gamma_{23}\log DC_{t-1} + \beta_5. \]  

(23)

The method of linearization that yields equations (22) and (23), and the calculated values for the constants of linearization—namely, \( \gamma_{15} \) to \( \gamma_{23} \)—are shown in Appendix III.

After introducing equations (22) and (23) into the model and adding the individual country dummies in each of the equations,36 the complete model was estimated by the FIML method. The data used are described in Appendix I, and the results are presented in Table 2.37 This table shows the point estimates of the individual behavioral parameters (excluding, for convenience, the estimated coefficients of the dummy variables) and the ratios of the coefficients to their respective standard errors.38 The

34The computer program employed to calculate the estimates is entitled RESIMUL and was written by Clifford R. Wymer.
35This approximation method automatically adjusts the domestic currency value of international reserves to offset the valuation effects of exchange rate changes. See Appendix III.
36Because of the presence of these dummies, equations (22) and (23) were treated as stochastic, although with the values for \( \gamma_{15} \) to \( \gamma_{23} \) from the linearization imposed. This effectively leaves the identity for real money balances as the sole nonstochastic equation.
37Since none of the countries in our sample have freely floating exchange rates, \( \Delta \log e \) is generally zero, and this variable was omitted from equation (1) during estimation. Since \( \log e_{t-1} \) is present in the term multiplied by \( \gamma_2 \), however, devaluations or revaluations can still affect the domestic price level via this term.
38These are denoted as “t-values,” even though, strictly speaking, this ratio has an asymptotic normal distribution. Hypothesis testing would thus have to be based on the normal distribution rather than the t-distribution. In this case, with a sample size of 232 observations, however, there is obviously no distinction.
### Table 2. Parameter Estimates

<table>
<thead>
<tr>
<th></th>
<th>Parameter</th>
<th>Point Estimate</th>
<th>T-Value</th>
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<tbody>
<tr>
<td><strong>Inflation</strong></td>
<td></td>
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<tr>
<td>Adjustment</td>
<td>$\gamma_1$</td>
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<tr>
<td></td>
<td>$\gamma_2$</td>
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<td></td>
<td>$\gamma_3$</td>
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<td>Income</td>
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<tr>
<td>$\sigma^2 = 0.841$</td>
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<tr>
<td>MSE</td>
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<td><strong>Balance of Payments</strong></td>
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</tr>
<tr>
<td>Adjustment</td>
<td>$\gamma_6$</td>
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<td></td>
<td>$\gamma_7$</td>
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<td>$\gamma_6 \beta_1 + \gamma_7 \beta_0$</td>
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<td>$\sigma^2 = 5.948$</td>
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<td>MSE</td>
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<td><strong>Government Sector</strong></td>
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<td>Expenditure</td>
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<td>Income elasticity</td>
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<tr>
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<tr>
<td>$\sigma^2 = 5.289$</td>
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<td>MSE</td>
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<tr>
<td>Revenues</td>
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<td>Income elasticity</td>
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<td>MSE</td>
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<tr>
<td>Output</td>
<td>$\gamma_{12}$</td>
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<td>2.98</td>
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<tr>
<td></td>
<td>$\gamma_{13}$</td>
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<td>13.46</td>
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<td>Constant</td>
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<td>$\sigma^2 = 5.757$</td>
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<td>MSE</td>
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<tr>
<td>Expected Inflation</td>
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<tr>
<td>Adjustment</td>
<td>$\gamma_{14}$</td>
<td>1.01</td>
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<tr>
<td>Domestic Credit</td>
<td>$\gamma_{15}$</td>
<td>1.236</td>
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<tr>
<td></td>
<td>$\gamma_{16}$</td>
<td>1.036</td>
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<tr>
<td></td>
<td>$\gamma_{17}$</td>
<td>0.162</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>$\gamma_{18}$</td>
<td>0.805</td>
<td>—</td>
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<tr>
<td>Constant</td>
<td>$\beta_4$</td>
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<td>7.03</td>
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<tr>
<td>$\sigma^2 = 9.323$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>MSE</td>
<td>1.724</td>
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</table>
constant terms in each equation were not constrained, and are thus reported in their composite forms. To give some general idea of the goodness of fit of each of the equations, the respective mean-square errors (MSE) and the corresponding variances of the dependent variables ($\sigma^2$) are presented. Such a heuristic comparison turns out to be necessary, since it is well known that more standard measures of goodness of fit of individual equations, such as the coefficient of determination and the standard error of estimate, do not have any formal meaning in the framework of systems estimation methods.\(^39\)

As theoretically expected, the results indicate that an excess supply of real money balances results in an increase in the rate of inflation. The parameter measuring this effect has a positive sign and is significantly different from zero at the 1 percent level. The money demand function embedded in this equation, which is restricted to have the same parameter values in the balance of payments and output equations, appears to be reasonably well determined. The equilibrium income elasticity, $\gamma_4$, is significantly greater than unity and close to the value that is generally obtained for developing countries.\(^40\) In financially developed economies, one might expect to observe a roughly proportional relationship between real money balances and real income,\(^41\) but in developing countries the

\(^39\)In simultaneous estimation, the $R^2$ is bounded ($-\infty$, 1) and not bounded (0, 1). See Basmann (1962).

\(^40\)See, for example, the results reported by Aghevli and others (1979) and Khan (1980).

\(^41\)The existence of a wide variety of close financial substitutes for money in those countries also allows for economies of scale in holding money, thereby giving rise to the possibility that the income elasticity may be less than unity. See Laidler (1977).
demand for cash balances often rises more than proportionately to the growth in income, owing to the secular process of monetization and the absence of alternative liquid financial assets in which private savings may be held.

The semielasticity of real money balances with respect to the expected rate of inflation has the correct sign and is significantly different from zero at the 1 percent level. The size of this parameter is also well within the range that has been observed in estimates for developing countries.\(^{42}\) In generating the series on expected inflation, \(\gamma_{14}\), the coefficient of expectation, \(\gamma_{14}\), was arbitrarily constrained to be unity. This was done mainly on grounds of simplicity, since allowing it to vary would have greatly complicated the estimation model.\(^{43}\) Furthermore, ordinary least-squares tests on the pooled sample using the money demand equation in Appendix V revealed that the value of \(\gamma_{14}\) that maximized the log-likelihood function was indeed unity. In the light of this result, our restriction on \(\gamma_{14}\) (which implies that full adjustment occurs within a year) would certainly seem to be reasonable.

If the domestic price level is pushed above its equilibrium relationship to foreign prices, pressures are built up that force the domestic rate of inflation down. This is captured by the parameter \(\gamma_{2}\), which turns out to be statistically significant at the 1 percent level. Since our theoretical analysis suggested that the parameter \(\gamma_{3}\) should take on a value of unity, this restriction has been imposed for efficiency of estimation. It should be remembered then that this model explains the deviations of domestic inflation from the foreign rate of inflation.

Unlike the equilibrium model emerging from the analysis associated with the monetary approach to the balance of payments, which assumes that international reserve flows will immediately offset any excess supply of money, this dynamic model assumes that some inertia exists in this relationship. The empirical results indicate that only about one half of the excess supply is reflected in reserve variations. As mentioned in Section I, the parameter \(\gamma_{6}\) is a mixture of the impacts of monetary changes on both the current and capital accounts, and its observed sign is consistent with either of these two channels. From the results, it appears that if the domestic price level deviates from the foreign price level, international

\(^{42}\) Khan’s (1980) estimates for 11 developing countries tend to cluster around a value of two, using quarterly data.

\(^{43}\) It would have made it more nonlinear in parameters. The alternative of searching for \(\gamma_{14}\), since it is bounded \((0, 1)\), would have been fairly time consuming. The estimation model has 208 parameters (including those of the country dummies) and 232 observations, so that even a single FIML estimate takes a considerable amount of computer time.
reserve flows will be generated and this elasticity is significant at the 5 percent level.

The nominal income elasticities of both government expenditure and revenues are close to unity and are highly significant. The specific values imply that in the steady state one would expect that government expenditure would move proportionally with inflation. On the other hand, it appears that revenues would tend to rise somewhat faster.44

While the major determinant of changes in real income is the difference between capacity real income and the actual level, monetary disequilibrium is a factor as well. The elasticity measuring the impact of the excess demand for real money balances on the growth rate, \( \gamma_{12} \), is significantly different from zero at the 1 percent level. This is one of the more important results to emerge from this exercise, both because it has not been investigated extensively in the context of developing countries and because of its important implications for stabilization programs.45

It also turns out that real income will consistently tend toward its capacity level, with any discrepancy between capacity real income and actual real income (of the previous period) being eliminated fairly rapidly.46 The coefficient of adjustment, \( \gamma_{13} \), is fairly large, although not quite unity,47 implying that deviations from capacity real income could apparently persist for only a short period if there were no excess demand for money.

The output effect of changes in the money supply allows real money balances to rise initially, or the income velocity to fall, when there is an increase in the rate of monetary growth, since this would raise money demand itself. This situation makes the results of the present model consistent with those emerging from the model proposed by Khan (1980), where this phenomenon is investigated at length. Finally, it should be

44 The elasticity is significantly greater than unity, which would mean that government revenues rise secularly as a proportion of nominal income. Of course, since the revenue data have not been adjusted for discretionary tax changes, the elasticity could be biased upward.

45 This result can be shown to be similar to that emerging from models of the rational expectations variety, where only unanticipated monetary changes affect output. For a discussion of the relationship between the specification in this paper and the models of Sargent and Wallace (1973) and Barro (1977; 1978), see Clements and Jonson (1979).

46 The equation can be interpreted in a partial-adjustment framework where the rate of growth of real income responds proportionally to the difference between suppliers' "desired" level of real output, as represented by the capacity level, and actual real output of the previous period. In this case, the parameter \( \gamma_{13} \) would represent the coefficient of adjustment, with the expression \( 1/\gamma_{13} \) measuring the average time lag.

47 A value of unity would mean that in the absence of any monetary disequilibrium, real income would always be at its trend value.
noted that certain alternative specifications for real income, such as the introduction of relative prices into the equation, were fruitless.48 The coefficient of the ratio of domestic to foreign prices was not significant even in a sample as large as this one.49 The simple model utilized here does reasonably well in explaining movements in real income.

Methods of testing the overall goodness of fit of structural models in any rigorous way are still in their infancy. One statistic that is customarily used, namely, the Carter-Nagar R², was 0.998, indicating the reasonableness of the overall specification. For the individual equations, the task of assessing goodness of fit is equally difficult, although a rough idea can be obtained by examining the mean-square errors relative to the variance of the dependent variable.50 All seven of the stochastic equations seem to be well specified on this criterion.51 This result was achieved without any recourse to special dummy variables other than the country dummies required by the pooled time-series cross-sectional estimation procedure.

Given that the model is dynamic and involves several feedbacks, it is also important to determine if the estimated parameters combine to yield a stable model.52 For this reason, the eigensystem of the estimated model was calculated. All the moduli, which are shown in Appendix IV, are less than unity, and therefore the estimated model can be considered dynamically stable. A related question is that of the sensitivity of the overall stability of the model to the particular values of the estimated parameters. This is a consideration in any theoretical analysis because it helps to identify the key parameters in the system. In the context of this model, the analysis can be made by evaluating the derivatives of the calculated moduli with respect to the relevant parameters.53 Three parameters are particularly crucial for the stability properties of the model. First, a small increase in the impact of excess real money balances

---

48 Such a model could be derived by relating domestic expenditure to the excess demand for real balances and utilizing the national income identity. See Laidler and O'Shea (1980).

49 This result is consistent with the well-known empirical observation that the elasticities of export supply and import demand differ widely from one developing country to another. Furthermore, the inclusion of this variable affected other parameters in the system. For these reasons, the current specification was chosen.

50 The expression \[1 - \frac{MSE}{\sigma^2}\] is bounded from above at unity and may be treated, heuristically, like an R².

51 While the coefficients in the domestic credit and money supply equations were imposed by the linearization procedure, as mentioned earlier, these equations were actually treated as stochastic in the estimation.

52 Even though the theoretical model can be considered linear in logarithms, the size of the matrix of endogenous variables makes it impossible to evaluate the stability of the model analytically. It is thus necessary to determine stability through numerical means.

53 See Appendix IV.
on the rate of inflation would raise one of the moduli above unity. Second, the stability of the system is apparently sensitive to both parameters in the output equation. This finding supports the earlier claim that the feedback running from real money balances to growth is very important to the dynamic behavior of the system.

III. Policy Implications of the Model

The estimated model of the previous section is now used to illustrate some policy issues that arise in connection with the implementation of a stabilization program designed to improve a country's external payments position. For this purpose, it is assumed that the estimated model can be taken to reflect the dynamic behavior of a "representative" developing country. This is, of course, a rather strong assumption, but it can be justified on two counts. First, since the parameters of the model were estimated from a pooled sample of observations drawn from 29 developing countries, the estimates represent in a sense the average parameter values for this sample as a whole. Second, the purpose is not to describe the specific behavior of a particular country, but rather to investigate the general path that might be followed by major economic aggregates in different circumstances. To illustrate the dynamic behavior, it is first shown how the model responds to two types of shock: a one-period increase in domestic credit, and a permanent increase in the level of capacity output.\(^{54}\) In each case, domestic prices are initially in equilibrium at given levels for the exchange rate and foreign prices. Output and employment begin at the capacity level; the government budget is in balance; and domestic credit, international reserves, and the nominal money stock are all constant. Then the focus shifts to the paths taken by these variables in response to each exogenous change. After the effects of these shocks are examined, the model is used to analyze the implications of two different types of financial program for a country's inflation rate, output and employment, and domestic credit. For purposes of the simulations, the model is no longer required to be linear in variables, and therefore its original nonlinear form is restored in order to conduct the various experiments reported in this section. This way the results are more useful, in the sense that they are taken directly from the type of (nonlinear) model that policymakers would presumably be considering. Also, in this case one can be certain that none of the simulation results are attributable to the linearization procedure employed in estimation.

\(^{54}\) The effect of a change in the relative price of domestic versus foreign goods (for example, an oil-price shock) could also be simulated by changing the level of \(\beta_0\), but that experiment is somewhat tangential to the present paper.
First, consider the effects of a one-period exogenous shock to domestic credit that causes a rise of 10 percent in the nominal money stock in the first year. This is accomplished by adding a stochastic component, $Z$, to the identity relating the rate of domestic credit expansion to the government's budgetary deficit. The $Z$ variable shocks the system for one period, after which the government spending and tax functions again determine the evolution of the budgetary deficit or surplus. In the sample used in this paper, domestic credit makes up, on average, about 75 percent of the money stock, while the remainder is backed by international reserves. Thus, $Z$ must create an increase of about 13.3 percent in domestic credit to raise the money stock by 10 percent at the end of the first period.

The lines in Charts 1 and 2 trace the effects of the one-period monetary shock on the endogenous variables of the model. The path of prices is also compared with that of a simple closed-economy monetary model in which real income is treated as exogenous, and thus the price level is the only endogenous variable. Despite the fact that both models are estimated using the same sample of data, Chart 1 shows that the dynamic path of prices in the open-economy system is quite different from that generated by the naïve model. In the closed-economy model, the price level will eventually rise by 10 percent in response to a once-for-all increase in the nominal money stock. In this case, prices rise by almost the same percentage as the monetary expansion in the first period, but then they overshoot the new equilibrium level as the increased opportunity cost of holding money reduces the demand for real balances at constant income. After rising by nearly 12 percent, the price level gradually tracks back to 10 percent above its initial level, with most of the adjustment completed in five years. By contrast, in the expanded approach, the monetary expansion initially stimulates both prices and real

55 As already noted, the fact that no direct effect of government spending on real output could be detected empirically means that only the monetary effects of changes in fiscal policy are taken into account in the model. In these circumstances, it makes no difference whether the present stochastic shock initially hits domestic credit, government spending, or taxes, since the time path traced by the model will be the same in all cases.

56 The model is constructed in such a way that the reserve leakages associated with the balance of payments deficit begin in the period after the monetary expansion that induces it. Thus, the monetary shock is assumed to take place right at the end of period one, and the reserve leakages start from the beginning of period two. Since no leakages occur during the first period, the money stock initially rises by the full extent of the increase in domestic credit.

57 The simple model assumes that a partial-adjustment process determines holdings of real money balances and imposes the same restrictions on the expectations mechanism as the model in the paper. The reduced form of the simple model was estimated for the pooled sample by the ordinary least-squares method. For details, see Appendix V.
Chart 1. Effects of a Monetary Expansion of 10 Percent on Money, Prices, and Output
(As percentage of initial value)

Chart 2. Effects of a Monetary Expansion of 10 Percent on International Reserves and Domestic Credit
(In percent)
output and employment. As in the previous case, the price level at first rises quite strongly in response to the excess supply of money. However, the fact that domestic prices are increasing relative to foreign prices soon induces price setters to moderate the domestic inflation rate, and at the same time the induced outflow of international reserves causes the money supply gradually to fall back toward its preshock level. Four years after the monetary expansion, domestic prices reach a maximum that is about 5.5 percent above their long-run equilibrium value and then begin to track back—at first quickly, but then more and more slowly—to equilibrium, as the cumulative effects of continuing payments deficits bring the money stock back toward its initial level. Nevertheless, in the model the inflation of domestic prices induced by the monetary expansion keeps the home country's exchange rate overvalued for quite a long time. Eight years after the expansion, the price level is still about 2.5 percent above its final equilibrium.

After the initial expansion, the government's budgetary position plays only a minor role in the evolution of domestic credit and the money stock. A small fiscal surplus is created as nominal income rises, because the response of tax revenue is slightly larger than that of nominal government spending; this surplus disappears as prices and output fall back to their initial levels. These effects are small because the parameters (γᵦγᵦ) that govern the short-run response of nominal government spending are estimated from the sample to be only slightly smaller than those that govern short-run changes in tax revenue (γ₁₀γ₁₁). However, the dynamic path of prices is quite sensitive to the values of these parameters. Since the government has the power to alter taxing and spending policies at will, it would undoubtedly be interesting to analyze the consequences of different types of budgetary policy in the model in more detail, although this is not done here.

While the simple model explicitly assumes that a monetary expansion leaves real output unchanged, the expanded model allows it to stimulate output in the short run. In percentage terms, the output effect of expansionary monetary policy is much smaller than its price effect. Output rises by about ½ of 1 percent in the second year after the monetary expansion, before slowly declining to its equilibrium level. Nevertheless, the stimulative effect of money on real output may not seem so small when it is recalled that this represents overemployment—that is, output is sustained for several periods at nearly ½ of 1 percent above its normal capacity level. If one is prepared to assume that the ratio of labor input to total output is reasonably stable, then the expanded model implies that

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58 The short-run responses to a change in nominal income are estimated from the sample as γᵦγᵦ = 0.775 for nominal government expenditure, and γ₁₀γ₁₁ = 0.837 for tax revenue.
a monetary expansion will temporarily increase employment of the labor force, and this employment effect will persist for several years. Conversely, if real money balances were lowered by 10 percent, this decline would have undesirable consequences for employment. While it certainly could be argued that the rise in unemployment would be fairly small, it should be kept in mind that in the typical developing country the impact falls disproportionately on certain sectors of the economy. The agricultural and rural sectors, since they are less reliant on credit, may not suffer as much from a restrictionary monetary policy, and often it is the fledgling manufacturing, services, and export sectors that bear the brunt. Thus, a small rise in overall unemployment may well mean an undesirable increase in urban unemployment, with all its attendant social and political ramifications.

Chart 2 traces the effect of the shock on international reserves and domestic credit. After the shock, reserves decline continuously until they approach a new equilibrium at about 68 percent of their initial level. As a result, domestic credit increases from just under 75 percent of the money stock to about 83 percent. In the new equilibrium, the expanded model yields the standard conclusion of the literature on the monetary approach to the balance of payments, namely, that an increase in domestic credit will ultimately lead to an equal reduction in international reserves and leave output, prices, and the nominal money stock unchanged. However, the adjustment path of this model is richer than the simple model in the sense that it allows a monetary disturbance to affect output, employment, and prices during the adjustment process. Furthermore, the simulation experiment using the parameters actually estimated for the sample of 29 developing countries suggests that even a one-period shock expansion of domestic credit can induce disequilibrium price effects that cause the country's currency to be overvalued for a substantial period, a result that seems to correspond to the experience of a number of developing countries.

Next, the effect of a once-for-all increase of 10 percent in the level of capacity output is considered. This increase might be due to such factors as technical innovation or growth in the labor force. Charts 3 and 4 present the effects of such a change. Again, the price effect in the closed-economy model is compared with the price path traced by the open-economy model with endogenous output and money stock. To ensure that the government budget will be in balance at the new higher level of real income, the income elasticity of tax revenue is arbitrarily set equal to that of government spending and the constant term in the tax function is adjusted so that this property holds. In the simple model, an increase of 10 percent in output would cause prices to decline steadily until they
Chart 3. Effects of an Increase of 10 Percent in Capacity Output
(As percentage of initial value)

Chart 4. Effects of an Increase of 10 Percent in Capacity Output
on International Reserves and Domestic Credit
(In percent)
were about 11 percent below their starting level, a direct consequence of the fact that the income elasticity of money demand is estimated to be about 1.18 for the sample. In the expanded model, current real output and employment begin to rise quite rapidly after the jump in capacity output (output has risen by nearly 9 percent by the end of the second year). The domestic price level at first falls sharply relative to prices abroad, declining by about 5½ percent (compared with its initial value) in the first two years. The excess demand for money, however, creates a balance of payments surplus that increases the money stock, so that gradually the price level turns around and there is a period of both rising prices and rising output that continues until current output has increased by 10 percent and domestic prices have risen to their initial level. In the final equilibrium, international reserves have risen by approximately 60 percent above their initial value (Chart 4), so that the proportion of the money stock that is backed by domestic credit declines from 75 percent to 62 percent.

Government financing plays no more than a negligible role in the subsequent movements of domestic credit, owing to the assumption that $\gamma_9 = \gamma_{11}$. Again, the final equilibrium is consistent with the conclusions of the monetary approach to the balance of payments. But here the adjustment process involves a rapid increase in actual output toward the capacity level, steady accumulation of international reserves, and a price level that first declines and then gradually returns to its initial equilibrium.

The results of a related simulation may also be summarized briefly. Suppose that there is a once-for-all rise in the rate of growth of capacity output, $g$, to 1 percent per period. The simulated time paths of most endogenous variables are broadly similar to those in the previous experiment. The only major difference is that because $\lambda_2$ is nonzero after the increase in $g$, actual output grows immediately at the same rate as capacity output without the catch-up that was apparent in the earlier simulation. Again, prices at first fall below their initial level as rising output pushes up the demand for real money balances. Output growth also induces a small budget surplus because, given the estimated parameters of the model, growth causes government revenue to rise slightly faster than expenditure. But this mild contractionary influence on domestic credit is more than offset by an overall payments surplus that induces an inflow of reserves at a rate that rises to a maximum of about 5 percent a year before gradually declining again. In the present simulation this adjustment occurs much more gradually than it did for the one-shot

\[ \lambda_1 = \gamma_1 \gamma_4 g \text{ and } \lambda_2 = (1 + \gamma_4 \gamma_{12} - \gamma_{13}) g. \]
increase in capacity output illustrated in Charts 3 and 4. Thus, after falling by about 7 percent by the twenty-fourth period after growth begins, prices start to rise toward their initial level, as international reserve accruals increase the rate of monetary expansion.

The simulations involving shocks to the level of capacity output and its rate of growth are both consistent with another frequently observed phenomenon that most models cannot explain: namely, that fast-growing developing countries frequently turn in balance of payments surpluses, even during years when domestic prices appear to be rising more rapidly than prices in the rest of the world. The results here are also consistent with an important converse proposition that has recently been emphasized by proponents of the “new” supply-side approach to macroeconomics. It is that government policies that adversely affect the rate of growth of capacity output may eventually give rise to a situation where the economy suffers from a protracted period of exchange rate overvaluation and balance of payments deficits. This proposition underscores the potential importance of policies that enhance the rate of growth of capacity supply in the design of economic stabilization programs for developing countries.

Having studied the effects of these exogenous shocks, we now make use of the extended model to analyze an important issue that frequently arises in the setting up of a stabilization program. Suppose that the authorities of a country wish to achieve some specific targeted improvement in the country’s external payments position—say, an increase of 50 percent in official holdings of international reserves. Suppose, too, that the authorities have the option of choosing between a “standard” program, in which the targeted increase is to be achieved in one year, and an “extended” program, in which the rise is spread over five years. Two questions now arise. First, given the estimated dynamic structure of our “representative” developing country, what are the annual domestic credit ceilings needed for success in achieving the balance of payments improvement that is targeted in the program and, given the revenue function, what is the size of the cut in government spending that would be required to attain these ceilings? This question is a particular instance of the “targets and instruments” approach to the theory of economic policy. In this case, the targeted improvement in the country’s external payments position is taken as given, and the structure of the model is allowed to determine both the setting of the policy instrument (domestic

60The analysis could also be cast in terms of a flow target: namely, a desired balance of payments position, or target reserves-to-imports ratio. While making the simulations somewhat different, the results should be qualitatively similar to the experiment performed here.
credit) required to hit the reserves target and the consequences for other important economic variables, such as output, employment, and prices.\footnote{61} This leads to the second question: Which of the two programs—standard or extended—is likely to have fewer undesirable effects on domestic prices, output, and employment? In particular, given some appropriate social rate of discount, which program involves the smallest total output and employment losses over its lifetime?

In Chart 5, the solid line is the target path for reserves in the standard program while the dashed line is the target path of reserves in the extended program. The dotted line and the dash-and-dot line give the corresponding settings of domestic credit that are required to achieve the targeted result within the time frame of each program. Several important implications of the expanded model are immediately evident from Chart 5. First, one might have expected that a one-step increase in reserves could be achieved via a similar reduction in domestic credit, after which the credit ceiling could be lifted. But the simulation results in Chart 5

\footnote{61 For this analysis, the target level of international reserves is taken as exogenous; this means that one equation must be eliminated from the model. We have chosen to drop the government-spending equation, so that the level of public expenditure in nominal terms is now determined by the domestic credit identity.}
show that this intuitive conclusion is not correct. To achieve a steady improvement in the economy's external position, it is necessary to have a fluctuating path of domestic credit in both cases, rather than steady restraint.\(^{62}\) While improvement in the external position requires domestic credit restriction in the first year of each program, the credit ceiling has to be raised again in the second year. This increase in domestic credit is quite small for the extended program but rather large for the standard program—a point that is discussed later. The main point, however, is that because the private sector's observed behavior is characterized by lagged adjustment, steady improvement in a country's balance of payments cannot, in general, be achieved through imposing a domestic credit ceiling that is fixed over time.\(^{63}\)

A second and more general conclusion from Chart 5 is that the one-year program requires changes in the setting of domestic credit that are much larger than those in the five-year program, and these oscillations have to continue for several years after the reserve improvement has been obtained, in order to hold international reserves steady at their new level. Specifically, given the assumption about price expectations, the standard program requires first an extremely large reduction in domestic credit, then a subsequent expansion to 180 percent of the initial level, and then a second rather severe contraction. By contrast, the extended program involves much less severe credit restraint, but one that continues, at varying levels, for the full five years. Chart 6 gives the budget surplus \((+)\) or deficit \((-)\) as a proportion of full employment nominal income. Again, the overall fiscal position of the government is seen to fluctuate much more in the standard program than in the extended one.

Having considered the setting of the government's policy instruments, the discussion now turns to the effects of each program on the other important variables in the domestic economy. Chart 7 gives the price effects of the two financial programs, while Chart 8 indicates their respective output effects. The standard program induces a severe price deflation in the first year, followed by a sharp inflation that gradually tails off after two or three years, as domestic prices return to their initial equilibrium level relative to prices in the rest of the world. By contrast, the five-year program displays a prolonged but much shallower dip in domestic prices. It is even more interesting to compare the output effects of the two programs given in Chart 8. If one again assumes that the labor-to-output

\(^{62}\) It is certainly possible that with a target that is defined in flow terms, the pattern for domestic credit would be quite different. This possibility should be kept in mind when examining the present simulations.

\(^{63}\) The fluctuating pattern is essentially the consequence of the built-in inertia in the model. We are indebted to Michael Mussa for pointing this out.
Chart 6. Budget Surplus as a Percentage of Full Employment Nominal Income
(In percent)

Chart 7. Prices as a Percentage of Their Equilibrium Level
(In percent)
ratio is relatively fixed in the short run, this chart can also be interpreted as a comparison of the employment effects of each program. In the one-year program, unemployment rises by 5 percentage points during the first year and falls abruptly in the second year. The next two years are characterized by relatively rapid inflation and slightly overfull employment, which dissipates in the fifth year. On the other hand, the extended program is initially characterized by a relatively mild increase of about 1 percent in the unemployment rate, and this gradually declines to zero over the next four years, rising briefly above full employment in the year after the targeted increase in international reserves has been completed.

In comparing the employment costs of the two programs, it is relevant to note that the area between the employment line and the full employment line for the standard program is much larger than the corresponding area for the extended program. This implies that if one takes a social rate of discount of zero and treats both underemployment and overemployment as equally “bad,” the employment costs of the standard program are considerably larger than those of the extended program.64 If unem-

64The costs of underemployment are universally acknowledged, but overemployment may also cause serious externalities in a developing economy, especially when it is concentrated in the industrial sector. Even if job prospects in this sector are only temporary, overemployment may induce a significant increase in migration to the cities, exacerbating urban problems and stretching public services beyond capacity.
ployment alone is taken as “bad” (the areas under the full employment line), the employment cost of the standard program is still larger than that of the extended program, and this discrepancy is larger the higher is the authorities’ rate of time preference.\textsuperscript{65} It may be concluded that, given the expanded model, the employment costs of a standard one-year program are unambiguously larger than those of an extended program, so that on this criterion the latter is to be preferred.

It is, of course, important to avoid drawing excessively general conclusions from the simulation analysis. In the first place, these results apply only to the “average” member of the sample of developing countries. The structural model might have to be modified in significant ways not only for countries excluded from this sample but also to take account of the special characteristics of each of the 29 included countries.

A second and more important factor that qualifies these results is the limited treatment of the behavior of expectations in the simulation model. While the adaptive mechanism that generates expectations of inflation seems to be empirically reasonable for the present sample of countries, many alternative assumptions are possible about the way in which market participants form their expectations about future price developments. To take just one example, it would be interesting to study the behavior of the model in conditions where expectations of inflation are based on current and past rates of monetary expansion.

Another aspect of the simulation analysis that needs qualification for real-world applications is the assumption that price expectations—and the mechanism that generates these expectations—are unaffected by the setting up of a stabilization program. Anyone who has been involved in the formulation of a financial program is aware that expectations of future price movements may be strongly affected by the announcement and implementation of the policy measures. For example, in a high-inflation country, price expectations may shift downward immediately when a financial program is announced. This sudden reduction in the anticipated inflation rate reduces the perceived opportunity cost of holding cash balances, increasing nominal money demand at the initial level of income and prices. Such an effect is, by its very nature, exceedingly difficult to quantify. Nevertheless, if the private sector becomes convinced that the program will succeed, the reduction in domestic credit required to achieve the targeted improvement in the country’s external position is smaller than would have been required if price expectations had been

\textsuperscript{65} In principle, a benevolent government that was certain to retain office forever would apply a social discount rate of zero. Obviously, most real-world governments can be presumed to have a shorter time horizon, so that they regard immediate employment losses as more costly than future losses.
unaffected by the announcement of the program. This reflects the familiar observation that if a program is widely viewed as stringent enough to achieve its objective, its domestic credit ceilings can be less deflationary than they would have had to be if the program was not regarded as credible.

It is also important to note that unless a government is prepared to intervene in the domestic price-setting process or the labor market, the price and output consequences of its financial program will essentially be determined by the private sector through behavior relations like those specified in Section I. Thus, the government cannot ensure by fiat that the conditions of stagflation will never occur. If expectations were affected by a program in the way described earlier and policymakers failed to take account of this in setting domestic credit ceilings, the program would tend to be more restrictive than was necessary to obtain the desired objective, and its price and output effects might be considerably more deflationary than had been anticipated.

The simplifying assumption that the reduction in domestic credit is achieved entirely by a cut in government spending requires less qualification. Practical experience with the setting up of programs like those designed by the International Monetary Fund suggests that once the implications of the required domestic credit ceiling for government financing are being worked through, it is often found that both government taxing and spending policies have important components that cannot be easily altered, so that it is usually around these policies that the most difficult political decisions take place. However, this should not be allowed to obscure the basic fact that once the target path for international reserves has been decided, there is only one set of domestic credit ceilings that is consistent with the achievement of that path, and the only question is that of making government financing requirements consistent with those ceilings.

The treatment of the supply side of the economy in this paper also warrants comment. In financial programming exercises, the effect of domestic credit restriction on aggregate supply has often been treated as a secondary problem. In particular, some analyses do not distinguish clearly between the effect of a program on actual output and its effect on full capacity output. This distinction is important because some of the same factors may affect both the growth of potential output and the rate of capacity utilization. Full capacity supply in the domestic economy is treated as exogenous to our model, while actual current output is endogenous. Thus, the model incorporates the short-run determinants of supply, but not the factors that are responsible for capacity growth in the longer run. If fixed capital formation is related to real government spending or
taxes, however, then a deflation of domestic credit that is achieved by either reducing public sector expenditure or raising tax revenue will affect the rate of growth of capacity output as well as actual output. Much, therefore, depends on the strength and direction of these structural relationships in a given developing economy. Many economists would probably argue that—whether the domestic credit ceiling is achieved by a reduction in real government spending or an increase in taxes—the effect will be a decline in aggregate net investment and a reduction in capacity growth. Alternatively, some economists and policymakers have recently argued, in effect, that a reduction in government spending in some developing countries might lead to a "crowding in" phenomenon, in which the decrease in government-induced capital formation is more than offset by a rise in private sector investment. If the first argument is relevant, so that capacity output is positively related to real public sector spending, then the conclusion of the preceding analysis that the extended financial program is superior to the standard one would be reinforced. Alternatively, if there is significant crowding in, then a standard program might be superior to an extended program in certain circumstances. Although the standard program would still have the same deflationary effect on current output in the short run, these adverse impact effects might be more than offset by faster growth of both actual and capacity output in subsequent years. All that can presently be said is that the relationship between government spending and growth of full capacity supply is an important empirical question that deserves further research in the context of developing countries.

IV. Conclusion

The basic purpose of this paper has been to formulate a model for developing countries that allows output, prices, international reserves, money, and government taxing and expenditure policies to be determined simultaneously. We believe that the model developed is a formal interpretation of the theory underlying the typical stabilization program implemented by the authorities to combat problems of inflation and an adverse balance of payments.

Since the focus of the exercise is on practical policy questions, empirical estimates of the relevant parameters are obviously required. However, because of the limited availability of data, it would be difficult to estimate the parameters of such a model from data for a single developing

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66 For a theoretical analysis of the relation between government fiscal policy and potential output in a developed economy, see von Furstenberg (1980).
country; and even if it were possible, it is not clear that these estimates would be applicable to other countries. Thus, a pooled sample of annual data for 29 countries, comprising 232 observations in all, was used to test the structure. The estimates indicate both that the model is representative of the structural characteristics of these 29 developing countries and that monetary disequilibrium does indeed have a significant effect on the behavior of prices, output, and reserves. To examine the policy implications, two simple simulation experiments were performed. It was found that during a portion of the adjustment period following an exogenous shock, the model produces time paths for prices and output that are consistent with real-world experience but that are not generally explained by simple monetary models. The last and most important aspect of the work was the comparison of two alternative types of program designed to achieve a specified improvement in the external position of a developing country—a standard (one-year) program and an extended (five-year) program. Several general conclusions may be drawn from this comparison.

The most important conclusion relates to the complexity of the linkages between the targeted reserve increase and the domestic credit policies needed to achieve it. The initial simulation experiment indicated that a change in domestic credit would essentially cause reserves to approach their new equilibrium level asymptotically. Nevertheless, when a given increase in international reserves must be achieved within a specified period of time, this model yields quite a complicated path for domestic credit ceilings, although the fluctuations are much more pronounced for the truncated one-year program than they are for the longer program. The implication of these results is that even a modest extension of the financial programming framework yields a model in which the relationship between the targeted reserve increase and domestic credit is complicated and depends on the structure of the economy. Conversely, measures to hold domestic credit at some prearranged level67 will not result in a smooth path of accumulation of international reserves, a conclusion that holds in this model even though it neglects such complications as the effect of changing expectations on international capital flows. The practical implication is that policymakers cannot “fine tune” domestic credit ceilings from quarter to quarter or even year to year without having much more comprehensive information about the structure of the economy than they can reasonably be expected to possess. One possible way out of this difficulty might be to devise some simple feedback rule in which the

67This is in the context of a model where real capacity output is constant over time. An analogous restriction in a growth context would obviously be the rate of domestic credit expansion.
domestic credit ceilings are altered in response to current and past deviations between targeted and actual reserves. But the derivation of such a "closed-loop" policy rule remains a question for further research.

A second general conclusion suggested by the findings in this paper is that programs designed to achieve quick results on the balance of payments via sharp deflation are likely to have significant and undesirable effects on output, employment, and factor incomes, particularly in the short run. In the expanded model, unemployment rises by 5 percentage points in the first year of the sharply deflationary program. A rise of this magnitude may well impose a heavy burden on a developing country both because incomes are already near the subsistence level and because the employment effect is likely to fall disproportionately on the nascent industrial sector. Furthermore, it is extremely difficult to take adequate account of the deflationary impact of expectations when devising the financial program, a problem that may tend to exacerbate the employment effects. These results present those who devise financial programs with a dilemma. On the one hand, the conclusion that the negative employment effects of an extended program are unambiguously smaller than those of a standard program provides a theoretical and empirical rationale for greater use of programs that have a longer time span. On the other hand, the longer the duration of a program, the more likely it is that the economy's adjustment may be blown off course by events that could not have been foreseen when the program was conceived. Careful and continuous monitoring of the program would thus seem to be essential if policymakers choose the gradualist approach.

While the model here is more comprehensive, and is believed to be more realistic, than those that have been specified hitherto, it clearly represents only a step in the direction of formulating, for developing countries, models that are capable of answering the questions that continually face policymakers in the context of their stabilization programs. To provide a general framework, obviously some realism was sacrificed by ignoring the special characteristics of individual developing countries. The hope is that this model can serve as a foundation on which more detailed structures can be built. Furthermore, the parameter estimates provided here, having been based on a cross-country sample, may be useful in analyses for developing countries where such information, for whatever reason, is not readily available.

Finally, it is important to underline the fact that both the estimates of the expanded model and the simulation results are sensitive to the assumptions made in this paper, particularly regarding the process of forming expectations. Because of space limitations, other potentially interesting simulation experiments—in particular, simulations involving
simultaneous changes in exchange rates and monetary policy—have not been conducted or reported. The model is, however, fully capable of handling such types of simulation. Only those simulation experiments that seemed to highlight the basic workings of the model have been considered here.

APPENDIX I

Data Definitions and Sources

Data

All data used in this study are taken from International Monetary Fund, *International Financial Statistics (IFS)*, and are annual, covering the period 1968–75 for each country. Lagged values of variables, therefore, cover the period 1967–74. All stock data are measured at the end of the period, and the price data are period averages. The precise definitions of the variables and the *IFS* line numbers are as follows:

- $P$ = consumer price index, 1975 = 100; line 64
- $R$ = net international reserves valued in domestic currency (line 1d multiplied by line ae)
- $G$ = government expenditure; line 82
- $T$ = government revenues; line 81
- $y$ = real income. This variable was generated by deflating nominal gross domestic product (GDP)–line 99b—by the consumer price index.
- $DC$ = net domestic credit of the consolidated banking system; line 32
- $M$ = money plus quasi-money; line 34 plus line 35
- $m$ = real money balances, that is, $M/P$
- $y^*$ = trend level of real income. This series was calculated from the equation
  \[ y^*_t = y^* e^{gt}, \]  
  where $y^*$ is the 1968 value of real income and $g$ is its trend growth rate over the period 1968–75.
- $P_t$ = U.S. consumer price index, 1975 = 100; line 64
- $e$ = index of the U.S. dollar exchange rate, 1975 = 100; line ae
- $\Delta CP_t$ = residual item obtained from the identity for the change in net domestic credit
  \[ \Delta CP_t = \Delta DC_t - G_t + T_t. \]  

Countries

The 29 countries in the sample are Argentina, Brazil, Chile, Colombia, the Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Panama, Paraguay, Uruguay, Jamaica, Jordan, Sri Lanka, India, Korea, Malaysia, Nepal, the Philippines, Singapore, Thailand, Burundi, Ghana, Kenya, Malawi, and Zambia.

The 28-country dummies, which take on a value of unity for the eight observa-
tions corresponding to a particular country and zero elsewhere, are entered into
the equations in the same order as in the preceding list.

APPENDIX II
Derivation of the Price Equation

Consider a small open economy that has both a traded goods sector and a
nontraded sector. The demand for nontraded goods \( Q_n^d \) can be specified simply
as a function of relative prices, the excess demand for real money balances, and
real income\(^68\) as follows:\(^69\)

\[
\log Q_n^d = -a_1 [\log P_n - \log \epsilon - \log P_f] + a_2 [\log m - \log m_f] + a_3 \log y,
\]

(26)

where

\[
P_n = \text{price of nontraded goods}
\]
\[
\epsilon P_f = \text{domestic price of traded goods, equal to the exchange rate times the foreign price level. This is assumed to be exogenous. All other variables are as defined in the text.}
\]

Similarly, the supply of nontraded goods \( Q_n^s \) can be made a positive function
of relative prices and real output\(^70\)

\[
\log Q_n^s = b_1 [\log P_n - \log \epsilon - \log P_f] + b_2 \log y.
\]

(27)

The change in the relative price of traded goods is determined by their excess
demand

\[
\Delta \log P_n - \Delta \log \epsilon - \Delta \log P_f = \kappa [\log Q_n^s - \log Q_n^d]
\]

(28)

where \( \kappa > 0 \).

Substituting in this equation for the demand for and supply of nontraded goods
given by equations (26) and (27), and further assuming that the income elasticities,
\( a_3 \) and \( b_2 \), are equal, one obtains

\[
\Delta \log P_n - \Delta \log \epsilon - \Delta \log P_f = \kappa [a_2 (\log m - \log m_f)]
- (a_1 + b_1) (\log P_n - \log \epsilon - \log P_f).
\]

(29)

Generally, statistics on the price of nontraded goods are not available for
developing countries, so that it would be difficult to work with an equation of the

\(^{68}\) Obviously, the concept of real income is complicated when the relative price of traded and nontraded goods is allowed to change. However, this problem is
of only limited relevance to the empirical results. The theoretical and empirical aspects of this problem are discussed in more detail in Knight and Mathieson
(1983).

\(^{69}\) See Clements (1980).

\(^{70}\) If the supply of nontraded goods were made a function of capacity rather than current output, a term representing a Phillips curve effect would appear in the
price equation (equation 32). We are indebted to Rudiger Dornbusch for emphasizing this point. This specification, however, did not prove to be empirically
robust.
form of equation (29). As an alternative, however, one can utilize the overall price index, which can be represented by a log-linear index of the form

$$\log P_t = \omega \log P_{nt} + (1 - \omega)[\log P_{n_t} + \log e_t],$$

(30)

where $\omega$ is the share of nontraded goods in total domestic expenditure.

In terms of the growth rate of the price of nontraded goods, equation (30) becomes

$$\Delta \log P_{nt} = \frac{1}{\omega} \Delta \log P_t - \frac{(1 - \omega)}{\omega} [\Delta \log P_{n_t} + \Delta \log e_t],$$

(31)

substituting for $\Delta \log P_{nt}$ in equation (29) gives

$$\Delta \log P_t - \Delta \log e_t - \Delta \log P_{n_t} = \kappa \omega a_s[\log m_{t-1} - \log m_t]$$

$$- \kappa (a_1 + b_1)[\log P_{t-1} - \log e_{t-1} - \log P_{n_{t-1}}].$$

(32)

This is precisely the reduced form inflation equation described in the text.

APPENDIX III

Log-Linear Approximation of Identities

For purposes of estimation and for the stability analysis, the structural model had to be made linear in the logarithms of the variables. This meant approximating the linear identities for the change in domestic credit and for the nominal money supply by a log-linear form, evaluated at the sample means of the relevant variables.

The domestic credit identity, which is specified as

$$DC_t = G_t - T_t + \Delta CP_t + DC_{t-1},$$

(33)

is approximated as

$$\log DC_t = \gamma_1 \log G_t - \gamma_2 \log T_t + \gamma_3 \log \Delta CP_t + \gamma_4 \log DC_{t-1} + \beta_4$$

(34)

where

$$\gamma_1 = \left(\bar{G}/\bar{DC}\right) = 1.236$$
$$\gamma_2 = \left(\bar{T}/\bar{DC}\right) = 1.036$$
$$\gamma_3 = \left(\Delta CP/\bar{DC}\right) = 0.1619$$
$$\gamma_4 = \left(\bar{DC}_t/\bar{DC}_{t-1}\right) = 0.805$$

with a bar over a variable signifying its sample mean value. The constant $\beta_4$ was estimated within the model and not imposed.

For the money supply identity, which is defined in stock terms as

$$M_t = R_t + DC_t,$$

(35)

we have chosen a first-order difference equation approximation that specifies that the valuation effects of exchange rate changes do not influence the level of the domestic money stock

$$\gamma_1 \log M_t = \gamma_5 \log (e_t \cdot R_t) - \gamma_6 (\log e_{t-1} \cdot R_{t-1}) + \gamma_7 \log DC_t$$

$$- \gamma_8 \log DC_{t-1} + \log M_{t-1} + \beta_5$$

(36)
where
\[ \gamma_1 = 1 + (\Delta \log R - \Delta \log e) + \Delta \log DC = 1.105 \]
\[ \gamma_2 = (R/M) + (\Delta \log R - \Delta \log e) = 0.250 \]
\[ \gamma_3 = (R/M) = 0.247 \]
\[ \gamma_4 = (DC/M) + \Delta \log DC = 0.568 \]
\[ \gamma_5 = (DC/M) = 0.467 \]

In equation (36), \( R \) is the domestic currency value of foreign exchange reserves. It can easily be shown that the inclusion of current and lagged values of the exchange rate, together with the preceding constants, ensures that both the money supply and the parameter estimates of the model are free of the effects of in-sample exchange rate changes on the domestic currency value of international reserves.

**APPENDIX IV**

Dynamic Stability of the Model

To determine whether the estimated system is stable, the eigenvalues of the model were calculated from the endogenous part of the estimated system. If \( \alpha_j \) is the \( j \)th eigenvalue of the matrix of coefficients of the endogenous variables, then since the model is a set of difference equations, the necessary and sufficient condition for stability is that the values of all moduli be less than unity, that is,

\[ |\alpha_j| < 1 \quad j = 1, \ldots, n. \] (37)

In the model here, it turns out that there are four real eigenvalues and two complex ones, which are complex conjugates of each other and which gave rise to an endogenous cycle. These, along with the corresponding moduli and the damping period (in years), are shown in Table 3. The values of the moduli indicate that the model is locally stable.

The sensitivity of the stability of the model to changes in particular parameters was examined by taking the numerical derivatives of each of the moduli with respect to the parameters in the system. If \( \gamma_i \) is the \( i \)th parameter in the model, then we calculate

\[ \frac{\partial |\alpha_j|}{\partial \gamma_i}. \] (38)

If this partial derivative is large, then a small change in a parameter could conceivably make the modulus greater than unity, and thus destabilize the system. Excluding the imposed constants, there are 14 behavioral parameters in the endogenous part of the model and six moduli. The results of the sensitivity analysis are given in Table 4.

\[ \text{If } \alpha_j \text{ is complex, that is, } \alpha_j = a + bi, \text{ then the modulus of } \alpha_j \text{ is given by } \sqrt{a^2 + b^2}. \]

\[ \text{This technique is described in Wymer (1976).} \]

\[ \text{Since } \gamma_i \text{ is a coefficient solely of an exogenous variable, its partial derivatives are all necessarily zero.} \]
Table 3. Stability Conditions of the Model

<table>
<thead>
<tr>
<th></th>
<th>Real part</th>
<th>Imaginary part</th>
<th>Modulus</th>
<th>Damping Period (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.991</td>
<td></td>
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<td>1.009</td>
</tr>
<tr>
<td>2</td>
<td>0.871</td>
<td></td>
<td>0.871</td>
<td>1.148</td>
</tr>
<tr>
<td>3</td>
<td>0.816</td>
<td></td>
<td>0.816</td>
<td>1.226</td>
</tr>
<tr>
<td>4</td>
<td>0.184</td>
<td></td>
<td>0.184</td>
<td>5.434</td>
</tr>
<tr>
<td>5</td>
<td>0.379</td>
<td>±0.495</td>
<td>0.624</td>
<td>1.603</td>
</tr>
<tr>
<td>6</td>
<td>0.251</td>
<td>±0.001</td>
<td>0.251</td>
<td>3.990</td>
</tr>
</tbody>
</table>

Table 4. Sensitivity Matrix of Moduli with Respect to Estimated Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_1$</td>
<td>0.331</td>
<td>0.000</td>
<td>0.005</td>
<td>0.000</td>
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<tr>
<td>$\gamma_2$</td>
<td>0.273</td>
<td>0.000</td>
<td>0.130</td>
<td>0.003</td>
<td>0.008</td>
<td>0.000</td>
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<tr>
<td>$\gamma_3$</td>
<td>1.0</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>$\gamma_4$</td>
<td>1.213</td>
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<td>$\gamma_5$</td>
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<td>0.003</td>
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<td>0.000</td>
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<tr>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>$\gamma_{14}$</td>
<td>1.0</td>
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<td>0.000</td>
</tr>
</tbody>
</table>

APPENDIX V

The Standard Money Demand Model

To highlight the simulation results of this model, its results have been compared in Section III with the path for inflation yielded by a standard dynamic money demand equation in which real income and the nominal stock of money are treated as exogenous. In the framework of this model, the stock of real money balances is assumed to adjust proportionately to the difference between the demand for real money balances and the actual stock in the previous period

$$\Delta \log m_t = \theta[\log m_t - \log m_{t-1}]$$  \hspace{1cm} \text{(39)}

where $\theta$ is the coefficient of adjustment, $0 \leq \theta \leq 1$.

Substituting for $\log m_t$ from equation (2) in the text, and solving for the level of real money balances, one obtains

$$\log m_t = \theta[\beta + \gamma_{d} \log y - \gamma_{s} \Pi] + (1 - \theta) \log m_{t-1}.$$

\hspace{1cm} \text{(40)}
Then, using the equation for the expected rate of inflation,
\[ \Pi_t = \gamma_{14} \Delta \log P_{t-1} + (1 - \gamma_{14}) \Pi_{t-1} \]  
which, for \( \gamma_{14} = 1 \)—the assumption used in the paper—implies that
\[ \Pi_t = \Delta \log P_{t-1} \]
one can write the estimating form as
\[ \Delta \log m_t = \theta \beta_1 + \theta \gamma_{14} \Delta \log y_t - \theta \gamma_{14} \Delta \log P_{t-1} + (1 - \theta) \Delta \log m_{t-1}. \]

With the addition of the country dummies, this model was estimated by the ordinary least-squares method on the same pooled sample as that used for the expanded model described in the text. The results were as follows:
\[
\begin{align*}
\Delta \log m_t &= -0.719 + 0.481 \Delta \log y_t - 0.237 \Delta \log P_{t-1} + 0.591 \Delta \log m_{t-1} \\
(3.96) & \quad (5.98) \quad (4.71) \quad (12.41) \\
R^2 &= 0.998 \quad SEE = 0.094
\end{align*}
\]

As can be seen, this equation does fit the data well, and all parameters have the correct signs and are significantly different from zero at the 1 percent level.

Using this estimated equation, along with the definitional equation for the price level
\[ \Delta \log P_t = \Delta \log M_t - \Delta \log m_t + \Delta \log y_t \]
the path of prices was simulated for the various experiments described in Section III.

References


74 The \( t \)-values are reported in parentheses below the coefficients; \( R^2 \) is the adjusted coefficient of determination; and \( SEE \) is the standard error of the estimated equation.


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Prices, Output, and the Trade Balance in Iran

Bijan B. Aghevli and Cyrus Sassanpour*

The rapid increase in oil prices during the last decade has been perhaps the most significant shock experienced by the world economy. A great deal of attention has been focused on the impact of higher oil prices on oil importing countries, but relatively little on its impact on the oil exporting countries. The purpose of this paper is to develop a macro-model designed to analyze the impact of the rise in oil prices on the economy of Iran. The basic framework is highly aggregated and incorporates only the most important factors relevant to such an analysis. Nevertheless, the estimation results of the model are encouraging because they predict fairly accurately the movements of the main economic variables over the sample period (1960–77), which ends before the recent political developments.

Our basic framework can be summarized as follows. In an oil producing country, the bulk of government revenues is derived from oil exports and denominated in foreign exchange. The domestic spending of these revenues increases aggregate demand for traded and nontraded goods, leading to an increase in imports, domestic output, and prices. In the absence of any exchange rate adjustment, prices of traded goods are determined from outside and most of the inflationary pressure is reflected in higher prices for nontraded goods. The rise in relative prices of nontraded goods increases the relative demand for imports and further increases their

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1 For earlier empirical work pertaining to other oil exporting countries, see Aghevli (1977b) for Indonesia, and Khan (1976) for Venezuela.

2 The rate of exchange of the Iranian currency in terms of the U.S. dollar was quite stable during 1960–77, remaining in the range of 68–75 rials per U.S. dollar.
growth until the economy reaches equilibrium at a higher level of imports, consistent with oil exports. The important question in this process is to what extent does the increase in government expenditures, arising from higher oil revenues, result in higher growth of output or in higher domestic inflation. The answer clearly depends on the size of the increases in oil revenues as well as the choice of the development projects undertaken by the government and the absorptive capacity of the economy.

A cursory comparison of the growth of output and prices in Iran during 1960–72 with that during 1973–77 highlights the impact of higher oil prices on the economy: the average growth of output rose from 9 percent to 13 percent, while the average inflation rose from 2 percent to 13 percent. The higher growth of output, however, was partly at the expense of the traded sector, because the accompanying higher inflation led to a movement of the terms of trade against this sector. Consequently, the non-oil exports all but vanished; the import-substituting sector was limited mainly to assembly plants based on imported inputs, with their output sold domestically behind high trade barriers; and imports increased substantially, their share in total output doubling from 15 percent to 30 percent during 1970–77. These developments have important longer-term implications for the economy. Oil resources are irreplaceable; their ultimate exhaustion, with the gradual erosion of the competitive position of the traded sector, will clearly leave the economy in a perilous situation. It is therefore essential that appropriate financial policies be adopted to provide an impetus to the growth of the traded sector and to ensure the viability of the economy when oil reserves are depleted.

Section I discusses the Government's budgetary policy and its impact on the money supply; Section II discusses the sources of domestic inflation; Section III discusses the private expenditure and income determination; Section IV specifies the demand for imports; Section V provides the estimation results for the complete model; Section VI contains the simulation results under alternative assumptions regarding the Government's oil revenues; and Section VII contains the major conclusions and policy implications of the paper.

I. Government's Budgetary Policy and Its Impact on Money Supply

Because of limited sources of financing in many of the developing countries, changes in the budget deficit are, to a large extent, reflected

3The share of non-oil exports in total exports declined from 12 percent in 1960
to 2.7 percent in 1977.
in changes in the rate of monetary creation. Even a balanced budget, however, can lead to monetary expansion when a large proportion of government revenues are in foreign exchange, that is, oil revenues. Unlike domestic taxes, foreign revenues in the form of royalties on natural resources do not induce a reduction in disposable income, and their domestic spending leads to the creation of additional money. In this case, the contribution of the budget to the monetary expansion is best measured by the Government’s domestic deficit, defined as the difference between the domestic expenditure \(DE\) and domestic revenue \(DR\). The change in the money supply \(M\) can then be written according to the following identity when \(PEX\) and \(PIM\) denote the private sector’s exports and imports and \(C\) denotes the flow of credit to the private sector from the domestic banking system and from external sources (that is, private capital inflows).

\[
\Delta M = DE - DR + PEX - PIM + C. 
\] (1)

The breakdown of the Government’s total expenditure into domestic and foreign components is not readily available. The above identity is therefore rewritten as follows, when \(GE\) denotes total government expenditure and \(IM\) denotes total imports (government plus private imports).

\[
\Delta M = GE - DR + PEX - IM + C. 
\] (2)

The Government is assumed to have planned its expenditures on the basis of a balanced budget policy; that is, in the long run, the authorities desired to spend all of the available revenues. In the short run, however, expenditures were adjusted, with a lag, to any abrupt changes in revenues. Government expenditures were therefore determined according to the following relationship, when \(GR\) denotes the Government’s total revenues.

\[
\Delta GE_i = \gamma(GR_i - GE_{i-1}). 
\] (3)

Rearranging terms results in equation (4).

\[
GE_i = \gamma GR_i + (1 - \gamma)GE_{i-1}. 
\] (4)

Government revenues were composed of oil revenues \(OR\) and domestic revenues \(DR\).

\[
GR = DR + OR. 
\] (5)

Oil revenues were determined exogenously according to official prices of

\(\text{**For an earlier discussion of this point, see Stillson (1976) and Aghevli (1977b).}**\)
oil and production levels. The Government derived its domestic revenues from direct taxes on income and property and indirect taxes on trade. These taxes were generally adjusted in line with the increase in income although as a result of various institutional and administrative factors the adjustment took place with a lag. The adjustment of the domestic revenues is specified as follows.

\[ \Delta DR_t = \delta (d_o + d_1 YP_t - DR_{t-1}). \]  

Rearranging terms results in equation (7).

\[ DR_t = \delta d_o + \delta d_1 YP_t + (1 - \delta) DR_{t-1}. \]  

II. Sources of Domestic Inflation

The domestic price level \( P \) is a weighted average of the price of traded goods \( P' \) and the price of nontraded goods \( P^n \).

\[ \ln P = w \ln P^n + (1 - w) \ln P'. \]  

We assume that the price of traded goods is determined exogenously in the world markets while the price of nontraded goods adjusts to equilibrate the domestic market according to the following adjustment mechanism, when \( (M/P) \) denotes the actual level of real money balances and \( m^* \) the desired level.

\[ \Delta \ln P^n = \lambda_1 [\ln (M/P)_{t-1} - \ln m^*] + \lambda_2 \ln (P'/P^n). \]  

Equation (9) indicates that first, any excess supply of money increases the pressure on the price of nontraded goods; and second, any rise in the price of traded goods leads to a rise in the price of nontraded goods, as it increases the demand for and reduces the supply of nontraded goods.

The desired demand for real money balances, \( m^* \), is specified as a simple function of income when \( a \) denotes the income elasticity.

\[ \ln m^* = \nu + a \ln Y. \]  

Substituting \( m^* \) from equation (10) in equation (9) and rearranging terms results in

\[ \Delta \ln P^n = \nu \lambda_1 + \lambda_1 \ln (M/P)_{t-1} - \lambda_1 a \ln Y_t + \lambda_2 \ln (P'/P^n). \]  

\(^5\) For a discussion of some of these factors see Aghevli and Khan (1977 and 1978). In an inflationary environment, the long collection lags of domestic taxes result in the creation of large budgetary deficits. In the absence of discretionary policy, the monetization of the deficits leads to higher rates of monetary expansion and results in a further increase in the inflation rate.
III. Private Expenditure and Income Determination

Private expenditure $E$ is specified in real terms as a function of income and excess supply of real money balances.

$$\ln (E/P)_t = e \ln Y_t + \beta [\ln (M/P)_{t-1} - \ln m^*].$$

(12)

In this monetary version of the expenditure function, an excess supply of money directly affects real expenditure, in contrast to a Keynesian version, in which an excess supply of money affects expenditure through the interest rate channel.\(^6\) Substituting $m^*$ from equation (10) and rearranging terms results in

$$\ln (E/P)_t = -\beta v + \beta \ln (M/P)_{t-1} + (e - \beta a) \ln Y_t.$$  

(13)

Domestic output $Y$ is determined according to the following identity:

$$Y = (E + GE + PEX - IM)/P.$$  

(14)

It should be noted that we have included only private exports and excluded oil exports from our definition of income. For national accounting purposes, oil revenues should clearly be included in any definition of gross national product. However, insofar as oil exports have negligible domestic value added, they do not contribute directly to the income of the domestic residents until they are spent by the Government. Thus, oil revenues that are not spent by the Government are excluded from our definition of income because they have no effect on the behavioral relationships of our model, which is designed to capture the behavior of the non-oil economy.

IV. Demand for Imports

As already mentioned, import data for the Government and the private sector are not separately available. Demand for total imports is therefore specified as a function of government expenditures and private expenditures. In addition, the terms of trade between imports and domestic goods ($P^i/P^n$) are also included to capture the impact of relative prices on the demand for the volume of imports.

$$\ln (IM/P)_t = m_0 + m_1 \ln (GE/P)_t + m_2 \ln (E/P)_t$$

$$- m_3 \ln (P^i/P^n)_{t-1}.$$  

(15)

The above formulation is basically along the lines suggested by the

\(^6\)For similar empirical formulation of the expenditure function, see Sassanpour and Sheen (1976).
literature on “The Monetary Approach to the Balance of Payments” in the sense that any excess supply of, or demand for, money is partly satisfied through the adjustment of private expenditure and, consequently, imports. In this framework, any increase in government expenditures resulting from higher oil revenues affects imports through three channels. First, government expenditure on foreign goods increases imports directly. Second, government expenditure on nontraded goods results in an expansion of money supply, leading to an increase in private expenditures on all goods including imports. Third, higher private expenditure leads to higher nontraded prices, further increasing the demand for imports.

V. Estimation Results

The complete model is composed of six behavioral equations and three identities, determining nine endogenous variables. The model was estimated for the period 1960–77, using an ordinary least-squares method. The list of variables is provided in Table 1. The estimated equations are provided in Table 2, where the t-values are given in parentheses underneath the coefficient.

Although preliminary, the empirical results are quite encouraging. All the coefficients of the model have the correct sign and, with only one exception, they are significant at 0.05 confidence level. The structural equations predict the behavior of the endogenous variables well, as indicated by the relatively high values of the $R^2$ coefficient.

The estimation of government expenditures indicates that these expenditures were adjusted in line with the increase in total revenues, such that

7 The monetary approach to the balance of payments specifies the overall balance of payments as a function of excess supply of, or demand for, money. Although our empirical results for the overall balance were quite encouraging, we chose to concentrate only on the import function and disregard the private capital flows, because our framework is based on a money-good economy and does not incorporate capital assets. In future revisions, attempts will be made to incorporate capital assets into the model. For a collection of papers on the monetary approach, see Frankel and Johnson (1976) and International Monetary Fund (1977).

8 Equations (4), (7), (8), (11), (13), (15), and identities (14), (2) and (5).

9 While a full-information maximum-likelihood (FIML) method would have been preferable for reducing the simultaneous bias error, this method could introduce large specifications errors (see Theil, 1971, p. 528). The use of two-stage least squares was also excluded because of the relatively small number of observations.

10 Sources and description of data are provided in the appendix.

11 The only exception is the coefficient of the terms of trade in the sixth equation. While the coefficient of real income in the private expenditure equation is not significant, there is no a priori restriction on the sign of this coefficient because it is a composite term (that is, $e - \beta a$).
Table 1. List of Variables

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<tr>
<th>Variable</th>
<th>Definition</th>
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<td>Money supply (broad definition)</td>
</tr>
<tr>
<td>$GE$</td>
<td>Government expenditure</td>
</tr>
<tr>
<td>$GR$</td>
<td>Government total revenue</td>
</tr>
<tr>
<td>$DR$</td>
<td>Government domestic revenue</td>
</tr>
<tr>
<td>$P$</td>
<td>Domestic prices (CPI)</td>
</tr>
<tr>
<td>$P^*$</td>
<td>Price of nontraded goods</td>
</tr>
<tr>
<td>$E$</td>
<td>Private expenditure</td>
</tr>
<tr>
<td>$Y$</td>
<td>Domestic real income (non-oil)</td>
</tr>
<tr>
<td>$IM$</td>
<td>Imports</td>
</tr>
<tr>
<td><strong>Exogenous variables</strong></td>
<td></td>
</tr>
<tr>
<td>$PEX$</td>
<td>Private exports (non-oil)</td>
</tr>
<tr>
<td>$C$</td>
<td>Changes in credit to the private sector from the banking system and external sources</td>
</tr>
<tr>
<td>$OR$</td>
<td>Government oil revenues</td>
</tr>
<tr>
<td>$P^1$</td>
<td>Price of traded goods</td>
</tr>
</tbody>
</table>

1 This index was calculated as a weighted average of trading countries' export price indices, adjusted for exchange rates.

the budget was balanced over the longer term. The adjustment coefficient $\gamma$ is about 0.62, which indicates that the mean lag of adjustment—the period required for about 63 percent of any disequilibrium between actual and desired expenditures to be eliminated—was about seven months. The estimation of government revenues indicates that non-oil revenues responded with a lag to the rise in income. The mean lag of response was about eight months, which was somewhat longer than the mean lag of government expenditures.

The estimation of the domestic price level indicates that the weight of nontraded goods in the consumer price index is about one half. The estimation of the price changes of nontraded goods indicates that the monetary factors significantly contributed to the increase in the price of these goods. The changes in the price of imports also had a significant effect on the changes in the price of nontraded goods. The income elasticity of the demand for money, $a$, calculated from this equation is about 1.2.

12 That is, the sum of the coefficients $GR$ and $GE_{t-1}$ is not significantly different from unity, which is the condition implied by equation (3).
13 The mean lag of adjustment is equal to $(1-\gamma)/\gamma$. The parameter $\gamma$ is in the range of 0.56–0.69, depending on whether the coefficient of $GR$ or $GE_{t-1}$ is used to calculate $\gamma$.
14 In principle, this is an identity with given weights, but because of unavailability of these weights we were forced to treat this identity as a behavioral equation and estimate the appropriate weights. The sum of the estimated weights of nontraded and traded goods is not significantly different from unity.

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### Table 2. Estimated Model

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Government expenditures</strong></td>
<td>$GE_t = 8.0 + 0.69 GR_t + 0.44 GE_{t-1}$</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.99$</td>
</tr>
<tr>
<td><strong>Government domestic revenues</strong></td>
<td>$DR_t = -16.6 + 0.12 YP_t + 0.40 DR_{t-1}$</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.99$</td>
</tr>
<tr>
<td><strong>Domestic price level</strong></td>
<td>$\ln P_t = 0.01 + 0.53 \ln P^*_t + 0.52 \ln P_t$</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.99$</td>
</tr>
<tr>
<td><strong>Price changes of nontraded goods</strong></td>
<td>$\Delta \ln P^*_t = 1.16 + 0.37 \ln (M/P)_t + 0.045 \ln Y_t + 0.60 \ln (P'/P)_t$</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.64$</td>
</tr>
<tr>
<td><strong>Real private expenditures</strong></td>
<td>$\ln \left(\frac{E}{P}\right)<em>t = 3.06 + 0.43 \ln \left(\frac{M}{P}\right)</em>{t-1}$</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.98$</td>
</tr>
<tr>
<td><strong>Volume of imports</strong></td>
<td>$\ln \left(\frac{IM}{P}\right)_t = 4.26 + 0.63 \ln \left(\frac{GE}{P}\right)_t$</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.99$</td>
</tr>
<tr>
<td><strong>Income identity</strong></td>
<td>$Y = (E + GE + PEX - IM)/P$</td>
</tr>
<tr>
<td><strong>Money supply identity</strong></td>
<td>$\Delta M = GE - GDR + PEX - IM + C$</td>
</tr>
<tr>
<td><strong>Budget identity</strong></td>
<td>$GR = DR + OR$</td>
</tr>
</tbody>
</table>

1 Corrected for autocorrelation.

The estimation of the real private expenditures indicates that the excess supply of money was the main factor explaining the variations in the ratio of private expenditures to income. The adjustment coefficient was about 0.4, which indicates that somewhat less than half of any excess supply of money was reflected in the increase in private expenditures. The income elasticity of real private expenditure, $e$, is about 0.7.\(^\text{15}\)

\(^\text{15}\) The coefficient of real income is equal to $e - \beta a = 0.18$. Using $\beta = 0.43$ for the real balances term and $a = 1.2$ for the income elasticity of money demand, calculated in the previous equation, results in the value of 0.7 for $e$. 

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The estimation of the import equation indicates that the increase in government and private expenditures contributed significantly to the increase in imports. The elasticity of imports with respect to private expenditures is close to unity, which is higher than the elasticity with respect to government expenditures. The relative price coefficient has the correct sign but is not significant.

VI. Dynamic Simulations

In order to test the reliability of the model for predicting the movements of the endogenous variables, a dynamic simulation of the model was conducted over the period 1960-77, using the parameter estimates obtained in the previous section and the actual values of the exogenous variables. A comparison of the simulated values of the endogenous variables with their actual values provides a rigid test for the reliability of the model, because under this simulation procedure the lagged endogenous variables are generated by the model and the errors are accumulated over time. The results (Charts 1–9) indicate that the model tracks the actual movements of the endogenous variables over the period remarkably well and, consequently, it can be utilized to predict the behavior of key economic variables, even outside the sample period.

In order to quantify the impact of the oil price increases in 1973-74 on the economy, a second set of dynamic simulations was conducted when oil revenues were assumed to have increased at a constant rate during the 1973-77 period. This constant rate was set according to two alternative scenarios: first, the rate was set equal to the average rate of increase over the 1973-77 period (that is, 42 percent); and second, the rate was set equal to the average rate of increase over the 1960-72 period (that is, 17 percent). Under the first alternative, oil revenues increased more gradually and did not exhibit the abrupt increase observed in 1973-74; consequently, they did not reach the actual values observed until 1977. Under the second alternative, oil revenues fell well below the actual values observed. The simulation results for these alternative scenarios, designated by SIM 1 and SIM 2 (Charts 1–9), and their comparison with the previous dynamic simulation based on actual oil revenues, enable us to isolate the impact of the oil price increases on the economy. It should be noted that in our framework higher accumulation of international reserves is equivalent to lower oil revenues. Consequently, different simu-

16 This dynamic simulation can be contrasted to a static one, where the values of lagged endogenous variables are assumed to be exogenously given and, consequently, the errors are confined to a single period.
Table 3. Simulation Results: 1973–77
(In percent)

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Simulated</th>
<th>SIM 1</th>
<th>SIM 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government expenditure</td>
<td>38.0</td>
<td>36.9</td>
<td>33.1</td>
<td>16.0</td>
</tr>
<tr>
<td>Output</td>
<td>13.4</td>
<td>13.2</td>
<td>11.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Price of home goods</td>
<td>12.2</td>
<td>11.2</td>
<td>8.6</td>
<td>8.6</td>
</tr>
<tr>
<td>Imports</td>
<td>34.4</td>
<td>36.5</td>
<td>30.9</td>
<td>15.2</td>
</tr>
</tbody>
</table>

1 Oil revenues assumed to increase at an average annual rate of 41 percent.
2 Oil revenues assumed to increase at an average annual rate of 17 percent.

The simulation results SIM 1 and SIM 2 indicate that the increase in oil revenues had a pronounced effect on the economy. Under the SIM 1 scenario a more gradual increase in oil revenues would result in a slower growth of government expenditure and, consequently, of output; the average growth of output would be about 11 percent, compared with the observed rate of 13 percent (Table 3). The lower growth of output would be accompanied by a lower inflation rate; the average inflation in home goods prices would be 8.6 percent, compared with the observed rate of 12.2 percent. The slower growth of output would also result in a slower growth of non-oil revenues, private expenditures, and imports.

The importance of oil revenues to the economy becomes abundantly clear under the SIM 2 scenario. A reduction of the increase in oil revenues to the levels observed prior to 1973 would have resulted in a sharp decline in the growth of output to about 3 percent. On the other hand, the inflation in home goods prices would continue to remain at 8.6 percent, the rate observed under the SIM 1 scenario.

A comparison of SIM 1 and SIM 2 results reveals that an increase in oil revenues initially results in higher growth rates without inducing higher rates of inflation; the growth rate under SIM 1 is much higher than under SIM 2, while the inflation rate is the same in both cases. The initial stability in the inflation rate is due to the fact that the increase in income levels leads to an increase in the demand for money, matching the increase in money supply associated with higher government expenditures. After a point, however, limitations on the absorptive capacity of the economy set in, slowing down the growth of output and leading to an excess supply of money and to higher domestic inflation. Consequently, the benefits of additional growth from further increases in government expenditures beyond this point should be weighed against the costs of inflation.17

17 For an analysis of the associated benefits and cost of inflation-financed growth, see Aghevli (1977a).
VII. Conclusions and Policy Implications

In this paper we have developed a macroeconomic framework to evaluate the impact of the rapid increase in Iran's oil revenues on its domestic economy. Our results confirm that higher oil revenues since 1973 were instrumental in improving the growth of the economy. Because of limitations on excess capacity in the economy, the higher growth rates were accompanied by higher rates of inflation in the prices of nontraded goods. Given a fixed exchange rate, the increase in the prices of nontraded goods led to a reallocation of resources from the traded goods sector to the nontraded goods sector; by 1977, non-oil exports had all but vanished, imports as a proportion of income had grown substantially, and the import-substituting sector was limited to those industries that were afforded substantial protection.

The above developments are a logical result of an oil producing country acting on its comparative advantage in oil. However, this policy ignores the fundamental difference between production based on the exploitation of exhaustible resources and the production of other goods and services. Oil resources represent a stock of capital assets in the economy, and if the capital stock is not to be depleted, oil revenues should be invested—either domestically or abroad—to provide a flow of earnings over time. Whether capital should be consumed at all is obviously an intergenerational choice, but it can be argued that in a less developed economy capital should not be depleted and, in fact, part of the earnings should be invested toward further diversification.

The basic policy implication of this analysis is that, in the longer run, oil producing countries need to develop non-oil industries and promote their traded goods sector if they are to sustain economic growth when the oil resources are exhausted. Financial policies should therefore be geared to the achievement of this longer-term objective. An important element of these policies would be to limit government domestic expenditures to levels consistent with the absorptive capacity of the economy. Otherwise, the rapid deterioration of relative prices against the traded goods sector would inhibit its development.

APPENDIX

Sources of Data


18 This was illustrated by our simulation results, indicating that, after a point, expansion of government expenditure mainly results in higher prices.
Description of Variables

\[ M = \text{broad money} = \text{narrow money (Source A; line 34)} + \text{quasi-money (Source A; line 35)} \]

\[ GE = \text{government expenditure (Source A; line 82)} \]

\[ GR = \text{government total revenue (Source A; line 81)} \]

\[ OR = \text{government oil revenue (Source B)} \]

\[ DR = \text{government domestic revenue} = GR - OR \]

\[ P = \text{consumer price index (Source A; line 64)} \]

\[ P^n = \text{price of nontraded goods (Source A; line 63a)} \]

\[ P^t = \text{price of traded goods (weighted average of trading partners' export prices adjusted for exchange rate)} \]

\[ YP = \text{non-oil GDP}^{10} = \text{GDP (Source A; line 99b)} - \text{oil exports (Source A; line 70a)} \]

\[ IM = \text{imports (Source A; line 98c)} \]

\[ PEX = \text{non-oil exports} = \text{exports (Source A; line 70)} - \text{oil exports (Source A; line 70a)} \]

\[ E = \text{private expenditures} = YP - GE - PEX + IM \]

\[ Y = \text{real income (non-oil)} = \frac{YP}{P} \]

\[ C = \text{changes in credit to the private sector from the banking system and from external sources} = \Delta M - GE + DR - PEX + IM. \]

References


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10Strictly speaking, non-oil GDP should exclude the value added of the oil sector. This value added, however, is quite small and can be excluded without appreciably affecting the broad magnitudes.

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Oil Wealth and Economic Behavior
The Case of Venezuela, 1965–81

Reza Vaez-Zadeh*

The purpose of this paper is to examine the short-run macroeconomic implications of natural resource availability—as well as its exhaustibility—in the case of Venezuela. Although considerable attention has been paid in the economic literature to the manner in which the economies of oil producers such as Venezuela are influenced by variations in the flow of income generated by oil resources, the models used in the studies have in general ignored two important distinguishing characteristics of oil-based economies. The first relates to the possible “confidence effect” that resource availability might have on the behavior of economic agents. This effect has been highlighted by the studies of the “Dutch disease”—that is, the problem of deindustrialization attributable to a booming export sector (Buiter and Purvis (1983), Corden and Neary (1982), Eastwood and Venables (1982), Neary and van Wijnbergen (1984), and van Wijnbergen (1984)). It arises from the impact of resource availability on future expected income, which can in turn influence saving behavior, the pattern of expenditure, and the composition of asset portfolios. The second important characteristic is the exhaustibility of oil resources. Although the economic literature is replete with studies of the implications of the exhaustibility of petroleum resources for optimal production and price strategies in petroleum-based economies, the short-run macroeconomic models of such economies have in general sidestepped the question of the depletability of the main source of income (Aghevli (1977), Aghevli and Sassanpour (1982), Khan (1976), and Knight and Mathieson (1980)). Although these models do recognize that the exhaustibility of oil has major implications from the point of view of economic management, in general they consider exhaustibility as a long-run concept with little or no consequences in the short run. The validity of such a position is questionable, however, because exhaustibility is

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likely to influence expectations about future income, thus inducing shifts in perceived wealth that may in turn affect private sector confidence and its behavior in the short run.

The analytical framework of this paper explicitly incorporates these key characteristics of major oil-based developing countries. The analysis suggests that, in the case of Venezuela, the impact of an oil price shock on the economy becomes considerably more pronounced once these features are taken into account. In particular, such a disturbance would lead to significantly greater variations both in the balance of payments and in domestic prices than is suggested by earlier models that ignore these features of resource-based economies. Consequently, remedial policies adopted in the face of such disturbances would need to be greater in intensity and, sometimes, longer in duration than those suggested by previous studies.

The model is applied to the Venezuelan economy over the period 1965-81. The choice of country was dictated both by data availability and by a desire to preserve the general characteristics of the model as far as possible, thus to make it applicable to other oil producing developing countries. Venezuela seems especially suitable for this purpose because it is a small and relatively liberal economy where the generality of the model specification could be preserved.

Moreover, during the sample period Venezuela maintained a free exchange system with no restriction on capital flows. Since early 1983, however, the Venezuelan exchange system has undergone major modifications, rendering it highly restrictive. In particular, a multiple exchange system has been introduced, and all private capital transactions are now channeled through the free exchange market and are subject to prior authorization. Choice of the period of study was based on these considerations.

The rest of the paper is organized as follows. The specification of the model is presented in Section I, followed in Section II by a discussion of the estimation results and their policy implications. Some simulation exercises are reported in Section III to highlight the impact of exogenous shocks on the economy, and the conclusions of the study are summarized in Section IV.

I. Model Specification

In the tradition of the "warehouse" models of oil supply, it is assumed that oil is stored in a warehouse so that the costs or technical difficulties

1 For a detailed discussion of other characteristics of oil producing developing countries, see Amuzegar (1983).
associated with its production or exportation are negligible. The usage rate is also assumed not to be constrained by any conservation motive. The analysis thus abstracts from the issues related to optimal pricing and production strategies over time, on which much of the literature on exhaustible resources has focused. This implies that, given an exogenous foreign price of oil, the rate of depletion is always equal to the quantity demanded at the going price. Oil revenues can thus be treated as exogenous (Motamed (1979)).

This assumption is not too restrictive because it is not always possible for a country such as Venezuela, which is a member of the Organization of Petroleum Exporting Countries (OPEC), to vary unilaterally its price or output sufficiently to achieve a targeted income. Moreover, so long as the price elasticity of demand for oil from a particular country is infinitely large, an output restriction is sufficient to render oil revenues exogenous. Although the global elasticity of demand for oil may be low, demand for a specific country’s oil exports need not necessarily be low. An approximate measure of this elasticity is given by

\[
\epsilon = \left[ \epsilon_w + (1 - s) \eta \right]/s,
\]

where

\( \epsilon \) = the price elasticity of the world demand for oil from country \( i \)
\( \epsilon_w \) = the price elasticity of world demand for oil
\( \eta \) = the supply elasticity of other oil producers
\( s \) = the share of country \( i \) in the world oil market.

Although this is an approximate measure, since it assumes that there is excess capacity in the combined production of competitors, it shows that the price elasticity of demand for oil from country \( i \) is larger, the smaller is its share of the market. For Venezuela, this share has varied between 3 percent and 5 percent. In the limiting case when the supply elasticity of other producers (\( \eta \)) is zero, the elasticity of demand for Venezuelan oil can be between 20 to 33 times larger than the elasticity of the world demand for oil. Given a large elasticity of demand for Venezuelan oil, the assumption of exogenous oil revenue is not too restrictive.

The role of oil as an intermediate input is left out of the model. As a result, non-oil producing sectors are not directly influenced by changes in oil prices.\(^2\) Such an omission is not too restrictive if the size of the

\(^2\)Allowing for oil as an intermediate input may be tantamount to building an automatic Dutch disease process into the model, with the non-oil export sector being adversely affected whenever oil export prices increase. This procedure may, of course, be justified in some countries such as Canada. See Knight and Mathieson (1980).
non-oil (including petrochemical) sector is small in relation to the size of the economy, or if the domestic use of oil is relatively unimportant (as is the case in many oil exporting developing countries). Moreover, in such countries the domestic production sector is usually insulated from movements in the export price of oil as a matter of policy. The cost of oil input in domestic production is thus not sensitive to developments in the oil price, and the impact on domestic production of higher oil revenues generated through price hikes does not work through the oil input component of domestic production.

The impact of oil resources does, however, enter the model on the demand side. Both the demand for real balances and the private demand for consumption and investment goods are influenced by these resources. In contrast to some recent theoretical models that recognize the separate impact of oil resources on demand but implicitly assume that these revenues accrue directly to the private sector (Eastwood and Venables (1982), Buiter and Purvis (1983), and Neary and van Wijnbergen (1984)), in the present model the influence of these resources on private behavior is indirect because oil revenues are assumed to be received entirely by the government. This indirect influence can be interpreted as the confidence effect of the oil wealth. It arises because the stock of oil may be viewed by the society as accumulated savings or as a source of wealth to be drawn upon in the future. The knowledge of the existence of this source of wealth, from which eventually all the inhabitants of the country can be expected to benefit, affects the public's confidence about prospects for future income, leading to adjustments in their permanent income. This will, in turn, have an influence on saving behavior, expenditure patterns, and the composition of asset portfolios. In other words, the indirect impact of oil wealth on current expenditures and desired holdings of real balances works not through a rise in current disposable income, but through expectations about future income.

In the oil-based economies, the large size of export earnings accruing to the government relative to the size of the economy imparts more importance to the operations of the government than in other developing countries. Because the oil sector is typically characterized as an enclave sector, the government's operations serve as the main link between that sector and the rest of the economy. This linkage implies that the loss of oil export proceeds will not automatically lead to a decline in aggregate demand. Since the loss falls entirely on the government, specific adjustment measures will be required to bring demand into line with resource availability. In contrast, where the economy is dependent on the export of a single agricultural crop, reduced crop prices abroad will result in lower incomes for many households as well as for the government,
thereby leading to a decline in aggregate demand and reducing the extent of required adjustment in financial policy.³

The collection of government receipts from oil exports, all of which are denominated in foreign currency, entails no deflationary impact because it does not represent a withdrawal from the domestic income stream. Similarly, the expenditure of these revenues on imports of goods and services does not immediately increase domestic liquidity and is not inflationary. Moreover, there is an immediate coincidence of oil-financed domestic expenditure with increases in domestic liquidity that may to some extent blur the distinction between monetary and fiscal policies.⁴

The rate of growth of the money supply is, therefore, greatly influenced by the government's domestic operations. The domestic budget balance—that is, the difference between the government's domestic revenues and domestic expenditures—becomes a highly useful concept in analyzing the impact of government operations on domestic liquidity.

Unlike much of the earlier work on macroeconomic models undertaken at the IMF, the model in this paper does not follow in a purely monetarist tradition but takes into account structural factors underlying inflationary and growth impulses. The model recognizes the interdependence of commodity and money markets by explicitly allowing for the spillover of disequilibrium effects across different markets. The level of absorption and prices are thus influenced by disequilibrium in both money and commodity markets. Moreover, in contrast to earlier models that focus on aggregate private expenditures, an explicit investment function is incorporated to isolate the impact of oil resources on productive potential. The specification of the model in disequilibrium form also helps to provide information on the lag structure of the economy.

The model consists of 9 behavioral equations and 8 identities explaining 17 endogenous variables. The definition of variables is given in Table 1, and the model is reproduced in Table 2. Lowercase letters denote the logarithm of the corresponding uppercase variable deflated by the price index, except \( p, p', \) and \( p'' \), which denote the logarithm of the corresponding price indices \( P, P', \) and \( P'' \). The symbols \( i \) and \( i_1 \) represent, respectively, domestic and foreign interest rates measured in percentages.

³ A fall in the relative price of the crop induces a shift to other profitable crops, whereas in oil exporting countries a switch to other exports that could adequately substitute for oil is clearly not feasible in the short run (see Lewis (1984)).

⁴ If the country is small, so that its import supply function is elastic, and if domestic and foreign goods are perfect substitutes and no import restrictions exist, it makes no difference whether the government initially spends oil revenues on domestic or on foreign goods and services. Rather than influencing domestic prices, any excess liquidity created through government operations will initially leak out through imports. See McKenzie and Schadler (1980).
## Table I. List of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endogenous variables</strong></td>
<td></td>
</tr>
<tr>
<td>CON</td>
<td>Actual private consumption expenditures</td>
</tr>
<tr>
<td>CON*</td>
<td>Private demand for consumer goods</td>
</tr>
<tr>
<td>CP</td>
<td>Credit to private sector</td>
</tr>
<tr>
<td>DR</td>
<td>Government domestic revenues</td>
</tr>
<tr>
<td>E</td>
<td>Desired private expenditures</td>
</tr>
<tr>
<td>G</td>
<td>Government expenditure</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>GR</td>
<td>Government revenues</td>
</tr>
<tr>
<td>IM</td>
<td>Imports of goods and services</td>
</tr>
<tr>
<td>IM*</td>
<td>Desired imports of goods and services</td>
</tr>
<tr>
<td>KF</td>
<td>Private investment (capital formation)</td>
</tr>
<tr>
<td>M*</td>
<td>Demand for money balances</td>
</tr>
<tr>
<td>MS</td>
<td>Nominal money stock broadly defined (M2)</td>
</tr>
<tr>
<td>NFAB</td>
<td>Net foreign assets of the banks</td>
</tr>
<tr>
<td>FNACB</td>
<td>Net foreign assets of the central bank</td>
</tr>
<tr>
<td>PKI</td>
<td>Net private capital inflow</td>
</tr>
<tr>
<td>P</td>
<td>Domestic price level (index)</td>
</tr>
<tr>
<td>P*</td>
<td>Price of nontraded goods (index)</td>
</tr>
<tr>
<td>X*</td>
<td>Real exports of goods and services other than oil</td>
</tr>
<tr>
<td>Y</td>
<td>Non-oil GDP</td>
</tr>
<tr>
<td>Y*</td>
<td>Demand for non-oil output</td>
</tr>
<tr>
<td><strong>Exogenous variables</strong></td>
<td></td>
</tr>
<tr>
<td>BOP</td>
<td>Residual item in the balance of payments (including, on a net basis, all the above-the-line variables except the trade balance, nonfactor services, government capital inflow, and short-term private capital inflows)</td>
</tr>
<tr>
<td>DA</td>
<td>Net domestic assets of the central bank</td>
</tr>
<tr>
<td>DOC</td>
<td>Domestic consumption of oil</td>
</tr>
<tr>
<td>F</td>
<td>Expected oil wealth</td>
</tr>
<tr>
<td>GDE</td>
<td>Government domestic expenditure</td>
</tr>
<tr>
<td>i</td>
<td>Expected domestic interest rate</td>
</tr>
<tr>
<td>ir</td>
<td>Foreign interest rate adjusted for expected exchange rate change</td>
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<tr>
<td>INV</td>
<td>Inventories calculated from national accounts data</td>
</tr>
<tr>
<td>MM</td>
<td>Money multiplier</td>
</tr>
<tr>
<td>OR</td>
<td>Oil revenues</td>
</tr>
<tr>
<td>P*</td>
<td>Prices of traded goods</td>
</tr>
<tr>
<td>PIM</td>
<td>Private imports</td>
</tr>
<tr>
<td>UCB</td>
<td>Change in cash balances of the treasury</td>
</tr>
<tr>
<td>YUS</td>
<td>Nominal U.S. GDP</td>
</tr>
<tr>
<td>(\pi)</td>
<td>Price of oil</td>
</tr>
</tbody>
</table>
Table 2. List of Equations

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral equations</td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>( m = a_1 + a_2 y + a_3 f + a_4 i + a_5 c + a_6 m_{-1} )</td>
</tr>
<tr>
<td>(2)</td>
<td>( con = b_1 + b_2 y + b_3 f + b_4 EFD_{-1} + b_5 con_{-1} )</td>
</tr>
<tr>
<td>(3)</td>
<td>( KFIP = u_0 + u_1 (Y/P) + u_2 q + u_3 (F/P) + u_4 (K/P)_{-1} )</td>
</tr>
<tr>
<td>(4)</td>
<td>( \Delta p = c_1 + c_2 \Delta y'' + c_3 \Delta k + c_4 \Delta EFD_{-1} + \Delta p' )</td>
</tr>
<tr>
<td>(5)</td>
<td>( \Delta y = D_1 + D_2 y'' + D_3 EFD_{-1} + D_4 (p'' - p') + D_5 y_{-1} )</td>
</tr>
<tr>
<td>(8)</td>
<td>( im = k_1 + k_2 (p'' - p') + k_3 e + k_4 g + k_5 m_{-1} )</td>
</tr>
<tr>
<td>(10)</td>
<td>( dr = l_1 + l_2 y )</td>
</tr>
<tr>
<td>(11)</td>
<td>( g = \lambda gr + (1 - \lambda) g_{-1} )</td>
</tr>
<tr>
<td>(13)</td>
<td>( PKI = w_0 + w_1 (i - i_1) + w_2 \Delta GDP + w_3 YUS )</td>
</tr>
<tr>
<td>Identities</td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td>( Y'' = CON'' + KF + G + X'' )</td>
</tr>
<tr>
<td>(7)</td>
<td>( e = \log (CON''P + KF/P) )</td>
</tr>
<tr>
<td>(9)</td>
<td>( GR = OR + DR )</td>
</tr>
<tr>
<td>(12)</td>
<td>( X'' = Y - CON - KF - G + IM - \Delta INV + DOC )</td>
</tr>
<tr>
<td>(14)</td>
<td>( GDP = Y + OR + DOC )</td>
</tr>
<tr>
<td>(15)</td>
<td>( \Delta M = G - DR + X'' - IM + \Delta CP + PKI + BOP )</td>
</tr>
<tr>
<td>(16)</td>
<td>( EFD = (M/P)'' - (M/P)_{-1} - \Delta (DA/P)MM )</td>
</tr>
<tr>
<td>(17)</td>
<td>( F = \pi_{-1} )</td>
</tr>
</tbody>
</table>

**Demand for Real Balances (m')**

The demand for real balances is assumed to depend on real non-oil income (\( y \)), the expected oil wealth (\( f \)), and the domestic (\( i \)) and foreign (\( i_1 \)) interest rate(s).\(^5\) The relationship between expected oil wealth and the demand for money represents a confidence or psychic factor, as discussed earlier, but it is also consistent with Friedman's (1959) hypothesis that demand for real balances depends on permanent rather than actual income. The inclusion of both non-oil income and expected oil wealth in the demand for money equation also permits a test of the plausible hypothesis that the elasticity of demand for money with respect to oil should differ substantially from that with respect to non-oil income, reflecting the dominant role of the government in oil-related transactions.

In a relatively open economy such as that of Venezuela, both foreign and domestic interest rates (\( i \) and \( i_1 \), respectively) should be included in the demand for money equation to represent the yield on foreign and

\(^5\) Because oil income accrues to the government, its impact on money demand (and other private demand variables) works indirectly through the government expenditure function. Thus, oil income has not been included as an independent variable in money demand and private expenditure equations.
domestic assets (Hamburger (1977)). In a completely open economy these assets are perfectly substitutable, so that the movements in their yields are perfectly correlated, and there is no need to include both interest rates in the equation. Because the degree of openness is an empirical question, however, the demand function is specified to include both interest rates (the time subscripts $t$ have been suppressed throughout the paper for ease of presentation):

$$m^d = m^d(y, f, i, i_t).$$

The actual stock of real balances is assumed to adjust with a lag to the desired stock:

$$\Delta m = \mu(m^d - m_{t-1}); \quad 0 \leq \mu \leq 1,$$

where $\mu$ is the speed of adjustment and $\Delta$ is the first difference operator:

$$\Delta X = X_t - X_{t-1}.$$

The above relationships result in the following estimating equation:

$$m = a_1 + a_2 y + a_3 f + a_4 i + a_5 i_t + a_6 m_{t-1},$$

where $a_2, a_3, a_4, a_6 > 0$ and $a_5 < 0$.

**Private Consumption Expenditures (con)**

The level of aggregate private consumption rises whenever there is an excess private demand for consumer goods:

$$\Delta con = b_0 (con^d - con_{t-1}); \quad 0 \leq b_0 \leq 1,$$

where $con^d$ denotes the desired level of private consumption. It is assumed to vary directly with non-oil real income ($y$) and expected oil wealth ($f$), and inversely with the level of monetary disequilibrium in the previous period:

$$con^d = con^d(y, f, EFD_{t-1}),$$

where $EFD$ denotes the level of disequilibrium in the money market, as defined later in this section (in the subsection “Monetary Disequilibrium”). Eliminating $con^d$ from the above relationships yields the estimating equation:

$$con = b_1 + b_2 y + b_3 f + b_4 EFD_{t-1} + b_5 con_{t-1},$$

where $b_2 > 0, b_3 > 0, b_4 < 0$, and $b_5 < 0$. 

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**Private Investment (KF)**

The desired level of real private capital stock \((K/P)^d\) is assumed to be a linear function of real non-oil income \((Y/P)\), expected real oil wealth \((F/P)\), and the opportunity cost of capital \((q)\):

\[
(K/P)^d = K[(Y/P), q, (F/P)];
\]

\(q\) is measured by the rental wage ratio,

\[
q = P(i - \pi)/W,
\]

where \(W\) represents the nominal wage index and \(\pi\) denotes the rate of change in capital goods prices.

An expansion in non-oil income would raise the desired capital stock, whereas an increase in the rental wage ratio would lower it by encouraging substitution of labor for capital. However, the impact of an increase in expected oil wealth on desired private capital stock is ambiguous. Because the immediate beneficiary of higher income from oil is the government, the direction of the effect would depend on the expected pattern of government expenditure. That is, the desired private capital stock may rise if government expenditures are viewed as complementary to private investment (as could be the case with government expenditures channeled to infrastructural investment). The desired private capital stock will decline if government expenditures are expected to be of a competing nature, concentrated on projects usually undertaken by the private sector. The sign of the coefficient of \(F/P\) is therefore indeterminate a priori.

In each period the actual level of the capital stock adjusts partially to the desired level:

\[
\Delta(K/P) = u[(K/P)^d - (K/P)_{t-1}]; \quad 0 \leq u \leq 1.
\]

The level of real gross fixed capital formation \((KF/P)\) is given by

\[
KF/P = \Delta(K/P) + DEP,
\]

where \(DEP\) denotes depreciation of the capital stock, assumed to be a constant proportion \(\Theta\) of the capital stock in the previous period; that is,

\[
DEP = \Theta (K/P)_{t-1}.
\]

---

6 Some studies (for example, Sundararajan and Thakur (1980)) have postulated an increasing relationship between the speed of adjustment \((u)\) and the availability of resources for private capital formation. The variable for availability, measured by the difference between aggregate savings and government investment, was not found to be a significant factor determining private investment in Venezuela.
The estimating relationship for $KFP$ is thus given by

$$KFP = u_0 + u_1 (Y/P) + u_2 q + u_3 (F/P) + u_4 (K/P)_{-1},$$  \hspace{1cm} (3)

where $u_1 > 0$, $u_2 < 0$, and $u_4 = \Theta - u$.

**Domestic Price Inflation**

The domestic price level ($p$) is assumed to be a weighted average of the prices of traded and nontraded goods ($p'$ and $p''$, respectively):

$$p = \omega p'' + (1 - \omega) p'; \hspace{1cm} 0 \leq \omega \leq 1.$$

Movements in prices of nontraded goods result from variations in money market disequilibrium or from changes in the excess of demand over potential supply in the goods market ($ECD$): \textsuperscript{7}

$$\Delta p'' = p''(\Delta ECD, \Delta EFD).$$

If potential output is assumed to be proportional to the real capital stock ($k$), one can write

$$ECD = y^d - \alpha k; \hspace{1cm} \alpha > 0,$$

where $y^d$ represents the level of demand in the goods market. These relationships give the following estimating equation for domestic inflation:

$$\Delta p = c_1 + c_2 \Delta y^d + c_3 \Delta k + c_4 \Delta EFD_{-1} + \omega \Delta p',$$  \hspace{1cm} (4)

where $c_2 > 0$, $c_3 = -\alpha c_2 < 0$, and $c_4 < 0$.

**Growth of Non-Oil Output ($y$)**

The supply of non-oil output ($y$) responds to excess demand in the commodity market, to the disequilibrium in the money market (with a time lag), and to relative prices:

$$\Delta y = d_1 + d_2 (y^d - y) + d_3 EFD_{-1} + d_4 (p'' - p')'; \hspace{1cm} d_2 > 0, d_3 < 0.$$

An improvement in the terms of trade in favor of nontraded goods could be expected to stimulate the supply of non-oil output because nontraded goods make up the bulk of domestic non-oil production. However, the increase in the relative price of nontraded goods may shift the consumption pattern away from such commodities, thus inducing a

\textsuperscript{7}The possibility that the divergence of relative prices from their long-run equilibrium value could also influence nontraded goods prices was excluded from the price equation, since empirical tests showed that this divergence was not significant.
cutback in production. The sign of the coefficient $d_4$ is therefore indeterminate a priori.

After rearrangement, the estimating equation can be derived as follows:

$$\Delta y = D_1 + D_2 y^d + D_3 EF D_{t-1} + D_4 (p^n - p') + D_5 y_{t-1},$$

where $D_2 > 0$, $D_3 < 0$, and $0 > D_5 = -d_2(1 + d_2) > -1$.

The demand for domestic non-oil output ($Y^d$) comprises public ($G$) and private demand for goods and services and demand for non-oil exports ($X^n$):

$$Y^d = CON^d + KF + G + X^n.$$  

**Imports (im)**

The level of actual real imports ($im$) rises whenever there is excess demand for imports:

$$\Delta im = k_0 (im^d - im_{t-1}); \quad 0 \leq k_0 \leq 1.$$  

The desired level of imports ($im^d$) is assumed to depend on planned private expenditures ($e$), on government real expenditures ($g$), and on the relative prices of traded and nontraded goods:

$$im^d = im(e, g, p^n - p').$$

The variables $e$ and $g$ enter the import function separately to account for the difference in the import content of private and government expenditures. The underlying demand for private expenditure is composed of desired consumption and planned investment:

$$e = \log \left( CON^d / P + KF / P \right).$$  

In the present formulation, the planned and actual levels of investment are assumed to be equivalent. In other words, plans to adjust to the desired capital stocks at a given speed are assumed to be fully realized.

The following equation can thus be derived:

$$im = k_1 + k_2 (p^n - p') + k_3 e + k_4 g + k_5 im_{t-1},$$

where $k_2 > 0$, $k_3 > 0$, $k_4 > 0$, and $1 \geq k_5 = 1 - k_0 \geq 0$.

**Government Revenues (GR) and Expenditure (G)**

Government revenues ($GR$) consist of oil revenues ($OR$) and non-oil revenues ($DR$):
Non-oil revenues are related to non-oil income:

\[ \text{dr} = l_1 + l_2 y; \quad l_2 > 0. \]  

(10)

Given the exogeneity of the price and demand for oil, the governments of oil producing countries can exercise little discretionary control over the bulk of their revenues, particularly in the short run. As a result they have attempted, to a larger extent than other countries, to adjust their expenditures in line with revenues. Indeed, studies of the Islamic Republic of Iran and of Indonesia have shown that the level of government expenditure in each period is established in these countries in such a way as to move toward a balanced budget over time (Aghevli and Sassanpour (1982) and Sassanpour (1985)). Adopting such an assumption allows the following relationship to be specified:

\[ \Delta g = \lambda (gr - g_{t-1}); \quad 0 \leq \lambda \leq 1, \]

which results in the estimating equation

\[ g = \lambda gr + (1 - \lambda) g_{t-1}. \]  

(11)

**Non-Oil Exports (X”)**

Non-oil exports are determined as a residual from the income identity:\(^8\)

\[ X^n = Y - CON - KF - G + IM - \Delta INV + DOC, \]  

(12)

where \( \Delta INV \) is the change in inventories, and \( DOC \) is domestic consumption of oil. Non-oil exports are thus affected by developments on both the demand and supply sides of the economy.

**Capital Flows (PKI)**

Capital flows usually respond to a variety of factors that no single relationship can adequately capture. Nevertheless, in the present model it is assumed that the differential in expected returns on domestic and foreign assets and changes in domestic and foreign incomes bring about changes in desired asset holdings, thus generating capital flows. Because most capital movements are to and from the United States, foreign variables refer to that country:

\[ PKI = w_0 + w_1 (i - i_f) + w_2 \Delta GDP + w_3 \Delta YUS, \]  

(13)

\(^8\)Non-oil exports accounted for no more than 5 percent of total exports in Venezuela during the sample period.
where

\[ GDP = Y + OR + DOC \]  

(14)

and \( YUS \) denotes nominal U.S. GDP. Note that estimating a net capital flow equation of the type specified assumes that foreign and domestic assets are not perfect substitutes.\(^9\) If assets are perfectly substitutable, this equation should be replaced by an interest arbitrage equation linking \( i \) and \( i_f \).

**The Money Supply Identity**

As noted earlier, the impact of government operations on domestic liquidity can be measured by the government's domestic budget balance; that is, by the difference between domestic revenues and domestic expenditures (\( GDE \)). In other words, even if the overall budget is in balance or in surplus, the net impact of the government's operations can be expansionary. It is more useful, therefore, to write the money supply identity in terms of the domestic budget balance, as follows:\(^10\)

\[ \Delta M = GDE - DR + X^* - PIM + \Delta CP + PKI + BOP, \]

where \( PIM \) denotes private imports, \( CP \) stands for credit to the private sector, and \( BOP \) represents a residual item in the balance of payments. Because complete data are not available for the government's domestic expenditures (\( GDE \)), the above identity is rearranged in terms of total government expenditure and total imports (Aghaei and Sassanpour (1982)):

\[ \Delta M = G - DR + X^* - IM + \Delta CP + PKI + BOP. \]  

(15)

In equation (15), \( BOP \) is exogenous, and all the other variables except \( CP \) are determined from the equations specified earlier. Therefore, this relationship now determines the flow of credit to the private sector.

**Monetary Disequilibrium**

Two measures of monetary disequilibrium have been used in the literature. The first embodies a stock concept, whereby disequilibrium is

\*If assets are perfectly substitutable, net capital flows will be indeterminate, and the estimates obtained from this equation cannot be interpreted meaningfully.

\(^10\)It is assumed that government foreign receipts equal oil export receipts plus net foreign borrowing.
measured in terms of the deviation of the actual stock of real balances from demand:  

\[ \text{ESD} = (M/P)^d - (M/P)_{i-1}, \]

where ESD is the excess stock demand for real balances.

This concept ignores the role that domestic credit expansion during the period plays in closing the real balance gap. Another measure, proposed by Blejer (1977) and Sundararajan (1986) among others, focuses on the concept of "flow disequilibrium," which makes appropriate allowances for the authorities' attempt to fill the real balance gap through credit creation. Accordingly, the flow excess demand (EFD) is defined as

\[ \text{EFD} = (M/P)^d - (M/P)_{i-1} - \Delta(DA/P)MM, \]

where MM is the money multiplier and \( \Delta DA \) refers to the change in the net domestic assets of the central bank during the period.

The choice of the disequilibrium concept has important implications for the dynamic effects of monetary policy in empirical models dealing with small open economies. In this study, the disequilibrium concept represented in equation (16) is used.

### Expected Income from Oil Extraction

The expected oil wealth \( (F) \) in each period is defined as

\[ F_i = E_i(PV_i) = E_i \left[ \sum_{i=n+1}^{T} \pi_i Q_i / (1 + d)^{i-1} \right], \]

where

- \( PV \) = the present value of the streams of income derived from oil over the lifetime of the resource
- \( d \) = the rate of discount
- \( Q_i \) = the rate of oil exploitation at time \( i \)
- \( \pi_i \) = the price of oil at time \( i \)
- \( T \) = the time of depletion of the oil stock
- \( E_i \) = the expectations operator.

Because \( T \) is unknown, this relationship cannot be readily incorporated in the model. For empirical purposes, a simplified version could be derived on the assumption that the expected rate of oil price inflation is equal to the discount rate. It is well known from the theory of exhaustible

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11 This difference between the two stocks can be viewed as the "flow" demand for real balances; see Sundararajan (1986).
resources that the optimal rate of extraction is determined at the point where the marginal productivity of the resource in all its uses is equalized (see Hotelling (1931) and Davarajan and Fisher (1981)). The expected rate of oil price inflation represents the marginal productivity of oil if left underground, whereas the rate of return on financial assets (or the interest rate) represents the marginal productivity of the resource if invested in financial assets. Thus, at the optimal rate of extraction, the rate of oil price inflation is equal to the interest rate.

In contrast, if expected oil price inflation is higher than the rate of interest, then the optimal policy dictates keeping the resource underground; if it is lower, no equilibrium rate of extraction will exist because it would be optimal to exhaust the resource instantaneously. Assuming that the social discount rate is equal to the rate of interest, and denoting the rate of oil price inflation in period \( t \) by \( r_t \), one can write

\[
F_t = E_t \left[ \sum_{i=1}^{T} \pi_t (1 + r_t)^{-(i-1)} Q_i / (1 + d_i)^{-(i-1)} \right]
\]

where \( S_t \) is the stock of proven oil reserves in time \( t \). Assuming static oil price expectations, \( E(\pi_t) = \pi_t \), the following relationship is obtained:

\[ F_t = \pi_{t-1} S_t. \]  \hspace{1cm} (17)

This simple relationship represents the confidence or wealth effect of natural resource availability. It also embodies the concept of exhaustibility of oil (since \( S_t \) is declining over time), so that this important feature of the oil producing countries is built into the model, albeit in an admittedly crude fashion.

**The Dynamic Process**

To trace the dynamic process embodied in the model, consider the effect of an increase in \( F \) brought about through a resource discovery, so

\(^{12}\)The theory from which these decision rules are derived assumes, among other things, a monopolistic market structure, no binding technological constraints, and full information—none of which may hold in practice. In addition, the decision rules will be more complicated because the rate of return on financial assets may itself be affected by the variations in the price of oil. Given these considerations, the simplifying assumption in the text may be somewhat unrealistic.

\(^{13}\)This assumption can be justified on the grounds that, in a market economy, the most obvious indicator of time preference is the rate of interest. In other words, the interest rate is supposed to adjust until it simultaneously equates the rate of time preference of the marginal individual in the society and the rate of return on productive investment.
that oil revenues do not necessarily rise immediately.\textsuperscript{14} If one abstracts from the accompanying leads and lags, the immediate confidence effect of higher expected wealth directly increases demand for real balances and private consumption expenditures and also influences private investment. These in turn will generate opposing forces that exert both upward and downward pressures on the level of income and prices (as explained in the next paragraph), so that the final outcome cannot be established a priori and needs to be determined empirically.

Initially, the higher demand for money will widen the real balance gap ($EFD$), since $\mu < 1$. This effect will depress the prices of nontraded goods\textsuperscript{15} and, hence, both imports and domestic inflation. The larger monetary disequilibrium will also dampen private demand for consumer goods and depress the growth of non-oil income. The excess of demand for non-oil commodities over potential output will then decline, further depressing non-oil goods prices and domestic inflation.\textsuperscript{16}

Thus, through its impact on demand for real balances alone, an increase in expected real oil wealth would eventually lead to lower domestic inflation and income; it is also likely to lead to an improvement in the current account of the balance of payments because imports decline while exports remain unchanged. The overall balance of payments may also improve if capital outflows—which result, according to equation (13), from a decline in income growth—are not too large.

These results do not, however, constitute the final outcome of an increase in $F$, because the larger $F$ also stimulates private demand for goods and services ($cond_4$). Consequently, aggregate demand ($y^d$) rises relative to supply, putting upward pressure on the prices of nontraded goods and dampening the demand for real balances. A lower monetary disequilibrium will then result that will help to weaken or offset the feedback effects generated through the initial impact of the larger expected oil wealth on demand for real balances.

The net effect of these forces on the prices of nontraded goods will change relative prices. Given the fixed exchange rate, a decline (increase) in the prices of nontraded goods while the level of traded goods prices remains unchanged will result in reduced (increased) demand for imports. Any change in relative prices will also have an impact on domestic

\textsuperscript{14} Oil revenues ($OR$) rise if the extraction rate or the price of oil increases. A resource discovery does not necessarily lead to either of these developments.

\textsuperscript{15} More precisely, the larger real balance gap will reduce the rate of change in nontraded goods prices compared with what that rate would have been in the absence of a change in the real balance gap.

\textsuperscript{16} The ensuing feedback effects will be strengthened or weakened depending on whether private investment is stimulated or depressed by a rise in $F$; that is, whether $u_3$ in equation (3) is positive or negative.
output, the direction of which is ambiguous a priori (as discussed earlier). The net result will feed into the dynamic system described above, strengthening or weakening some of the feedback effects. The final outcome of the movements in the variables depends on leads and lags (which were ignored in the discussion above) as well as on the relative speeds of adjustment and the strength of impact multipliers. These factors also determine the stability characteristics of the system. The eventual outcome for non-oil income, public and private expenditures, and imports will determine GDP and non-oil exports. The capital account as well as the overall balance of payments outcome will then be established, and the level of credit to the private sector will be determined by the money supply identity.\textsuperscript{17}

The distinguishing characteristic of the dynamic process embodied in this model can best be seen with respect to the impact of an increase in oil production (rather than in oil wealth). In contrast to the earlier work on oil producing countries, where an increase in oil production usually leads to a rise in prices and non-oil output, in the present model the impact of an increase in oil production on prices and on non-oil output is ambiguous. The expansion of oil output results in lower availability of the resource (that is, in a smaller $S$), and thereby in smaller expected oil wealth $F$. This outcome will tend to depress domestic output and prices, provided that the impact of the oil wealth effect on private expenditures is stronger than its impact on demand for money, as discussed above.\textsuperscript{18} In contrast, the expansion in oil revenues arising from the larger output will raise government expenditures, which may serve to reverse this trend. The overall impact is therefore not clear a priori.

\section*{II. Estimation Results}

The definition of variables and the complete model are presented, respectively, in Tables 1 and 2 above. The behavioral relationships of the model were estimated by a two-stage least-squares method using annual

\textsuperscript{17} Although the starting point of the above discussion is the effect of a change in $F$, the subsequent argument could be applied to changes in any other variable of the model. Clearly, however, the sequence of events as well as the final outcome will vary according to the nature of the original change. The feedback effects of movements in money supply and capital flows fall on credit to the private sector. Although the exchange rate variable does not enter the model explicitly, the impact of changes in this variable can be analyzed in a similar way. Because a change in the exchange rate affects oil revenues and prices of traded goods instantaneously, its impact on endogenous variables is equivalent to the combined effect of changes in these variables.

\textsuperscript{18} This effect is absent from the previous empirical works on oil exporting countries.
data for the period 1965–81. To ensure that cross-equation restrictions on the parameters of the money demand equation were satisfied, the variable \((M/P)^d\) was replaced by the antilog of 

\[
(1/\mu)[\hat{m} - (1 - \mu)m_{t-1}]
\]

in all estimating equations, where \(\hat{m}\) is the predicted value of \(m\) obtained from the estimated demand for money equation. Similarly, the unobservable variable \(cond\) is formulated from the estimated private consumption equation using the relationship

\[
cond = (con - bscon_{t-1})/(1 - bs),
\]

where \(bs\) is the estimated coefficient of \(con_{t-1}\). This variable was then used to calculate demand for domestic non-oil output \((y^d)\) and for private expenditures \((e)\). A dummy variable \((D)\) was introduced in the capital flow equation to account for unexplained variations in capital flows in 1980/81.

The estimation results are presented in Table 3. On the basis of the usual statistical criteria, the model performs well. The explanatory power of the model's equations is quite reasonable, and all coefficients have the expected signs. Moreover, of the 39 estimated coefficients, all but 8 are significant at more than the 90 percent confidence level, and half are significant at the 99 percent confidence level.

The Confidence Effect of Oil Wealth

The estimation results clearly indicate the existence of an oil wealth effect on the behavior of the economic agents, an aspect that has been neglected in previous analyses of the economies of major oil producers. The variable \(f\) (or \(F\)) is highly significant in all the equations where it appears: those for the demand for money, private consumption, and private investment. As expected, both money demand and private consumption respond positively to changes in expected oil wealth. A 1 per-

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19 Data sources are given in the appendix. The consumer price index \(P\) has been used as the deflator except in the case of imports, for which an index of traded goods prices—calculated from partner country data—has been used. A systems estimation method, such as full information maximum likelihood (FIML), would have been preferable for reducing the simultaneous equation bias and to ensure that the a priori restrictions on parameters were satisfied. Such a method, however, could result in large specification errors, especially for small samples.

20 The coefficient of \(m_{t-1}\) in equation (1) in Table 3 is equal to \(1 - \mu\).

21 These results should be interpreted with caution because, for small samples, the properties of the probability distribution of coefficients estimated by the two-stage least-squares method are not well known. Goldfeld (1966) believes that this procedure tends to produce conservative \(t\)-statistics.
Table 3. Estimated Model

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand for real balances (equation (1))</td>
<td>[ m = 8.362 + 1.228y + 0.154f - 0.00111y + 0.327m_{t-1} ]</td>
</tr>
<tr>
<td></td>
<td>[ (-4.712) (4.457) (2.894) (-1.701) (2.021) ]</td>
</tr>
<tr>
<td></td>
<td>[ R^2 = 0.992 \quad H = 0.335 \quad SEE = 0.045 ]</td>
</tr>
<tr>
<td>Real private consumption (equation (2))</td>
<td>[ \Delta \text{con} = -0.632 + 0.229y + 0.063f - 0.000011EFD_{t-1} + 0.680\text{con}_{t-1} ]</td>
</tr>
<tr>
<td></td>
<td>[ (-2.754) (4.866) (2.900) (-0.592) (9.329) ]</td>
</tr>
<tr>
<td></td>
<td>[ R^2 = 0.997 \quad H = -1.183 \quad SEE = 0.019 ]</td>
</tr>
<tr>
<td>Real private investment (equation (3))</td>
<td>[ KFIP = -1645.94 + 1.071(Y/P) - 0.01(F/P) - 0.159(K/P)_{t-1} + 1125.76q ]</td>
</tr>
<tr>
<td></td>
<td>[ (-2.101)(4.248) \quad (-2.493) \quad (-1.349) \quad (-2.666) ]</td>
</tr>
<tr>
<td></td>
<td>[ R^2 = 0.924 \quad DW = 1.449 \quad SEE = 1586.0 ]</td>
</tr>
<tr>
<td>Domestic inflation (equation (4))</td>
<td>[ \Delta p = 0.115 + 0.265\Delta y' + 0.410\Delta k - 0.000001 \Delta EFD + 0.034\Delta p' ]</td>
</tr>
<tr>
<td></td>
<td>[ (5.403) (3.385) \quad (-7.243) \quad (-0.967) \quad (0.803) ]</td>
</tr>
<tr>
<td></td>
<td>[ R^2 = 0.966 \quad DW = 2.140^2 \quad SEE = 0.019 ]</td>
</tr>
<tr>
<td>Growth of non-oil income (equation (5))</td>
<td>[ \Delta y = +1.545 + 0.466y' + 0.017(p^* - p') - 0.000001EFD_{t-1} - 0.622\text{y}_{t-1} ]</td>
</tr>
<tr>
<td></td>
<td>[ (-2.052) (5.078) (0.882) (-0.141) (-4.279) ]</td>
</tr>
<tr>
<td></td>
<td>[ R^2 = 0.795 \quad DW = 2.342 \quad SEE = 0.02 ]</td>
</tr>
</tbody>
</table>
Imports (equation (8))

\[ \log m = -5.585 + 0.316e + 0.835g + 0.878(p^* - p^t) + 0.418\text{int}_{t-1} \]

\( R^2 = 0.993 \quad H = -0.562 \quad \text{SE} = 0.047 \)

Government domestic revenues (equation (10))

\[ dr = -8.608 + 1.605g \]

\( R^2 = 0.954 \quad DW = 1.930^2 \quad \text{SEE} = 0.069 \)

Government expenditure (equation (11))

\[ g = 0.304gr + 0.698g_{t-1} \]

\( R^2 = 0.976 \quad H = 0.158 \quad \text{SEE} = 0.068 \)

Private capital flows (equation (13))

\[ PKJ = -7121.360 + 1738.04(i - \pi_t) + 0.157\Delta GDP + 0.009\Delta YUS - 27070.80 \]

\( R^2 = 0.919 \quad DW = 2.073^2 \quad \text{SEE} = 2920 \)

\( \text{Note: Figures in parentheses are } t \text{-ratios; } R^2 \text{ is the adjusted coefficient of determination; } DW \text{ is the Durbin-Watson statistic; } H \text{ is the Durbin } H \text{-statistic; and } \text{SEE} \text{ is the standard error of the estimate.} \)

1 The domestic interest rate was deleted from this equation because it did not prove to be significant and its inclusion did not improve the standard error of the equation. Moreover, since bolivars have been stable in relation to the U.S. dollar for almost all of the estimation period, the expected exchange rate change has been assumed to be zero. The foreign interest rate was proxied by the three-month U.S. Treasury bill rate. Various formulations of actual and expected inflation were also included in this equation to reflect the opportunity cost of holding money instead of real assets but were dropped because their estimated coefficients were found invariably to carry the wrong sign, to be statistically insignificant, or to lead to unstable simulations. This does not necessarily imply, of course, that this opportunity cost of holding money is irrelevant to the money demand function in Venezuela, only that the mechanism for its measurement is more complicated.

2 Corrected for autocorrelation by the Cochrane-Orcutt transformation.
cent increase in the expected oil wealth, everything else remaining equal, eventually raises both the real demand for money and private consumption by 0.2 percent. Because demand for money is stimulated by resource availability, expansionary monetary policy would be less inflationary in the presence of the oil wealth effect than in its absence.

Expected oil wealth tends to have an adverse impact on private investment (since the parameter $u_3$ is negative). As discussed earlier, this may reflect the competing nature of private and government investment expenditures as perceived by private entrepreneurs. The availability of petroleum resources reduces the private sector’s propensity to save and its demand for investment. As a result, the growth prospects of the economy would depend, to a larger extent than in other countries, on the activities of the government. This finding highlights the importance of the composition of government expenditure for the growth prospects of oil-based economies. Whether oil wealth will act as a stimulant or a barrier to economic growth in the long run depends on the government’s ability to take a leading role in expanding the productive capacity of the economy through appropriate expenditure policies and through appropriate incentive schemes for the private sector to help mitigate the adverse influence of oil wealth on private investment.

**Monetary Disequilibrium**

The results indicate that monetary disequilibrium is not a significant variable in the determination of private expenditures. The implication of this result is that, given the financial structure of the economy, monetary disequilibrium probably affects the interest rate, the exchange rate (relative prices), or capital flows and that it influences expenditures, mainly indirectly, through prices; direct effects are insignificant. Thus, the role of credit policy would also be to influence the interest rate, the exchange rate, and capital flows, and, through them, expenditures.

**Demand for Money**

The estimated results of the money demand equation indicate that the main determinants of money demand in Venezuela are non-oil income and expected oil wealth. Contrary to expectations, the influence of the foreign interest rate on Venezuela’s open economy is not highly significant (t-probability of the estimated coefficient is 0.89), and the long-run interest elasticity of money demand is not very large; a 1 percent increase in the foreign interest rates, everything else remaining unchanged, reduces the demand for real balances by 0.02 percent. As can be expected
in an open economy, equation (1) reveals the rapid adjustment of the actual to the desired level of the real money stocks ($\mu = 0.67$): 90 percent of all the adjustments occur in the first 24 months following a disturbance.22

**Private Expenditures**

The results show that real private consumption is also determined primarily by the income and wealth variables ($y$ and $f$, respectively). The influence of monetary disequilibrium on private consumption decisions seems to be negligible.23 The actual level of real private consumption exhibits substantial sluggishness in adjusting to the desired level; only 50 percent of the adjustment occurs in the first two periods after a disturbance.

In addition to expected oil wealth and non-oil income, as shown by the results the relative price of capital is also an important determinant of private investment demand. Because the interest rate enters the calculation of the relative price variable, it could be argued that private investment is sensitive to changes in the interest rate, so that the growth rate of the economy is also affected by movements in the rate of interest. The estimated coefficient of lagged capital stock does not turn out to be significant, pointing to the possibility that the positive effect arising from replacement investment is offset by the low speed of adjustment of actual investment to the desired level.

**Non-Oil Income**

The estimated equation for the growth of non-oil income indicates that domestic output responds strongly to the disequilibrium in the home-goods market but is not significantly affected by monetary disequilibrium or the terms of trade.24 The results indicate, however, that an improvement in the relative price of nontraded goods could stimulate the supply

22 Adjustment over $T$ periods is calculated as $\sum_{t=0}^{T-1} \mu (1 - \mu)^t$.
23 A variable that does not appear to be significant in a particular equation could, however, be significant in the context of the model as a whole, and its omission could result in appreciable changes in other coefficients of the model.
24 The coefficients of $y^t$ and $y_{t-1}$ (the variables that constitute the components of excess demand in the goods market) are significant at the 1 percent level in equation (4). The results for this equation, as well as for those for domestic inflation, are quite reasonable in view of the fact that these equations are estimated in the first-difference form; even if original errors are independent, negative correlation could be introduced in first-difference equations, rendering both the standard error of the coefficients and the $R^2$ biased.
of domestic non-oil output despite a shift in demand from domestic to imported commodities.

**Inflation**

The rate of inflation is determined primarily by the level of disequilibrium in the commodity market, which is measured by the excess of demand over potential output (Table 3). The disequilibrium variable enters the equation through its components $y^d$ and $k$, and its impact on the inflation rate cannot be easily quantified. As indicated by relevant elasticities, however, the rate of inflation is more responsive to supply rather than demand factors; a 1 percent increase in the growth of potential output, everything else remaining equal, reduces the rate of inflation by 0.41 percent, whereas the same increase in the growth of demand raises the inflation rate by 0.27 percent.

**Imports**

The estimation result of the import equation indicates that government expenditure and relative prices are the main determinants of import demand. The elasticity of imports with respect to government expenditure is almost four times larger than that with respect to private expenditure, reflecting mainly the large import content of government outlays. The relative price elasticity of imports is estimated at 1.5, indicating that a 1 percent devaluation would reduce imports by 1.5 percent. However, the adjustment of actual imports to the desired level is very slow; the mean lag of adjustment (calculated as $(1 - k_s)/k_s$) is shown to be 17 months.

**Government Expenditure and Revenues**

The estimated equation for government expenditure indicates that the government’s budgetary policy has been formulated as if to aim at a balanced budget over the long term. It also shows that government expenditures are adjusted slowly in response to changes in revenues; no more than 30 percent of any difference between government revenues and expenditures can be corrected in any one period. Government domestic revenues are shown to be strongly responsive to non-oil income, which alone explains 95 percent of their variations. Inclusion of oil revenues as a separate explanatory variable in this equation did not improve explanatory power, and the variable did not turn out to be significant. To

25 The estimated coefficients of grand $g_r$ and $g_{r-1}$ add up to unity.
the extent that oil receipts have any indirect impact on domestic revenues, this effect is therefore likely to be captured by the non-oil income variable.

Capital Flows

The estimated equation for capital flows indicates that private short-term capital flows respond strongly to interest rate differentials between Venezuela and the United States and to GDP growth in both Venezuela and the United States. If the interest rate differential widens by 1 percentage point in favor of domestic rates, short-term capital flows would grow by Bs 1,738 million. The growth of domestic output results in larger movements in capital flows than does growth of U.S. GDP. A structural change in the behavior of capital flows seems to have occurred in 1980, as indicated by the strong statistical significance of the dummy variable.

The above discussion has focused on the direct impact of changes in explanatory variables on the dependent variables. It has ignored the feedback effects from the rest of the model implied by a simultaneous system. Because the model is nonlinear in variables, it cannot be solved to obtain the impact and dynamic multiplier effects of the exogenous variables on the endogenous variables. The model is therefore simulated to examine the effects of exogenous shocks and changes in policy variables.

III. Simulation Results

To test its reliability in tracking the endogenous variables, the model was simulated over the sample period using the estimated coefficients, the actual values of the exogenous variables, and the lagged values generated by the model. Simulation results (presented in Chart 12 in the

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26 These results are in contrast to those obtained by Khan (1974), in which GDP growth in either country was not found to be a significant factor affecting capital movements in Venezuela.
27 Given the wide fluctuations in these flows, the extent of the variations explained by the capital flow equation (92 percent) is quite impressive. The results of this equation are superior to those obtained by Khan (1974), both in terms of the explanatory power of the equation and the significance of the variables. This superiority could be attributable in part to Khan’s use of the change in U.S. interest rates as an explanatory variable instead of interest rate differentials, as in the present study.
28 This procedure is called dynamic simulation. It provides a more rigorous test of model stability than static simulation because in static simulation actual values of the lagged endogenous variables are used, whereas in dynamic simulation errors can accumulate over time.
appendix) indicate that the model tracks the time path of the endogenous variables quite well. In almost all cases, the turning points are well captured by the simulated results. As shown in Table 4, correlation of the actual and simulated series of endogenous variables is quite high. The smallest correlation coefficient is obtained for the capital flow equation. Even in this case, however, the correlation is close to 0.9—quite impressive given the volatility of such flows.

To quantify the impact of the wealth effect and of a change in oil prices, the following experiments were conducted. First, oil prices were assumed to increase by 25 percent in 1970 and to return to their historical level in the following year. This assumption implies that both oil revenues (OR) and expected oil wealth (F) increase by 25 percent in 1970 and 1971, respectively. In the rest of this section this experiment is referred to as the full oil price shock. In the two succeeding experiments, the impact of this type of disturbance was broken down into two separate components, the income effect and the confidence effect. First, oil revenues were allowed to increase by 25 percent in 1970, with the expected oil wealth remaining unchanged (referred to as the partial oil price shock). Although this is an unlikely possibility in practice, it serves to demonstrate the impact of an oil price hike on the economy as captured by earlier models of oil producing countries that concentrate on the income effect and exclude the expected wealth effect of such shocks. The final experiment attempts to record the latter effect, represented by the influence of a temporary increase in F that is not accompanied by a change in oil revenues (called the resource discovery shock).

29 A price hike always affects expected oil wealth, even if the price hike is accompanied by an equivalent expansion in oil output. In the latter case, expected oil wealth decreases in the period when output grows but remains unchanged in the subsequent periods (F = π_τ - 1 S).

30 Again, this is an unlikely scenario because it implies a temporary increase in S. It is examined here in an attempt to isolate the impact of oil wealth on the economy.

Table 4. Correlation Between Actual and Simulated Values, 1966–81

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>0.985</td>
</tr>
<tr>
<td>con</td>
<td>0.999</td>
</tr>
<tr>
<td>P</td>
<td>0.996</td>
</tr>
<tr>
<td>m</td>
<td>0.992</td>
</tr>
<tr>
<td>KE/P</td>
<td>0.929</td>
</tr>
<tr>
<td>g</td>
<td>0.989</td>
</tr>
<tr>
<td>dr</td>
<td>0.959</td>
</tr>
<tr>
<td>im</td>
<td>0.990</td>
</tr>
<tr>
<td>PKi</td>
<td>0.909</td>
</tr>
</tbody>
</table>
The results of these experiments are reported in Charts 1–11, which record the difference between the values of endogenous variables after the shock and those before the shock, which were obtained from a control simulation. These differences are expressed in percentages, except in the case of inflation (INF), relative prices ($P^*/P'$), capital flows (PKI), and the balance of payments ($\Delta R$), for which the absolute difference between the values obtained from shock simulations and from the control simulation has been presented.

The results of the first two experiments clearly show that ignoring the wealth effect can have serious adverse implications for the design of economic policy in the face of disturbances. Consider the impact of various shocks on real private consumption expenditures. A temporary increase of 25 percent in the price of oil at an unchanged level of wealth effect (or partial oil price shock) would increase real private consumption by about 0.9 percent above the level consumption would have attained in the absence of the disturbance. This occurs within five periods following the shock (Chart 1). Thereafter the impact dissipates slowly, reflecting the sluggishness of the adjustment, but consumption remains slightly above the control level even ten years after the original shock.

The impact of a full oil price shock—that is, a price shock when its associated wealth effect is not neutralized—is much more substantial. Real private expenditures rise by more than 1.5 percent within two years and remain at a higher level than that resulting from a partial oil price shock.

**Chart 1. Impact of Exogenous Disturbances: Real Private Consumption**

*In percentage deviation from control simulation*

![Chart 1](image)

Note: Here and in Charts 2–11, POS indicates partial oil price shock, FOS indicates full oil price shock, and RDS indicates resource discovery shock.
shock. The steeper increase is attributable to the impact of the wealth effect on private consumption. This finding is confirmed by results of the third experiment, in which the shock consists of a resource discovery, so that only the oil wealth is increased (by 25 percent). This experiment also shows that the impact of a temporary increase in expected wealth, although substantial, tends to wear off rapidly and, unlike the impact of an increase in oil revenues, dissipates completely about ten years after the original shock.

The significance of the oil wealth effect is more pronounced in the case of its impact on private capital formation (Chart 2). Whereas changes in real private investment resulting from the partial oil price shock are almost imperceptible, those brought about by the full price shock are substantial. The wealth effect associated with the full price shock results in an immediate decline of about 4 percent in private real investment. This is corrected in the next period, however, because the growth of non-oil income—itself stimulated by the increase in expected oil wealth—compensates for the adverse impact of higher expected wealth on investment. For the rest of the simulation periods, the level of real private capital formation remains above the level it would have attained in the absence of the shock. The effects of two types of price shocks on non-oil income tend to converge as the influence of higher expected oil wealth dissipates, leading eventually to the same proportionate expansion in non-oil output (Chart 3).

**Chart 2. Impact of Exogenous Disturbances: Real Private Investment**
*(In percentage deviation from control simulation)*

![Chart 2](chart2.png)

**Note:** See note to Chart I.

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Chart 3. Impact of Exogenous Disturbances: Non-Oil Revenues
(In percentage deviation from control simulation)

The confidence effect of the oil wealth influences primarily the behavior of the private sector. As a result, government expenditure responds in an almost identical manner irrespective of the nature of the oil price disturbance and is only slightly affected by the resource discovery shock (Chart 4). Both types of oil price shocks lead to a sharp expansion of about 5 percent in expenditure in the first period, followed thereafter by

Chart 4. Impact of Exogenous Disturbances: Government Expenditure
(In percentage deviation from control simulation)
a slow adjustment toward the historical level. However, reflecting their responsiveness to non-oil income, government domestic revenues are affected differently by the two types of price shocks. Government revenues rise more substantially if the oil wealth effect is present than if it is not (Chart 5).

Reflecting the dominant influence of government expenditure on imports, a pattern similar to that of the former emerges for imports in the aftermath of exogenous disturbances (Chart 6). The time path of imports is also affected, however, by the impact of disturbances on relative prices. Because of the associated wealth effect, the full oil price shock causes a larger improvement in relative prices, in favor of nontraded goods, than does the partial oil price shock (Chart 7). This outcome reinforces the indirect influence of the wealth (or confidence) effect on imports, so that the initial difference between the effects of full and partial oil price shocks on imports is larger than the difference observed in the impact of these shocks on government expenditure. The time paths of imports resulting from the two types of shocks converge later, in line with the diminishing influence of the temporary increase in the wealth effect.

The oil price shocks have a sharp but ephemeral impact on capital flows (Chart 8). In the first period net inflows grow by almost Bs 530 million.\(^{31}\)

\(^{31}\)The charts for capital flows (Chart 8) and the balance of payments (Chart 9) record the time path of the absolute (rather than percentage) difference between the shock simulations and the base run. This is necessary because these variables can be positive or negative during the sample period.

**Chart 5. Impact of Exogenous Disturbances: Government Revenues**

*(In percentage deviation from control simulation)*

![Chart 5](chart5.png)

Note: See note to Chart 1.
Chart 6. Impact of Exogenous Disturbances: Imports
(In percentage deviation from control simulation)

chart showing imports over time with different disturbance scenarios.

Note: See note to Chart 1.

Chart 7. Impact of Exogenous Disturbances: Relative Prices
(In percentage deviation from control simulation)

chart showing relative prices over time with different disturbance scenarios.

Note: See note to Chart 1.

over the historical level in response to the full oil price shock, of which Bs 470 million is due to the income effect and the rest to the confidence effect (indicated by the partial price shock and the resource discovery shock, respectively). Thus, although the wealth effect has an appreciable impact on private capital flows, its impact is overshadowed by the influence of the growth in oil revenues (and hence in domestic GDP) on such
flows.\textsuperscript{32} In the second period, net inflows decline as GDP growth slows down, and the impact of the shocks fades rapidly in the subsequent periods as GDP growth is restored to its historical level.\textsuperscript{33}

These results imply that the failure to take the wealth effect of oil price hikes into account could lead to a substantial underestimation of their adverse effect on the balance of payments in the medium term. This conclusion is confirmed by the results obtained for the balance of payments under various external disturbances (Chart 9). In the first period, both types of price shocks result in an improvement in the balance of payments as oil exports increase, but the impact of the full oil price shock is more pronounced, owing mainly to the influence of the wealth effect on capital flows. This improvement is followed by a sharp deterioration in the balance of payments, reflecting the combined effects of the growth of imports, increase in capital outflows, and reduction in export revenues (from the level achieved immediately after the shock). Again, the wealth effect has a substantial impact that causes a deterioration in the balance of payments that is sharper under the full price shock than under the non-price shock. \textsuperscript{32}GDP growth is an argument in the capital flows equation.

\textsuperscript{33}Because oil is the dominant component of GDP in Venezuela, GDP grows rapidly in the first period as oil revenues increase. The second period witnesses a decline in GDP (compared with the historical trend) as oil revenues are restored to their original level. Thereafter, GDP growth reflects only the increase in non-oil output because oil income remains unchanged.
partial shock. Moreover, although under the partial shock the balance of payments improves during several succeeding periods, this is not the case under the full price shock. The demand effect of the temporary increase in expected oil wealth wears off slowly, thus helping to raise the level of absorption and resulting in a larger deterioration in the balance of payments.

The time paths of inflation (INF) in response to different types of oil price shocks are markedly distinct (Chart 10). Initially the rate of inflation rises in relation to the historical level as a result of either type of price shock, reflecting the dominance of demand effects associated with higher oil revenues. The increase is considerably steeper in the case of the full oil price shock, however, owing to the impact on private expenditure of the wealth effect associated with this type of disturbance. In the next period the supply effect of higher oil revenues becomes dominant, resulting in a decline in the inflation rate. Again the decline is steeper—and the inflation rate actually falls below the historical level—in the case of the full price shock as the wealth effect leads to a greater monetary disequilibrium, which, in turn, exerts a further dampening impact on domestic inflation. Eventually, as the impact of the higher expected oil wealth wears off, both types of shocks produce a similar trend in domestic prices, with the inflation rate remaining below the historical level.

The discussion so far has indicated that the presence of an oil wealth or confidence effect exacerbates the impact of oil price shocks on the economy of Venezuela. In particular, because of the wealth effect these
disturbances entail, they are likely to affect the balance of payments more substantially and bring about wider fluctuations in domestic prices than previously thought. Although the impact of oil price shocks on domestic price inflation would be eventually dampened by the wealth effect, an oil price hike could generate stronger inflationary pressures in the initial stages. Therefore, in periods of rising oil prices, achieving balance of payments equilibrium or price stability would pose more significant policy challenges than previously recognized.

Although an analysis of the nature and adequacy of different policy responses that may be called for in the face of oil price shocks is beyond the scope of this paper, monetary policy implications are evident from the simulation results. The demand for real balances, and hence the level of monetary disequilibrium, shifts significantly as a result of the various shocks (Chart 11). Failure to account for the wealth or confidence effect of oil price shocks, however, leads to a serious underestimation of the shift in demand for real money balances; whereas the full oil price shock leads to an increase of more than 4 percent in the demand for money in the first period after the shock, the partial oil price shock causes an increase of no more than 1 percent. The magnitude of the shift in monetary disequilibrium, and that of the task confronting monetary policymakers, is thus substantially larger when the wealth effect of resource availability is taken into account. In addition to its implication for the magnitude of policy response, the wealth effect has significant implications for the timing of monetary policy. The results show, for instance,
that failure to take the wealth effect into account may result in a gradualist policy in the face of shocks, with the magnitude of intervention increasing slowly and reaching its peak five to six years after the original shock. If the wealth effect is recognized, in contrast, the appropriate policy response would consist of a massive initial intervention which diminishes in intensity in subsequent periods.

**IV. Conclusions**

The paper has examined the implications of the availability and exhaustibility of oil resources for the economy of Venezuela in the framework of a model that incorporated the concept of exhaustibility and specified the main channels through which the availability of the resource (and the flow of income generated by it) affects economic variables. The estimation and simulation results confirmed that the availability of the resource entails a confidence effect that influences the behavior of the private sector. It was also confirmed that this effect is transmitted through demand for real balances and private expenditures (consumption and investment).

The empirical results indicated that, through its impact on money demand, the confidence effect associated with the availability of oil eventually dampens the inflationary consequences of expansionary pol-
icy. The confidence effect, however, adversely influences private saving and investment, and it imparts more significance to the pattern of government expenditure—as opposed to its level—in the oil producing countries compared with other developing countries. This implies that the growth prospects of the economy would depend on the ability of the government, which is the recipient of oil revenues, to embark on adequately productive projects that compensate for the adverse effect of expected oil wealth on the willingness of the private sector to undertake investment and that prepare the country for the eventual depletion of oil resources. A further implication is that private investment would need to be encouraged through incentive schemes that compensate for the adverse influence of oil wealth.

The speed of adjustment in money demand was found to be rapid, whereas that in the real sector tended to be sluggish, implying that changes in monetary disequilibrium are transmitted to the rest of the economy more quickly than are movements in the level of disequilibrium in the goods market. The authorities may thus have more time in containing the impact of real shocks to the economy than they will have in containing the consequences of financial disturbances.

The simulation results also showed that the impact of an increase in oil prices on the economy can be substantially more pronounced in the presence of an oil wealth effect than in its absence. In particular, failure to take the confidence effect of resource availability into account could lead to serious underestimation of the adverse influence of an oil price hike on the balance of payments and inflation. Moreover, it was shown that, eventually, the wealth effect tends to dampen the inflationary impact of rising oil prices, but it continues to exacerbate the adverse impact of such developments on the balance of payments. Thus, a major policy challenge facing the authorities during periods of rising oil prices would be that of devising a response that reconciles the dual objectives of balance of payments equilibrium and price stability. Moreover, in designing their policies in the face of disturbances, the authorities would have to keep in mind not only the nature of the shock but also the extent of the wealth effect associated with the country’s petroleum resources.

Although the nature and effectiveness of various policy responses that could be initiated to achieve balance of payments equilibrium and price stability in the aftermath of exogenous shocks were not discussed, the simulation results indicated that, at least in the case of monetary policy, the magnitude of the required response is substantially larger if the wealth effect is taken into account. It was also shown that the timing of intervention could be critical to the success of any monetary policy initiative. To devise an appropriate policy response, the authorities would
need to know the time paths of the target variables that are likely to emerge both as a consequence of exogenous disturbances and in response to a policy intervention. Experiments similar to those conducted in this paper could serve to shed some light on these outcomes.

Although the model performed well in terms of the usual statistical criteria, the policy implications mentioned above need to be interpreted cautiously, primarily because of the small size of the sample and the large number of exogenous variables. In addition, the model needs to be modified slightly to account for the changes in the exchange system of Venezuela that have occurred since early 1983, so that its relevance and robustness could be tested against the developments in the Venezuelan economy during the post-sample period. For example, the model could be rendered more appropriate for policymaking purposes by endogenizing such important variables as the behavior of banks, represented by the excess reserves ratio, and the behavior of the private sector, such as the cash deposit ratio. The model could also be extended to incorporate more explicitly other policy variables, such as the exchange rate.

APPENDIX

Data Sources and Simulation Results

All the data used in the study, except for those mentioned below, have been obtained from the International Monetary Fund’s International Financial Statistics (Washington, various issues).

The index of traded goods price ($p'$) was calculated as the weighted average of trading partners’ export prices, adjusted for the exchange rate. The countries and weights used were the following: United States (0.33), Netherlands Antilles (0.14), Canada (0.08), Japan (0.06), Italy (0.06), Brazil (0.04), Germany (0.03), other (0.26).

The level of oil production ($OP$) and the stock of oil reserves ($S$) in 1982 were obtained from various issues of the Petroleum Economist (London). The stock of oil for other periods was obtained as

\[ S_t = S_{1982} + \sum_{i=t+1}^{1982} OP_i; \quad t = 1963-81. \]

Domestic oil consumption ($DOC$) was obtained from various IMF reports on Venezuela.

The following variables were derived residually:

- non-oil GDP, $Y$:
  \[ Y = GDP - oil \text{ exports} - \text{domestic consumption of oil} \ (DOC); \]
- private expenditures, $E$:
  \[ E = Y - GE - X^* + IM - DINV; \]
Chart 12. Dynamic Simulations
(In millions of bolivares unless noted otherwise)

A. Real GDP

B. Real private consumption

C. Real private investment

D. Government expenditure

E. Absorption
Chart 12 (concluded).

F. Real money balances

G. Relative prices (percent; 1967 = 100)

H. Imports

I. Private capital flows

J. Balance of payments
private capital inflows (net), \( PKI \):

\[
PKI = \Delta M - GE + DR - X^* + IM - \Delta CP;
\]

domestic government revenues, \( DR \):

\[
DR = GR - OR.
\]

The dummy variable \((D)\) was set equal to unity for 1980 and 1981 and equal to zero otherwise. Domestic and foreign interest rates were measured by the rate offered on one-year deposits in Venezuela and by the three-month U.S. Treasury bill rate, respectively.

Simulation results, discussed in Section III of the text, are presented graphically in Chart 12, panels A–J.

References


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Financial, Exchange Rate, and Wage Policies in Singapore, 1979–86

Ichiro Otani and Cyrus Sassanpour*

Singapore’s recent experience with the conduct of financial and exchange rate policies suggests that the authorities’ ability to implement an independent monetary policy has been constrained. Because the economy is small and highly integrated with international markets, movements in the money supply have been influenced significantly by developments in the external sector, and domestic interest rates have been determined largely by foreign rates. At the same time, the authorities’ exchange rate policy has been geared toward the often conflicting objectives of mitigating external inflationary pressures and sustaining economic activity by increasing external competitiveness.

The cornerstone of financial policies in Singapore has been budgetary discipline, evidenced by the government’s budget surpluses that have been recorded every year since the late 1960s. These surpluses have been substantially augmented by savings generated by the social security scheme (Central Provident Fund) and government-controlled financial institutions (for example, the Post Office Savings Bank), which have been deposited in government accounts with the Monetary Authority of Singapore (MAS). Consequently, government financial operations have drained liquidity from the banking system, creating persistently tight liquidity conditions.

Because the banking sector has easy access to international capital markets, the tight conditions of domestic liquidity have been eased by the inflow of funds from abroad. In the process, the authorities have provided domestic liquidity to the banking system by purchasing foreign exchange from, or arranging swap transactions with, the commercial banks. As a

* This paper was published in Staff Papers, International Monetary Fund, Vol. 35 (September 1988), pp. 474–95. The views expressed are the authors’ and do not necessarily represent those of the IMF.

1 Edwards and Khan (1985) found that over 90 percent of movements in domestic interest rates in Singapore were explained by changes in foreign rates.

2 Under these swap arrangements, the MAS typically purchases foreign exchange from commercial banks at the prevailing spot exchange rate with the provision to unwind the swap on a future date at a rate determined at the time of the arrangement.
result, the short-run increases in the net foreign assets of the MAS have been closely associated with increases in government deposits with the MAS. Reflecting these financial policies, monetary aggregates have exhibited significant short-term fluctuations, but over the longer run the upward trend in foreign assets has sustained the underlying growth of domestic liquidity.

Exchange rate movements have reflected the authorities' reserve management policies. During 1979-84, increases in foreign reserves were rather moderate, and the effective exchange rate of the Singapore dollar appreciated substantially. Since early 1985, however, the level of reserves has risen sharply, and the effective exchange rate depreciated markedly, reversing most of the appreciation that had taken place earlier.

To benefit from the emerging pattern of external demand, the authorities pursued a high wage policy during 1979-85 with a view to inducing a shift in production away from labor-intensive to capital-intensive and "high-tech" activities. During this period labor costs increased at an annual average rate of 15 percent as nominal wages increased rapidly and the employers' (as well as workers') contributions to the Central Provident Fund were raised significantly. This wage policy had important implications for Singapore's external competitiveness and, thus, for economic activity. During the first half of the 1980s, Singapore's external competitiveness, measured in relative unit labor costs adjusted for the exchange rate, deteriorated by more than 60 percent, contributing to the slowdown in economic activity and to the severe, but short-lived, recession in 1985—the first decline in more than two decades. In 1986, concerned with the loss of external competitiveness, the authorities implemented several measures to reduce labor costs, including imposing limits on nominal wage increases and reductions in contributions to the Central Provident Fund. The reduction in unit labor costs, together with the depreciation of the Singapore dollar, helped to regain some of the lost external competitiveness and contributed to economic recovery.

Although the causal links between key macroeconomic variables described above have been well identified, there has been little attempt to formalize such relationships. The present paper is an attempt to fill this gap. The major objectives are to analyze transmission processes and to quantify the importance of alternative policy instruments in influencing key macroeconomic variables, including output, prices, the ex-

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3 This rate is defined as a weighted average of the bilateral exchange rates between the Singapore dollar and the currencies of Singapore's major trading partners and competitors.

4 Different aspects of financial and exchange rate policies in Singapore have been reviewed by studies contained in Singapore (1981).
change rate, and foreign reserves. For this purpose, a simple short-term model is formulated and estimated, and various policy simulations are conducted.

Section I discusses the underpinnings to the specification of the model, taking into account the unique features of the Singapore economy. Section II presents the estimates of the behavioral equations, and Section III analyzes the simulation results based on alternative policy scenarios. Section IV makes some concluding remarks and draws policy implications for macroeconomic management in Singapore. Data sources and definitions are given in the appendix.

I. Model Specification

In this section a simple macroeconomic model is formulated to describe the movements of foreign reserves, the exchange rate, prices, real output, and government revenue and expenditure.

Foreign Reserves

Because financial operations have consistently resulted in a significant drainage of liquidity, as explained earlier, a familiar feature of financial operations in Singapore has been increases in net foreign assets to eliminate the domestic excess demand for money. To describe this aspect of adjustment, we assume that actual holdings of real money balances \((M/P)\) adjust with a lag to the difference between the desired holdings \((M/P)^d\) in the current period and the actual holdings in the previous period. The rationale behind this equation is that, if the current demand exceeds the actual holdings in the previous period, the public adjusts its holdings by adding to its balances, and vice versa. This partial adjustment mechanism, expressed in terms of natural logarithms, can be described as

\[
\Delta \ln (M/P)_t = k [\ln (M/P)^d_t - \ln (M/P)_{t-1}],
\]

where \(k\) is the coefficient of adjustment and is expected to be positive and less than unity, and \(\Delta\) is the first-difference operator.

The demand for real balances is specified as a function of real output \((Y)\) and the domestic interest rate \((r_d)\), with the latter measuring the opportunity cost of holding money:

\[
\ln (M/P)^d_t = \alpha_0 + \alpha_1 \ln Y_t + \alpha_2 (r_d)_t,
\]

\(^5\)In analyzing the money demand in Singapore, Khan (1981) found that the empirical results rendered considerable support for this type of dynamic specification.
where $\alpha_1$ denotes the income elasticity and is expected to be positive, and $\alpha_2$ is the semi-interest-rate elasticity and is expected to be negative.

From the money supply identity, changes in the stock of money are equal to the sum of changes in net foreign assets ($R$) and changes in net domestic assets ($D$):

$$\Delta M_t = \Delta R_t + \Delta D_t.$$  \hspace{1cm} (3)

This relation can be log-linearized about the sample means and expressed in terms of the rate of change of variables in real terms as

$$\Delta \ln (M/P)_t = m_0 + m_1 \Delta \ln (R/P)_t + m_2 \Delta \ln (D/P)_t,$$  \hspace{1cm} (4)

where $m_1 = (\bar{R}/\bar{M})$ and $m_2 = (\bar{D}/\bar{M})$ are, respectively, ratios of the sample means of net foreign assets and net domestic assets to the money supply, lagged by one period.

Substituting equations (2) and (4) in equation (1) and rearranging terms result in an equation that expresses the rate of change of net foreign assets in real terms as a function of variables in the demand for money equation, the lagged level of real balances, and the rate of change of domestic assets in real terms:

$$\Delta \ln (R/P)_t = (m_0 + k\alpha_0)/m_1 + k\alpha_1/m_1 \ln Y_t + k\alpha_2/m_1 (r_d)_t,$$

$$- k/m_1 \ln (M/P)_{t-1} - m_2/m_1 \Delta \ln (D/P)_t.$$  \hspace{1cm} (5)

According to equation (5), reserve accumulation occurs as long as the demand for money is left unsatisfied at the beginning of the period and is not met by domestic credit creation during this period.\(^6\)

### Exchange Rate

Exchange rate policy in Singapore should be viewed as an integral part of the authorities’ financial management. By providing domestic liquidity to the commercial banks through swap arrangements or outright purchases of foreign exchange, the authorities have accumulated foreign assets to relieve the upward pressure on the exchange rate. At the same time, however, the authorities have had to consider the implications of the intervention policy for monetary stability and thus face a trade-off between the exchange rate and monetary objectives.\(^7\)

\(^6\)This formulation is consistent with the monetary approach to the balance of payments, as highlighted by Frenkel and Johnson (1976) and International Monetary Fund (1977), and as applied to small open economies by Otani and Park (1976) and Sassanpour and Sheen (1984).

\(^7\)Branson (1981) emphasized the importance of this type of trade-off facing the policymakers in a small open economy such as Singapore.
It may be argued that the change in the exchange rate is a function of the gap between the authorities’ desired level of the exchange rate ($E^d$) and the actual rate prevailing in the preceding period ($E_{t-1}$), as shown in equation (6):

$$\Delta \ln E_t = \phi[\ln E^d_t - \ln E_{t-1}],$$  \hspace{1cm} (6)

where $\phi$ is the adjustment coefficient and is expected to be positive and less than unity; $E$ is defined as the value of the domestic currency in terms of the foreign currency, such that an increase in $E$ denotes an appreciation of the Singapore dollar.

The desired level of the exchange rate in a given period is assumed to be set by the authorities, who take into consideration the ratio of foreign assets to total assets at the end of the preceding period. As the level of foreign assets increases relative to domestic assets, reflecting the sales of domestic currency to the banking system, the desired level of the exchange rate would be lowered, other things being equal. In addition, the desired level of the exchange rate is assumed to respond to the discrepancy between the foreign inflation rate ($\Pi f$) and the domestic rate ($\Pi$), with the lagged exchange rate as an anchor. This inflation rate differential can be interpreted as an indicator representing the premium or discount on the Singapore dollar, or as the *expected* rate of change in the exchange rate:

$$\ln E^d_t = \beta_0 + \beta_1 \ln (R/D)_{t-1} + \beta_2 [(\Pi f - \Pi)_{t-1} + \ln E_{t-1}],$$  \hspace{1cm} (7)

where $\beta_1$ is expected to be negative and $\beta_2$ to be positive. In this equation, if the role of foreign reserves becomes negligible in the authorities’ exchange rate policy, the desired level of exchange rate would be influenced more by purchasing power parity, and thus the value of $\beta_2$ would be close to unity. In this case, the real exchange rate would be constant in the long run. In contrast, if the role of foreign reserves becomes significant, $\beta_2$ would be close to zero, and the real exchange rate may not be constant in the long run.

Combining equations (6) and (7), we can express the dynamic adjustment of the exchange rate as

$$\Delta \ln E_t = \phi \beta_0 + \phi \beta_1 \ln (R/D)_{t-1} + \phi \beta_2 (\Pi f - \Pi),$$

$$+ (\beta_2 - \phi) \ln E_{t-1}.$$  \hspace{1cm} (8)

*Had information been available on the premium or discount of the Singapore dollar in relation to the currencies of Singapore’s major trading partners and competitors, such information could have been used in place of the inflation rate differential. This information is available, however, only for the exchange rate between the Singapore dollar and the U.S. dollar.
This functional specification is the authorities' reaction function and reflects their foreign reserve management policy as well as other factors influencing the exchange rate.9

Prices

The wholesale price index in Singapore, which is composed entirely of price indices of traded goods, reflects price developments in the world markets as well as movements in the exchange rate. Therefore, variations of the wholesale price index \( P_w \) are specified as a function of changes in import prices \( P_m \) and export prices \( P_x \), both denominated in terms of domestic currency:

\[
\Delta \ln (P_w)_t = w_0 + w_1 \Delta \ln (P_m)_t + w_2 \Delta \ln (P_x)_t,
\]

where \( w_1 \) and \( w_2 \), respectively, measure the contribution of import and export prices to changes in \( P_w \). Both \( P_m \) and \( P_x \) are exogenously determined world market prices of Singapore's imports and exports, adjusted for the exchange rate.10

The rate of change in the consumer price index—\( \Pi = \Delta \ln P \)—has diverged from that in the wholesale price index, mainly because of changes in prices of nontraded goods in response to domestic demand and supply conditions. Thus the rate of change in the consumer price index is specified in equation (10) below as a function of the excess supply of domestic liquidity, which may serve as a counterpart to excess demand for nontraded goods. The domestic rate of inflation is also expected to respond positively to the excess of real output above its potential level.

The potential output path, in logarithms, is defined as \( Y_0 e^{\mu T} \), where \( Y_0 \) is the initial output level, \( \mu \) is the potential (or steady-state) growth rate, and \( T \) is the time-trend term. In addition to demand and supply forces described above, the rate of change in the wholesale price index is included as an explanatory variable to capture the influence of traded-goods prices on the consumer price index:

\[
\Delta \ln P_t = \gamma_1 \{ \ln (M/P)_{t-1} - \ln (M/P)^d_t \} + \gamma_2 \ln (Y/Y_0 e^{\mu T})_t + \gamma_3 \Delta \ln P_w_t,
\]

\( ^9 \)Equation (8) could be only one of many plausible specifications to represent the authorities' reaction function. It is not the purpose of this paper, however, to identify their true reaction function; such an attempt would require testing alternative reaction functions.

\( ^{10} \)That is, \( P_m = P_m^* / E \) and \( P_x = P_x^* / E \), where \( P_m^* \) and \( P_x^* \) are world market prices of imports and exports, respectively.
where \( \gamma_1, \gamma_2, \) and \( \gamma_3 \) are expected to be positive. Combining equations (2) and (10) and rearranging terms result in
\[
\Delta \ln P_t = - (\gamma_1 \alpha_0 + \gamma_2 \ln Y_t) + \gamma_1 \ln (M/P), - ,
\]
\[
+ (\gamma_2 - \gamma_1 \alpha_1) \ln Y_t - \gamma_1 \alpha_2 (r_d),
\]
\[
+ \gamma_3 \Delta \ln (P, t) - \gamma_2 \mu T.
\]

(11)

**Real Output**

Given the openness of the economy and the limited size of the domestic market,\(^11\) overall economic activity in Singapore is dominated by the activity in the external sector, which in turn is influenced in large part both by external demand conditions for Singapore's output and by domestic supply factors. As a result, the behavioral equation for real output needs to be derived from the demand and supply functions.

The world demand for Singapore's output could be posited as a function of the world real income \((Y^*)\) and the real exchange rate, representing the ratio of Singapore's output price relative to that of its competitors in the world market \((E \cdot P/P^*)\):\(^12\)
\[
\ln Y^d_t = \lambda_1 + \lambda_2 \ln Y^*_t + \lambda_3 \ln (E \cdot P/P^*)_t ,
\]
where \( \lambda_2 \) is assumed to be positive and \( \lambda_3 \) to be negative.

The supply of output in the short run is assumed to depend on the inverse of real wages \((P/W)\) and the utilized capital stock \((UK)\).
\[
\ln Y'_t = \delta_1 + \delta_2 \ln (P/W)_t + \delta_3 \ln (UK)_t ,
\]
where \( \delta_2 \) and \( \delta_3 \) are expected to be positive. Solving equation (13) for \( P \), substituting the solution in equation (12), and assuming that the actual output equals the demand, we derive the output equation as
\[
\ln Y_t = \psi_0 + \psi_1 \ln Y^*_t + \psi_2 \ln (E \cdot W/P^*)_t + \psi_3 \ln (UK)_t ,
\]
where
\[
\psi_0 = \frac{\lambda_1 \delta_3 - \lambda_3 \delta_1}{\delta_2 - \lambda_3}, \quad \psi_1 = \frac{\lambda_2 \delta_3}{\delta_2 - \lambda_3}, \quad \psi_2 = \frac{\lambda_3 \delta_2}{\delta_2 - \lambda_3}, \quad \psi_3 = \frac{-\lambda_3 \delta_3}{\delta_2 - \lambda_3}.
\]

\(^11\) The value of Singapore's exports has averaged about 140 percent of gross domestic product (GDP) in recent years.

\(^12\) The domestic consumer price index was used as a proxy for the GDP deflator; although the latter would have been more appropriate in this equation, the former was chosen to limit the number of endogenous variables and provide a link with the rest of the model.
Given the sign conditions in equations (12) and (13), $\psi_1$ and $\psi_3$ are expected to be positive and $\psi_2$ to be negative. The term $E \cdot W/IP^*$ is an indicator of external competitiveness and, for estimation purposes, is proxied by the relative unit labor costs adjusted for the exchange rate ($E \cdot RULC$), where $RULC$ is the ratio of Singapore's unit labor costs to that of its major trading partners.$^{13}$ The utilized capital stock is proxied by the real value of bank credit extended to the private sector ($C_{ps}/P$).$^{14}$ The first difference of equation (14), together with the proxy variables discussed above, yields the following equation:

$$\Delta \ln Y_t = \psi_1 \Delta \ln Y^*_t + \psi_2 \Delta \ln (E \cdot RULC)_t + \psi_3 \Delta \ln (C_{ps}/P)_t.$$ (15)

**Government Finances**

Government revenue has been increasing in Singapore because of high rates of economic growth and a buoyant tax structure. Public expenditure has also been rising in recent years, reflecting government efforts to meet the need for housing and infrastructure. Owing to budgetary discipline, however, expenditures have been maintained successfully within available domestic resources; indeed, since 1968 the government's fiscal operations have continuously resulted in surpluses.

Within this framework, the government expenditure ($GE$) function is formulated on the assumption that the government attempts to adjust its expenditure with a lag to increases in revenue. In other words, the more government revenue ($GR$) exceeds expenditure, the faster the latter rises:

$$\Delta \ln GE_t = g (\ln GR_t - \ln GE_{t-1}),$$ (16)

where $g$ denotes the adjustment coefficient and is expected to be positive and less than unity. Rearranging terms in equation (16) leads to

$$\ln GE_t = g \ln GR_t + (1 - g) \ln GE_{t-1},$$ (17)

which formulates government expenditure as a weighted average of current government revenue and the lagged level of expenditure.$^{15}$

$^{13}$ Branson and Love (1988) also used the index of unit labor costs, adjusted for changes in the exchange rate, to represent external competitiveness.
$^{14}$ In many developing and newly industrialized countries, the availability of bank credit plays an important role in influencing the rate of capacity utilization. The role of credit in output functions has been emphasized by Kapur (1976) and Keller (1980).
$^{15}$ In the estimation process, a constant term was added to this equation to capture the budgetary surpluses that have been recorded.
Government revenue is specified simply as a log-linear function of nominal income:

$$\ln GR_t = q_0 + q_1 \ln (P \cdot Y)_t,$$

where $q_1$ measures the elasticity of total revenue with respect to nominal income.16

**Domestic Assets**

With the money supply identity defined as in equation (3), the monetary sector is completed by defining the net domestic assets ($D$) of the banking system. The change in net domestic assets is equal to changes in stock of credit to the private sector and changes in net credit to the government ($GC$), including other items (net):17

$$\Delta D_t = \Delta (C_{ps})_t + \Delta GC_t.$$

(19)

The change in net credit to the government ($GC$) is defined as

$$\Delta GC_t = (GE_t - GR_t) - GNBB_t,$$

(20)

where the first term represents budgetary operations and the second term indicates changes in net government borrowing from the banking system for nonbudgetary operations ($GNBB$). As a result of budgetary surpluses and funds generated by the social security scheme and other operations, the government has been a net depositor of funds with the banking system.

**Working of the Model**

The essence of the model,18 which conforms with the variety of formulations suggested by the monetary approach to the balance of payments, is that reserve accumulation occurs as long as the demand for money is not satisfied by increases in net domestic assets (equation (5)). In this

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16 In this formulation, the actual and desired levels of revenue are assumed to be the same. Aghevli and Khan (1977) assumed that revenue adjusts with a lag to its desired level. This formulation was suggested for high-inflation countries because the authorities attempt to adjust revenue in the face of its declining value in real terms.

17 Private sector credit is treated as an exogenous variable in this model. It could be assumed that the stock of credit to the private sector is, in principle, demand determined, and this demand is always met by the supply of credit from the banking system.

18 The process described below is presented in a static framework, but the actual process should be viewed in a dynamic setting in which interactions among variables occur simultaneously. This is done in Section III.
SINGAPORE'S FINANCIAL, EXCHANGE RATE, AND WAGE POLICIES

model, the excess demand for money arises from the government's contractionary financial operations, which reflect traditional budget surpluses and sizable buildups of deposits by the government with the monetary authorities (equations (19) and (20)).

Because reserve accumulation reflects the monetary authorities' foreign exchange purchases from (or swaps with) the commercial banks, a significant reserve accumulation would prevent the exchange rate from appreciating (equation (8)). This effect would reinforce the direct influence of rising foreign prices on the traded-goods prices (equation (9)), which would in turn increase domestic consumer prices at a faster pace if they were rising, or decrease them at a slower pace if they were falling (equation (11)).

A more depreciated exchange rate would safeguard the external competitiveness and improve growth performance, provided that wage costs remain unchanged (equation (15)). A higher real output level, in turn, would increase the demand for money and reduce the pressure on domestic prices. Thus, the direct impact of exchange rate changes on these prices would be counteracted by the influence of output, and the net impact would depend on the relative size of the relevant coefficients.

Developments in domestic prices and real output have implications for the level of government revenue (equation (18)). To the extent that expenditure grows in line with revenue (equation (17)), however, the net monetary impact of budgetary operations should be minimal.

The upshot of the discussion is that a tight financial policy could trigger foreign exchange intervention that might induce a depreciation of the domestic currency and might lead eventually to an expansion of output. This possibility, however, depends on the values of the parameters of the behavioral equations and is thus an empirical question.

II. Empirical Results

Table 1 summarizes the estimates of the complete model, which comprises seven behavioral equations and three identities. The model is estimated by the two-stage least-squares method for the period 1979–86, using quarterly data. The behavioral relationships are in general well estimated, and the model as a whole appears to capture the essential features of the Singapore economy.

19 The beginning of the observation period corresponds to the first full year following the total liberalization of exchange controls in June 1978. Thus the structural equations specified in this model may not be suitable for the period before mid-1978.
<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Equation</th>
<th>Estimated Model, 1979–86</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Behavioral equations</strong></td>
<td></td>
<td>R² = 0.73</td>
</tr>
<tr>
<td><strong>Foreign reserves</strong></td>
<td>$\Delta \ln (R/P)_t = -4.55 + 1.01 \ln (Y)_t - 1.1 (r_e)<em>t - 0.81 \ln (M/P)</em>{t-1} - 0.39 \Delta \ln (D/P)_t$</td>
<td>SEE = 0.04</td>
</tr>
<tr>
<td></td>
<td>(3.4)** (4.5)** (2.2)* (5.5)** (5.5)**</td>
<td>DW = 1.86</td>
</tr>
<tr>
<td><strong>Exchange rate</strong></td>
<td>$\Delta \ln (E)<em>t = 0.07 - 0.04 \ln (R/D)</em>{t-1} + 0.37 (\Pi_t - \Pi)<em>{t-1} - 0.28 \ln (E)</em>{t-1}$</td>
<td>R² = 0.76</td>
</tr>
<tr>
<td></td>
<td>(5.4)** (5.2)** (6.7)** (3.4)**</td>
<td>SEE = 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DW = 1.70</td>
</tr>
<tr>
<td><strong>Wholesale prices</strong></td>
<td>$\Delta \ln (P_w)_t = 0.001 + 0.20 \Delta \ln (P_s)_t + 0.90 \Delta \ln (P_m)_t$</td>
<td>R² = 0.96</td>
</tr>
<tr>
<td></td>
<td>(0.1) (2.4)* (8.2)**</td>
<td>SEE = 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DW = 1.92</td>
</tr>
<tr>
<td><strong>Consumer prices</strong></td>
<td>$\Delta \ln (P)<em>t = 0.45 + 0.07 \ln (M/P)</em>{t-1} - 0.09 \ln (Y)_t + 0.10 (r_e)_t + 0.07 \Delta \ln (P_w)_t - 0.001 T$</td>
<td>R² = 0.65</td>
</tr>
<tr>
<td></td>
<td>(1.6) (1.9) (2.2)* (1.0) (1.3) (1.1)</td>
<td>SEE = 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DW = 1.97</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Output</th>
<th>( \Delta \ln (Y)_t = -0.01 + 0.35 \Delta \ln (Y^*_t) - 0.14 \Delta \ln (E \cdot RULC) + 0.82 \Delta \ln (C/p) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>0.78</td>
</tr>
<tr>
<td>SEE</td>
<td>0.02</td>
</tr>
<tr>
<td>DW</td>
<td>2.10</td>
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</table>

<table>
<thead>
<tr>
<th>Government revenue</th>
<th>( \ln (GR)_t = -11.90 + 1.47 \ln (P \cdot Y) + 0.50 \text{ Dummy}^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>0.78</td>
</tr>
<tr>
<td>SEE</td>
<td>0.18</td>
</tr>
<tr>
<td>DW</td>
<td>1.51</td>
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</table>

<table>
<thead>
<tr>
<th>Government expenditure</th>
<th>( \ln (GE)<em>t = 1.15 + 0.57 \ln (GR) + 0.28 \ln (GE)</em>{t-1} + 0.50 \text{ Dummy}^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>0.76</td>
</tr>
<tr>
<td>SEE</td>
<td>0.19</td>
</tr>
<tr>
<td>DW</td>
<td>2.28</td>
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</table>

<table>
<thead>
<tr>
<th>Money supply</th>
<th>( \Delta M_t = \Delta R_t + \Delta D_t )</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Domestic credit</th>
<th>( \Delta D_t = \Delta C_{mu} + \Delta CG_t )</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Credit to government</th>
<th>( \Delta CG_t = GE - CR - GRBB )</th>
</tr>
</thead>
</table>

Note: R² is the adjusted coefficient of determination; SEE is the standard error of estimates; DW is the Durbin-Watson statistic; ** and * indicate that the estimated coefficient is significantly different from zero at a critical level of 1 percent and 5 percent, respectively.

1 Corrected for autocorrelation in residuals by the Cochrane-Orcutt method.

2 The dummy variable takes a value of unity for the first quarter of 1986, and of zero otherwise, to capture the once-and-for-all change in the accounting entries that resulted from the transaction of land ownership.
The estimated equation for foreign reserve movements suggests that the extent of these changes is indeed systematically related to the excess demand for money that is not met by changes in domestic credit. From this equation, the long-run income and interest rate elasticities of the demand for money are calculated to be about 1.2 and −0.1, respectively. Furthermore, using the average sample value of $m_1 = 0.7$, the adjustment coefficient, $k$, is estimated to be about 0.6, which implies that about 60 percent of the excess demand for money would be satisfied by reserve accumulation within one quarter and over 80 percent of this excess would be met within two quarters. The estimated speed of adjustment of the money market is therefore rather fast, which is consistent with the observation that Singapore’s financial markets are highly integrated with the foreign markets.

Although movements in foreign reserves are found to be the principal mechanism for meeting changes in the excess demand for money, the level of these reserves relative to domestic assets is a significant factor influencing the level of the exchange rate. The estimated coefficient of this explanatory variable suggests that, as the level of foreign assets increases relative to the domestic assets, the upward pressure on the exchange rate is relieved. At the same time, the estimated coefficient of the term for the inflation rate differential is found to be statistically significant, indicating that the authorities have implicitly taken into account changes in relative prices in managing the exchange rate. The coefficient of the lagged endogenous variable, together with the coefficient of the inflation rate differential term, suggests that about 76 percent of the gap between the desired level and the actual level of the exchange rate is adjusted within a given quarter, indicating a reasonably rapid exchange rate adjustment.20

The rate of change in wholesale prices, as expected, is explained almost entirely by changes in import and export prices denominated in the domestic currency, indicating the openness of the economy and the role of the exchange rate in the transmission of inflationary pressures from abroad.21 The rate of change of consumer prices, however, is influenced more by overall domestic conditions, which suggests that the demand and supply conditions for nontraded goods are important determinants of consumer prices.

20 The estimates of $\phi$ and $\beta_2$ involve a second-degree polynomial in $\beta_2$. The roots of the polynomial are −0.76 and 0.49. Because $\beta_2$ is assumed to be positive and less than unity, only the latter root is the meaningful solution. Given $\beta_2 = 0.49$, $\phi$ is calculated to be 0.76.

21 Although the sum of the point estimates of $w_1$ and $w_2$ exceeds unity, the variance-covariance matrix for these estimates suggests that, with a 95 percent probability, one cannot reject the hypothesis that the sum of $w_1$ and $w_2$ equals unity.
The coefficients of the estimated output function have the expected signs and are statistically significant. It is noteworthy that the availability of credit to the private sector, as observed in many developing and newly industrialized countries, is a significant factor for influencing short-term fluctuations in output. Moreover, it is found that the relative unit labor costs adjusted for the exchange rate play an important role in growth performance, as expected for a highly open economy such as Singapore.

The estimated equations for government revenue and expenditure capture the essential characteristics of the budgetary operations. The large and statistically significant elasticity of revenue with respect to nominal income reflects the progressive income tax structure in Singapore. The sum of two estimated coefficients in the expenditure equation is not significantly different from unity. This finding indicates that attempts have been made to keep the level of expenditure in line with total revenue. The coefficient of adjustment for the expenditure equation is estimated to be in the order of 0.7, implying that about 90 percent of adjustment occurs within two quarters.

### III. Simulation Results

This section analyzes the results of various simulation exercises. The major objectives are, first, to examine the overall explanatory power of the model and, second, to explore the impact of alternative policy scenarios on key macroeconomic variables.

For the purpose of investigating the overall performance of the model, the system of the estimated behavioral and the definitional equations were simulated dynamically during the observation period, 1979–86. The simulation results for the key variables are depicted in Chart 1. The comparison between the actual and the simulated values of real output, consumer prices, the exchange rate, and foreign reserves all suggest that the model as a whole tracks the recent developments rather well, capturing even major turning points—that is, the decline of output in 1985, the decline in consumer prices from mid-1985, and the sharp turnaround in the exchange rate in late 1984. The gaps between the actual and the simulated values for the consumer prices and the exchange rate are serially correlated for certain periods, but they do not seem to be excessive, given the tendency that the errors in a dynamic simulation are accumulated over time and hence are more magnified than in a static simulation.

22 The variance-covariance matrix for the two coefficients in the government expenditure equation indicates that, with 95 percent probability, one cannot reject the hypothesis that the sum of the coefficient of ln (GR) and that of ln (GE)_{t-1} equals unity.
Chart I. Selected Macroeconomic Variables for Singapore, 1979–86

Output\(^1\) (1980 constant prices; billions of Singapore dollars)

Consumer prices (1980 = 100)

Exchange rate\(^2\) (1980 = 100)

Foreign reserves (billions of Singapore dollars)

Note: Simulated values represent the results of dynamic simulation, taking as given the actual values of exogenous variables.

\(^1\) Output measured in terms of real GDP.

\(^2\) An increase indicates an appreciation of the Singapore dollar.
To examine the effects of policy actions and changes in exogenous factors on key macroeconomic variables, several simulation exercises were conducted. One of the compelling issues facing the Singapore authorities in recent years has been the impact of the high-wage policy, pursued in the first half of the 1980s, on the performance of the economy in terms of output and employment. Although this is a complex issue, a partial answer may be provided by analyzing the results of a simulation exercise based on the assumption that the authorities' wage policy was rather conservative, such that the growth rate of nominal wages adjusted for changes in labor productivity was kept at the same rate as the weighted average of those in Singapore's major competitor countries. To capture this hypothetical case, it is assumed that the relative unit labor costs (unadjusted for the exchange rate) were fixed at the level of 1980 for the period 1981-86. Thus the assumed level of relative unit labor costs were, on average, about 16 percent below the actual level; all other exogenous variables take the actual values.

The results of this scenario (case 1) and that of the base run (dynamic simulation) are contained in Table 2. According to this simulation, the level of output would have been about 3 percent higher than the base-run outcome, mainly because this wage policy would have contributed directly to the improvement in Singapore's external competitiveness. A higher output level would have enlarged the excess demand for money and increased the need to supply domestic liquidity by purchasing foreign exchange. In turn, foreign reserves would have increased, the exchange rate would have declined, and external competitiveness would have improved. As indicated, compared with the base run, the level of foreign reserves would have been higher by about 6 percent and the nominal exchange rate would have been lower by about 1 percent. Primarily because of the output effect, consumer prices would have been slightly below the result suggested by the base-run simulation.

Another important issue facing the authorities has been the effectiveness of financial and exchange rate policies. To analyze this issue, consider case 2, which represents the hypothetical situation wherein the public sector financial institutions' deposits in the government's accounts with the MAS had been reduced by S$0.2 billion in each quarter. In other words, the equivalent of about 1 percent of total liquidity had been injected in the banking system in each quarter. In this situation, with the

As suggested by Lucas (1976), however, the parameters of the behavioral relationships could change as the authorities pursue alternative policies. Thus, the results should only be interpreted as indicative of the direction of changes and of the rough magnitudes of the effects.
Table 2. Simulation Results, 1981–86

(Period average)

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Simulation Period</th>
<th>Foreign Reserves (in billions of Singapore dollars)</th>
<th>Exchange Rate (1980 = 100)</th>
<th>Consumer Prices (1980 = 100)</th>
<th>Output (In 1980 constant prices; billions of Singapore dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base run</td>
<td>1981–86</td>
<td>14.7</td>
<td>116.7</td>
<td>114.7</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td>1984–86</td>
<td>17.1</td>
<td>118.9</td>
<td>116.7</td>
<td>7.8</td>
</tr>
<tr>
<td>Case 1</td>
<td>1981–86</td>
<td>15.6</td>
<td>115.5</td>
<td>114.2</td>
<td>7.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.1)</td>
<td>(-1.0)</td>
<td>(-0.4)</td>
<td>(2.8)</td>
</tr>
<tr>
<td>Case 2</td>
<td>1984–86</td>
<td>15.7</td>
<td>120.8</td>
<td>116.8</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-8.2)</td>
<td>(1.6)</td>
<td>(0.1)</td>
<td>(-0.3)</td>
</tr>
<tr>
<td>Case 3</td>
<td>1984–86</td>
<td>16.2</td>
<td>119.4</td>
<td>117.2</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-5.3)</td>
<td>(0.4)</td>
<td>(0.4)</td>
<td>(-2.6)</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses represent percentage differences from the base-run results. Case 1: relative unit labor cost is fixed at the level of end-1980 for the period 1981–86. Case 2: the government deposits with the Monetary Authority of Singapore (MAS) are reduced by S$0.2 billion in each quarter during 1984–86. Case 3: the quarterly growth rate of world income in real terms is reduced by 1 percentage point.
excess demand for liquidity being partially alleviated, the need for the monetary authorities to acquire foreign exchange would have been reduced, leading to a reduction in foreign reserves to a level about 8 percent below the base-run result. In the process, the domestic currency would have been allowed to appreciate by nearly 2 percent compared with the base-run outcome. This, in turn, would have contributed to stabilizing prices, but at the same time would have worsened external competitiveness and thus output performance. This scenario exemplifies the severe constraint that the authorities have been experiencing with their conduct of financial and exchange rate policies.

To highlight the impact of external demand conditions, case 3 examines the hypothetical situation wherein the growth rate of world income in real terms had been 1 percentage point less than the actual growth rate, or the average level of that income had been about 6.5 percent lower than the actual. In this case Singapore's output would have been about 3 percent lower than the base run, indicating that approximately half of the variation in the world economic activity would have been transmitted to Singapore. Because a lower output level would have reduced the demand for liquidity, the level of international reserves would have been about 5 percent below the level suggested by the base-run simulation. Lower foreign reserves would have contributed in turn to an appreciation of the Singapore dollar compared with the base-run result. Despite this appreciation, consumer prices would have risen, mainly as a result of a lower level of output relative to the liquidity position of the economy.

**IV. Concluding Remarks**

The purpose of this paper has been to examine the impact of financial, exchange rate, and wage policies in Singapore on key macroeconomic variables such as output, prices, and foreign reserves. Toward this end, a simple short-term model was formulated, estimated, and used to conduct several policy simulations. A few conclusions can be drawn from this analysis.

First, the exchange rate policy in Singapore has been largely influenced by the liquidity implications of the government's contractionary budgetary and other financial operations. As a result, there has been a trade-off that the authorities need to consider in their decision to adopt a particular mix of exchange rate and reserve levels.

Second, the authorities' high-wage policy pursued in the first half of the 1980s contributed to rapid increases in the domestic labor costs relative to those of Singapore's competitors. This, together with the sharp appreciation of the Singapore dollar, contributed to a significant loss of
external competitiveness and a severe recession in 1985. Had the authorities adopted a more moderate wage policy, the output would have been significantly higher than the actual, and the 1985 recession probably would have been avoided, or at least its severity would have been reduced. Now that the relative unit labor costs adjusted for the exchange rate have declined to a level prevailing in the early 1980s, reflecting both the depreciation of the domestic currency and the sharp decline in wages and other labor costs, growth prospects should improve noticeably over the medium term.

Third, considering the openness of the economy, economic activity has been influenced by the external environment, particularly the level of world income in real terms. The model estimates suggest that financial and exchange rate policies had relatively limited influence in insulating the domestic economic activity from external shocks, mainly because price stability was also one of the major objectives of the authorities.

The experience of Singapore, albeit unique in many respects, may offer some lessons for other countries with small and highly open economies and no impediments to international capital movements. Singapore's experience suggests that flexibility in financial, exchange rate, and wage policies is crucial in achieving noninflationary growth with external payments viability. Should exchange rate policy to improve external competitiveness jeopardize an inflation target, as is often the case in many open economies, other policy instruments merit consideration. As demonstrated in this paper, an appropriate wage policy may be an important complement to the exchange rate policy. Over the longer run, these policies could help to maintain external competitiveness and to adapt the structure of production to the changing pattern of external demand. The vulnerability of these economies to external developments would thus be lessened.

**APPENDIX**

**Data Sources and Definitions**

Data used for estimation were obtained from various issues of four primary sources:

Variables were defined as follows (with data sources indicated as above):

- $R$: Net foreign assets of the banking system (Source A)
- $M$: Broad money—currency plus demand deposits plus quasi-money (Source A)
- $C_{ps}$: Outstanding credit to the private sector by the banking system (Source A)
- $D$: Domestic credit (Source A)
- $CG$: Net claims on the government (Source A)
- $GE$: Government expenditure including net lending (Source A)
- $GR$: Government revenue (Source A)
- $GNBB$: Government nonbank borrowing (Source A)
- $E$: Nominal effective exchange rate (calculated from data provided in Sources A and B)
- $P$: Consumer price index (Source A)
- $P_w$: Wholesale price index (Source A)
- $P_x$: Export price index (Source A)
- $P_m$: Import price index (Source A)
- $RULC$: Ratio of Singapore's unit labor costs to that of its major trading partners and competitors (calculated from data provided in Sources A, B, and C)
- $r_d$: Three-month interbank deposit rate (Source D)
- $\Pi$: Percentage change in $P$ (Source A)
- $\Pi_f$: Percentage change in the arithmetic average of export and import prices in foreign currency terms (Source A)
- $Y$: Real GDP (Source C)
- $Y^*$: Weighted average of real GDP or gross national product (GNP) in Singapore’s major trading partner countries (Source A).

References


Domestic Credit and Exchange Rates in Developing Countries

Some Policy Experiments with Korean Data

Leslie Lipschitz*

This paper models alternative policy responses to various sorts of disturbances—or "shocks"—to the steady-state path of a developing economy. Its objective is to arrive at some generalizations about appropriate credit and exchange rate policies. The typical "developing" country with which the paper is concerned is small (that is, it exercises no monopoly power over its trade), its structure of production and finance is relatively undifferentiated, its external capital flows are restricted, and its trade is subject to some quantitative restrictions. The model, in terms of which the analysis is conducted, reflects these characteristics and is estimated using Korean data for the period 1965–78, a period of rapid economic development and political stability. Obviously, there is no "typical" developing country, and the rapid growth in the Republic of Korea is hardly typical. Even in the limited sense specified, Korea is more representative of the characteristics of a developing country in the early part of the sample period than toward the end. Nevertheless, the availability and reliability of Korean data, and the fact that no major modifications were required to fit the institutional characteristics of the country, encouraged the use of Korea as a test case. (A detailed description of the data is provided in Appendix I.)

In line with the objective of modeling financial policy alternatives, the specification of the model assigns a central role to money. Money stock disequilibria affect trade, absorption, and prices directly, but the model

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1 The paper builds on earlier work by the author—Lipschitz (1978 and 1979)—and on related work by Hemphill (1974) and Sundararajan (1986).
cannot be characterized as a simple monetary approach to the balance of payments because absorption and the restrictive system governing trade are modeled explicitly. The importance of expectations in asset demand functions (in this case, the demand for money) is recognized, but expectations enter flow equations only indirectly via money stock disequilibria. These expectations are Muth rational to the extent that they are consistent with the solution of the model. In modeling the policy alternatives, it is difficult to claim complete immunity from the standard criticism of such exercises—namely, that behavioral parameters adjust to incorporate any systematic information on economic policy (see Lucas (1976)). Such criticism may be even more trenchant insofar as behavioral relations are estimated in a basic model upon which various counterfactual policy responses are subsequently imposed. Nevertheless, the questions addressed are relevant, and no other mechanism for examining them quantitatively is available. The results should be seen as illustrative rather than as having precise numerical significance.

The policy analysis consists of two sets of counterfactual simulations: one testing the efficacy of various policy responses to temporary shocks, the other examining policy responses to permanent changes in the economic environment. In each set, three kinds of shocks (or sustained changes) are examined: a domestic supply shock, a money demand shock, and a terms of trade shock. In both sets of simulations, six different policy packages—ranging from very strict rules, such as a fixed exchange rate and a fixed rate of domestic credit expansion, to systematic adjustments in both the exchange rate and credit policy—are examined in response to each of the shocks.

A few of the general points that emerge from the analysis are worth mentioning at the outset. First, exchange rate changes are a powerful instrument of adjustment even when the estimated price elasticities of trade are small. Second, even in a country that does not have an open financial system that is integrated with the rest of the world, monetary conditions have a large and rapid effect on the balance of payments. Third, in many cases the most effective policies for stabilizing the external balance entail large fluctuations in exchange rates and prices. To the extent that these fluctuations are themselves regarded as unacceptably costly, less drastic measures may be preferred. Fourth, the source of a

2 Trade is extremely important—for example, in situations of export-led growth—but is difficult to model. Several recent papers invoke the literature on the monetary approach to the balance of payments as a justification for ignoring trade and focusing exclusively on below-the-line reserve changes. Branson (1983) provides criticism of this approach. For a synthesis of the various approaches to balance of payments analysis, see Frenkel, Gylfason, and Helliwell (1980).

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disturbance to the economy is often more important to determining the
best policy response than the manifestation of the disturbance. So, for
example, inflation that results from unwarranted monetary expansion
might require a different policy reaction from that required by the same
rate of inflation caused by a rise in import prices. Fifth, policy adjustment
lags—that is, lags between disturbances and policy reactions—are very
important. The length of these lags may significantly affect the path of
the economy, especially when the disturbance to the economy is of short
duration. Finally, the appropriate policy response to any disturbance
depends on the expected duration of the disturbance; forming a view on
this is probably the most difficult element of policymaking.

I. Specification of the Model

The model focuses principally on the transmission mechanisms
through which money stock disequilibria affect flow demand and supply.
Monetary impulses can affect the economy via interest rates, prices, or
money stock disequilibria that enter directly into flow excess demand
functions. The traditional (IS-LM) Keynesian models focused exclusively
on interest rate transmission; the early monetarists focused chiefly on
prices and the real balance effect. Both often worked in an equilibrium
framework. This model allows monetary disequilibrium to persist and to
affect the goods market directly.3

Monetary disequilibria can be dissipated through changes in prices,
output, or the balance of payments. The extent to which monetary equi­
librium is restored through each of these mechanisms depends on several
other variables such as current capacity utilization, the restrictiveness of
the trade regime, and relative price developments. These elements are
modeled explicitly.

The basic model consists of four behavioral equations and two identi­
ties. The inflation rate, export volume, import volume, and real absorp­
tion are determined by behavioral equations; real income and nominal
money are determined by identities. Subsequently, the model is ex­
panded to include reaction functions for exchange rate policy and domes­
tic credit policy. There is no explicit money demand equation, although
the parameters of the money demand function are estimated implicitly.
The behavioral equations are all log linear, and the identities are lin­
erized in logarithmic form about the trend values of included variables.

3 Other recent papers—for example, Blejer (1977)—have allowed money stock
disequilibrium to have an effect on flow equations but have not allowed the effect
to be determined in so general a framework.
In the description of the model, lowercase letters refer to the logarithms of the variables represented by the corresponding uppercase letters.

**Monetary Disequilibrium**

The desired stock of real money balances at the end of period \( t - 1 \) is postulated to depend on the nominal interest rate on alternative assets in period \( t(t_i) \) and the expected real expenditure in period \( t \). In the first, and simplest, version of the model, the nominal money supply is the sum of an exogenously set domestic credit counterpart and a net foreign assets counterpart that results from past external payments imbalances and can be adjusted through the balance of payments over the ensuing period. Prices, too, are endogenously determined by foreign prices, excess demand for domestic goods, and the exchange rate, which is treated as exogenous in the first version of the model. The discrepancy between actual and desired real money balances at the beginning of the period affects flows during the period.

The notation for expected variables is as follows: \( E(abs, ; t - 1) \) denotes the expected value of real absorption during period \( t \) on the basis of information available at the end of period \( t - 1 \). With the logarithm of the price index denoted by \( p \) and that of the nominal money stock by \( m \), the monetary disequilibrium term that affects flows in period \( t \) may be characterized as

\[
mdis \equiv \alpha_0 + \alpha_1 E(abs, ; t - 1) + \alpha_2 I_i - m_{t - 1} + p_{t - 1}.
\]  

(1)

In Korea, most official interest rates are either fixed by government fiat or are subject to government regulation. For this reason, the rate used in the model is that quoted in the unregulated, unofficial money market. Equation (1) is not estimated explicitly, but it is incorporated in the flow equations of the model and is estimated implicitly, subject to the constraint that parameters \( \alpha_1 \) and \( \alpha_2 \) are the same across equations.

---

4 Broad money is used. This use is consistent with the Bank of Korea's exercising control over the entire banking system, rather than over only the money base, and with the empirical findings of Park and Ha (1982).

5 In the sense of Foley (1975) and Buiet (1980), this is neither a pure stock (beginning-of-period) model nor a pure flow (end-of-period) model. But, insofar as continuous money stock equilibrium does not obtain and changes in the real money supply reflect disequilibria elsewhere in the system, it is a flow model.

6 Note that \( I_i \) is the interest rate offered during period \( t - 1 \) for deposits during period \( t \) and is thus part of the information set at the end of period \( t - 1 \).
The Price Equation

The price level is represented by a geometric index of home prices \((p_h)\) and import prices \((p_m)\):

\[
p = \epsilon p_h + (1 - \epsilon) p_m
\]

(2)

or

\[
p_h - p_m = \frac{1}{\epsilon} (p - p_m).
\]

(3)

Home prices are determined by domestic demand and supply. A disequilibrating increase in the money supply should affect prices more or less according to the capacity for increasing output or imports and thereby raising real absorption. The capacity for increasing output is captured by a capacity utilization variable \((yrdis)\), characterized as the percentage deviation of real output \((yr)\) from potential output \((yr^*)\), with the latter defined simply as a constant markup over trend. Besides the influence of money and capacity utilization on home prices, there is a separate relative price influence. If at the beginning of the period the relative price between home goods and imports is high compared with the long-run equilibrium value, there is a tendency for the rate of home-price inflation to fall. Thus, the equation for home-price inflation may be written

\[
\Delta p_h = \beta_0 + \beta_1 \alpha_s + \beta_1 \alpha_1 E(abs_t; t - 1) + \beta_1 \alpha_2 I_t - \beta_1 m_{t-1}
+ \beta_1 p_{t-1} + \beta_2 yrdis_t + \beta_3 (p_h - p_m)_{t-1},
\]

(4)

where the long-run equilibrium relative price is incorporated in the constant. From equations (2), (3), and (4), the price inflation equation may be written as

\[
\Delta p_t = \epsilon \beta_0 + \epsilon \beta_1 \alpha_0 + \epsilon \beta_1 \alpha_1 E(abs_t; t - 1)
+ \epsilon \beta_1 \alpha_2 I_t - \epsilon \beta_1 m_{t-1} + \epsilon \beta_1 p_{t-1} + \epsilon \beta_2 yrdis_t
+ \beta_3 (p - p_m)_{t-1} + (1 - \epsilon) \Delta p_m.
\]

The Export Equation

The export equation incorporates the small-country assumption—that is, Korea is assumed to be too small to exert monopoly power over its exports. Thus, export prices \((px)\) are determined in the world market,

\[
The specification of this equation draws on Aghevli and Rodriguez (1979).
\]

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and export volume (xv) depends on the supply response. This response is governed by domestic prices (or costs), current output (yr), and domestic capacity utilization (yrdis). As is conventional, a partial adjustment model is employed with the adjustment parameter λ:

\[ xv_t = \lambda \gamma_0 + \lambda \gamma_1 (px - p)_t + \lambda \gamma_2 yr_t + \lambda \gamma_3 yrdis_t + (1 - \lambda) xv_{t-1}. \] (6)

The relative price term is made up of a foreign price, an effective (or weighted) exchange rate, and a domestic price. As such, it is incomplete insofar as the economic price received by exporters ought to reflect various implicit and explicit subsidies. The relative price term used in estimating the equation may therefore be regarded, at best, as a reasonable proxy for the actual economic relative price.

**The Import Equation**

During the sample period, imports in Korea were subject to a considerable degree of control through a restrictive licensing system. It is assumed that import policy has two competing objectives: to maintain real reserves as close as possible to the desired real level (R*), and to allow the volume of imports to be as close as possible to the desired level (IMP*). By minimizing a quadratic cost function in these two objectives, subject to the balance of payments identity, one can derive a linear decision rule for the optimal issuance of licenses (IMPL) that depends on the desired volume of imports, and also on exports (X), net capital inflows (K), and the difference between actual and desired reserves, all measured in terms of imports:

\[ IMPL = \eta [IMP^*_t - 1 + (1 - \eta) (X_t + K_t - (R^*_t - R_{t-1})). \] (7)

The desired real reserve level is determined by running a trend through peaks of imports, multiplying the resultant peak-import series by the...
average reserve-import ratio over the sample period, and deflating by import prices. The authorities' perception of the desired import volume is based on the most recent data—that is, the last period's desired import volume as reflected in the last period's license applications. The desired volume of imports ($imp^*$) is specified as a log-linear function of total expenditure—that is, real absorption ($abs$), the domestic price level relative to import prices ($p - p_m$), exports calibrated in terms of imports ($xvm$) to reflect the imported component in exports, and the excess demand for money. The concerns about the relative price term, expressed in connection with the export equation, are equally applicable in this equation:

$$imp^*_t = \sigma_0 + \sigma_1 abs_t + \sigma_2 (p - p_m)_t + \sigma_3 xvm_t + \sigma_4 \alpha_0$$
$$+ \sigma_4 \alpha_1 E(abs_{t-1}; t - 1) + \sigma_4 \alpha_2 I_t$$
$$- \sigma_4 m_{t-1} + \sigma_4 p_{t-1}.$$  (8)

To maintain the log-linearity of the system, equation (7) was rewritten using the logarithms of the variables involved; equation (8) was substituted into equation (7); and, on the assumption of serial correlation in exports, the export terms were gathered into one. It was assumed that import arrivals adjust partially, by a proportion in each quarter, to licenses issued. These simplifications yielded the following equation for estimation:

$$imp_t = \phi \eta (\sigma_0 + \sigma_4 \alpha_0) + \phi \eta \sigma_1 abs_{t-1} + \phi \eta \sigma_2 (p - p_m)_{t-1}$$
$$+ \phi (\eta \sigma_3 + 1 - \eta) xvm_{t-1} + \phi \eta \sigma_4 \alpha_1 E(abs_{t-1}; t - 2)$$
$$+ \phi \eta \sigma_4 \alpha_2 I_{t-1} - \phi \eta \sigma_4 m_{t-2} + \phi \eta \sigma_4 p_{t-2}$$
$$+ \phi (1 - \eta)(k_t - r^*_t + r_{t-1}) + (1 - \phi) imp_{t-1}.$$  (9)

The Absorption Equation

Expected absorption is an important argument in the monetary disequilibrium term. To close the model satisfactorily, it is preferable to specify an absorption equation that does not require data on exogenous contemporaneous variables or on future expected variables in the set of explanatory variables. For this reason, and because the model seeks to highlight financial influences on the real sector, a simple real absorption equation is specified. The growth of real absorption ($\Delta abs$) is assumed to tend toward some steady-state rate determined by real factors. Absorption, however, is deflected from its long-run growth path by monetary disequilibrium as captured by the expression for excess money
demand. In the absence of any current disturbance, there is assumed to be a natural tendency for deviations from trend absorption ($\Delta abs_t$) in the last period to be reversed in the current period:

$$\Delta abs_t = \mu_0 + \mu_1 \alpha_t + \mu_2 \alpha_{t-1} E(abs_{t-1}; t - 1) + \mu_3 \alpha_2 I_t$$

$$- \mu_1 m_{t-1} + \mu_2 p_{t-1} + \mu_3 abs_{t-1} - \mu_4 tabs_{t-1}. \quad (10)$$

All variables (except that for current absorption) in this equation are effectively lagged and, hence, are part of the information set available at the end of the period $t - 1$. Although $I_t$ appears to be contemporaneous, in effect it is the interest rate offered in period $t - 1$ for deposits during period $t$ and is therefore information available at the end of period $t - 1$. Thus, it is possible to equate $abs_t$ and $E(abs_{t-1}; t - 1)$ for the purpose of estimation.11

The Identities

Two identities are included in the model. A real income identity,

$$YR_t = ABS_t + XV_t - IMP_t + TS_t, \quad (11)$$

defines real income as the sum of domestic absorption and the foreign balance on goods and services, where $TS$ is the (assumed exogenous) balance of trade in services as recorded in the national income statistics. A broad money identity,

$$M_t = DC_t + NFA_t - 1 + (XV_t PX_t) - (IMP_t PM_t) + K_t, \quad (12)$$

sets broad money equal to domestic credit ($DC$) plus the last period's net foreign assets ($NFA$) of the banking system plus the changes in net foreign assets during the current period. $PX$ and $PM$ are, respectively, export and import unit value indices, and $K$ represents the net nontrade receipts in the external accounts. For conformity with the other equations of the model, these identities were linearized in logarithmic form about trend growth rates. (Appendix II provides details on the linearization.)

II. Estimation and Simulation Results

The constraints embodied in the theoretical specification of the model—both across-equation restrictions on parameters and constraints imposed by the linearization of the identities—were imposed during

11 Note that, whereas combinations of variables have been expressed by a single symbol (for example, $yrdis$ or $xvm$) in some equations, in all cases the equations have been written out for estimation in terms of the individual variables, with the parameters and constants attached to each variable expressed as a nonstochastic function.
estimation of the model. The estimation program and the properties of the estimator are discussed in Wymer (1977).

In general, the parameters of the model are very well determined. Table 1 sets out the equations of the model as estimated; Table 2 provides estimates of all the parameters, of which some are presented only in composite form in Table 1. Of the 18 parameters estimated, all had the expected sign, 11 were significantly different from zero at the 99 percent level of confidence, and 3 were significantly different from zero at the 95 percent level. The other 4 coefficients, which were not as well determined, were those attached to capacity utilization in the price equation (β2), the export (γ1) and import (σ2) relative price variables, and the parameter attached to the volume of exports in the desired import equation (σ3). There is no good a priori explanation for the poor determination of β2, except perhaps the rather crude characterization of capacity utilization.

Table 1. Stochastic Equations
(Sample period: first quarter of 1965 through fourth quarter of 1978)

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Price inflation</td>
<td>[ \Delta p_t = -0.2341 - 0.0540 \text{mdis}<em>t + 0.1035 \text{yrdis}<em>t ] (1.39) (3.86) (1.8) [ -0.1633(p - pm)</em>{t-1} + 0.2841 \Delta pm</em>{t-1} ] (6.65) (5.18)</td>
</tr>
<tr>
<td>(ii) Exports</td>
<td>[ xv_t = -18.6934 + 0.1509(px - p)_t + 0.2699 \text{yr}_t ] (3.65) (0.66) (1.98) [ -2.4069 \text{yrdis}<em>t + 0.8653 xv</em>{t-1} ] (3.66) (14.11)</td>
</tr>
<tr>
<td>(iii) Imports</td>
<td>[ \text{imp}<em>t = 1.8547 + 0.401 \text{abs}</em>{t-1} + 0.0906(p - pm)<em>{t-1} ] (1.63) (2.23) (0.83) [ + 0.2025 xv m</em>{t-1} - 0.1494 \text{mdis}<em>{t-1} ] (3.30) (2.58) [ + 0.0963(k - r^*<em>t + r</em>{t-1}) + 0.4786 \text{imp}</em>{t-1} ] (2.01) (5.11)</td>
</tr>
<tr>
<td>(iv) Absorption</td>
<td>[ \Delta abs_t = -4.0638 - 0.0656 \text{mdis}<em>t - 0.4829(\text{obs}</em>{t-1} - \text{tobs}_{t-1}) ] (4.50) (2.90) (4.50)</td>
</tr>
</tbody>
</table>

Note: t-ratios are given in parentheses beneath parameter estimates. The term t-ratio denotes the ratio of a parameter estimate to the estimate of its asymptotic standard error and does not imply that this ratio has a Student's t-distribution. Because the model was estimated by a full-information maximum-likelihood (FIML) procedure, the distribution of the estimated parameters is asymptotically normal. In a sufficiently large sample, this ratio is significantly different from zero at the 5 percent level if it lies outside the interval ±1.96 and is significantly different from zero at the 1 percent level if it lies outside the interval ±2.58.

In equations for items (i), (iii), and (iv), the monetary disequilibrium term was estimated as:

\[ \text{mdis}_t = \text{constant} + 1.0834 \text{abs}_{t-1} + 3.6574 \text{t} - (\text{m}_t - \text{p}_t)_{t-1} \] (3.87) (4.46)

The constant terms in the equations were unrestricted, and they incorporate the constant in the monetary disequilibrium term in equations for items (i), (iii), and (iv) and the constant in the trend (or potential output) estimate in equations for (ii) and (iv). The Carter-Nagar R² was 0.9969.
Table 2. Detailed Parameter Estimates
(Sample period: first quarter of 1965 through fourth quarter of 1978)

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimate</th>
<th>t-ratio(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Price inflation</td>
<td>Parameter</td>
<td></td>
</tr>
<tr>
<td>(\varepsilon)</td>
<td>0.7159</td>
<td>-0.0754</td>
</tr>
<tr>
<td>(\beta_1)</td>
<td>13.05</td>
<td>3.98</td>
</tr>
<tr>
<td>(ii) Exports</td>
<td>Parameter</td>
<td></td>
</tr>
<tr>
<td>(\lambda)</td>
<td>0.1347</td>
<td>1.1203</td>
</tr>
<tr>
<td>(\gamma_1)</td>
<td>2.20</td>
<td>0.80</td>
</tr>
<tr>
<td>(iii) Imports</td>
<td>Parameter</td>
<td></td>
</tr>
<tr>
<td>(\phi)</td>
<td>0.5214</td>
<td>0.8154</td>
</tr>
<tr>
<td>(\eta)</td>
<td>5.57</td>
<td>9.14</td>
</tr>
<tr>
<td>(iv) Absorption</td>
<td>Parameter</td>
<td></td>
</tr>
<tr>
<td>(\mu_1)</td>
<td>-0.0656</td>
<td>-0.4829</td>
</tr>
<tr>
<td>(\mu_2)</td>
<td>2.90</td>
<td>4.50</td>
</tr>
</tbody>
</table>

Note: The parameters of the monetary disequilibrium term in equations for items (i), (iii), and (iv) were estimated as follows—parameter \(\alpha_1, \alpha_2, \alpha_3, \alpha_4\) estimate 1.0814, -3.6574; t-ratio: 3.87, 4.46.

The term t-ratio denotes the ratio of a parameter estimate to the estimate of its asymptotic standard error and does not imply that this ratio has a Student's t-distribution. In a sufficiently large sample, this ratio is significantly different from zero at the 5 percent level if it lies outside the interval \(\pm 1.96\) and is significantly different from zero at the 1 percent level if it lies outside the interval \(\pm 2.58\).

Reservation with respect to the reliability of the export and import price data were expressed in Section I (under “The Export Equation”), and unreliable data may be the reason for the poor determination of the relative price coefficients. The poor determination is, however, an important negative result.\(^1\) In a pure elasticities framework it would cast doubt on the efficacy of an exchange rate change for correcting a trade imbalance. As indicated in Section III, however, these doubts are dispelled once the other expenditure effects of an exchange rate change are taken into consideration. The coefficient on export volume in the desired import function is disentangled from a complicated composite coefficient (see equation (9)) derived by simplifying the licensing rule (equation (7)) and by ignoring lags in the export variable. This is the most brutal simplification in the model, and it casts some doubt on the interpretation of the coefficient \(\sigma_3\) as estimated. For this reason, the large standard error on this coefficient is not surprising.

Most of the coefficients in the model seem quite reasonable, although they are rather different in some cases from those obtained in other econometric models of Korea. In the inflation equation, the share of

\(^1\)See Otani and Park (1976) for a similar problem with the significance of relative prices.
domestically generated inflation is about 72 percent, that of imported inflation about 28 percent; these results are plausible, although some other estimates show a slightly larger share for imported inflation (see, for example, Nam (1980)). In addition to the direct effect of import prices \((1 - \epsilon)\) on the wholesale price index, there is an indirect relative price effect \((\beta_3)\). Insofar as inflation is led by domestic prices, this relative price effect acts as a constraint on inflation by redirecting domestic demand toward imports. Thus, as expected, the coefficient \((\beta_3)\) on the relative price term in the inflation equation is negative, but that \((\sigma_2)\) in the import equation is positive. The effect of the monetary disequilibrium term on price inflation is small but well determined. A 10 percent discrepancy between the demand for and supply of money will add (or subtract) half a percentage point to (or from) the inflation rate.

The estimated long-run relative price elasticity of exports \((\gamma_4)\) is of reasonable magnitude although, probably for reasons discussed already, not very well determined. However, the extent to which exports actually rise in response to a change in demand, as reflected in relative prices, depends critically on the output response, which is affected to a considerable extent by the relation between output and potential output. The size of the parameter \((\gamma_9)\) governing this relation suggests that there is substantial substitution between production for the domestic market and production for export. Domestic demand restraint, therefore, would have a strong direct effect on export supplies in addition to the indirect relative price effect that is usually observed. Noteworthy, however, is that actual exports adjust to the determinants of export supply rather slowly. Only 13 percent of the adjustment takes place in the first quarter, and the mean lag is over six quarters.

The import equation provides an interesting, although possibly naive, result with respect to the restrictiveness of the licensing system. The weight on desired imports \((\eta)\) in the linear decision rule (equation (7)) is over 81 percent, that on desired reserves \((1 - \eta)\) less than 19 percent. This suggests that the licensing regime for imports is not as strict as it is often thought to be. But there may be other reasons for this result. For example, the authorities may borrow to maintain the desired level of reserves (that is, change \(K\) in equation (7)) and may resort to manipulating the restrictiveness of the licensing system for imports only in extreme cases. Alternatively, the authorities may restrict imports of consumer goods in response to an increased demand for intermediate imports, thereby dampening the amplitude of fluctuations of aggregate import demand. The elasticity of import demand with respect to absorption \((\alpha_1)\) is large, but not implausibly so, and is well determined. The relative price elasticity \((\sigma_2)\) is rather small, perhaps because a large part of the import
bill is made up of intermediates that are necessary to domestic production and are consequently not very price sensitive. The monetary disequilibrium effect on import demand ($\omega_4$) is highly significant and remarkably large; indeed, monetary disequilibrium seems to exert more of an effect on import demand than on the growth of absorption or the rate of inflation.

The adjustment of imports to licenses issued is rapid, with over 52 percent ($\phi$) of the adjustment occurring in the first quarter. However, the two lag structures involved in the specification of the import demand equation are difficult to sort out. The equation is specified on the assumption that there is a one-period lag between desired imports and the issue of licenses; on this assumption, 52 percent of licenses issued result in import arrivals in the same quarter. It is not unlikely that the first lag—that is, one quarter between desired imports and licenses issued—may be overestimated and that the second lag—that between the receipt of the license and the import arrival—may be underestimated. In any event, the general result that the lags attached to the realization of import demand are much shorter than the lag attached to changes in export supply seems quite reasonable. Supply invariably takes longer to adjust than demand. In addition, the fact that Japan, which is geographically very close to Korea, is the major supplier of Korean imports strengthens the argument for relatively short import delivery lags.

The parameters of the absorption equation are of plausible magnitude and are significantly different from zero at the 99 percent level of confidence. A 10 percent discrepancy between the demand for and supply of money changes the growth of absorption by almost seven tenths of a percentage point. However, the effects of shocks are relatively short lived; if absorption exceeds trend absorption by 10 percent in any particular year, in the absence of any residual monetary imbalance the growth of absorption will be reduced by 4.8 percentage points in the following year.

Testing the validity of the structure of the model and of the restrictions on parameters is difficult. Various tests are discussed in Appendix III, and the results in general are fairly favorable to the model.

### III. Reaction Functions and Policy Analysis

The estimated model contains no government policy reaction functions. Although the efficacy of monetary and exchange rate policies for stabilizing an economy subject to various sorts of shocks is our chief concern, domestic credit (the monetary policy instrument) and the ex-
change rate have been left exogenous. In this section the model is enlarged to include some a priori reaction functions. These are not estimated but are imposed because our concern is not with what was done but with what might have been done.

The enlarged model is used to characterize six different policy regimes, each with a different mix of exchange rate and credit policies. These six different regimes are then each subjected to three shocks: an output shock that temporarily reduces production capacity; a monetary shock that temporarily reduces the demand for money; and a terms of trade shock induced by a short-lived rise in the foreign currency price of imports. The results are tabulated and discussed in a way that endeavors to throw light on the general subject of financial policies and stabilization.

**Reaction Functions and Six Policy Regimes**

Both instruments of demand management—domestic credit and the exchange rate—are postulated to react to the two indices of excess demand, that is, inflation and the balance of trade. The reaction function for domestic credit is specified as

\[
\Delta dc_t = \omega_0 + \omega_1 \Delta tb_{t-1} + \omega_2 (\Delta p_{t-1} - \Delta p_{t-2}),
\]

where \( \omega_1 \geq 0, \omega_2 \leq 0, \) and \( tb = xv + px - imp - pm. \)

Domestic credit deviates from its long-run growth path \((w_0)\) to stabilize demand. Both a deterioration in the trade balance and an acceleration of inflation elicit a tightening of credit policy from the authorities. It is worth noting that there is a lag between the shocks that precipitate policy changes and these changes. This delay will be referred to as the information lag.

To endogenize the exchange rate, it is necessary to abandon the shorthand that has allowed us to represent by a single symbol variables denominated in foreign currency and converted into domestic currency by the exchange rate. In the model thus far, for example, we have written \( px \) for \( e + px_f, \) where \( e \) is the domestic currency price of foreign currency and \( px_f \) is the export price in foreign currency. For simplicity, and because

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13 For a discussion of domestic credit as the monetary policy instrument, see Guittán (1973).
14 In addition to the Lucas-type, rational expectations critique of counterfactual experiments discussed in the opening paragraphs, this procedure is subject to the criticism that the parameter estimates may be distorted by a simultaneity bias in that variables treated as exogenous were really endogenous. This criticism may be leveled at virtually any estimated model, however, in that the modeler has always to draw an arbitrary line between endogenous and exogenous variables.
over the period examined almost all of Korea's trade-related payments were settled in U.S. dollars, $e$ is the exchange rate in relation to the U.S. dollar, and foreign currency variables are measured in U.S. dollar terms. In the enlarged model with endogenized exchange rates, the exchange rate is put into the notation explicitly, and an $f$ is appended to foreign currency variables. The reaction function for the exchange rate in the managed exchange rate regimes is specified as

$$
\Delta e_t = \pi_1 \Delta tb_{t-1} + \pi_2 (\Delta \rho_{t-1} - \Delta pmf_{t-1}),
$$

where $\pi_1 \leq 0$, $\pi_2 \geq 0$.

This reaction function allows some flexibility. Where the exchange rate is used as a general tool of demand management and is adjusted in reaction to both changes in the trade balance and changes in the relative rates of inflation at home and abroad, neither $\pi_1$ nor $\pi_2$ is set at zero. Where the authorities try to use the exchange rate to keep domestic prices in line with those abroad (specifically, import prices), $\pi_1$ may be set at zero and $\pi_2$ at unity. Except for the lag, this gives us the familiar condition of purchasing power parity or the condition for maintaining the real exchange rate.\(^{15}\)

The model was not estimated using sample data from a period in which Korea allowed its currency to float freely, and so substantial a change in institutions might well alter behavior in some fundamental way. It is arguable, therefore, that it is even more risky to make inferences from a free-floating exchange rate reaction function imposed on the model than from some of the other reaction functions. Technically, however, a free float could be characterized in the following way. Assuming that trade in services is relatively stable and that capital inflows are subject to official control, then the stochastic element in the balance of payments is the trade account. Given flows in capital and services, export receipts have to cover a given proportion of import payments; deviations from this norm will not be financed by the authorities and will consequently precipitate exchange rate changes. In this system there is no government intervention and, consequently, no information lag. It may be characterized as one polar extreme of the managed floating system in which $\pi_2$ is zero, $\pi_1$ is very large, and the lag on $\Delta tb$ is eliminated—that is,

$$
\Delta e_t = \pi_1 \Delta tb_t.
$$

Clearly, as long as the exchange rate affects the trade balance in the normal way, changes in the trade balance become very small as $\pi_1$ becomes

\(^{15}\)As will be seen below, the choice of the import rather than the export price as the representative foreign price has important implications for the stability of this exchange rate policy.
very large. As one experiment, and subject to the caveats discussed, the pure floating system is included among the policy regimes considered.16

Using the specified reaction functions, six different policy regimes are set up.

(1) The first sets $\omega_1 = \omega_2 = \pi_1 = \pi_2 = 0$; that is, it is what we shall call a pure hands-off regime. The exchange rate and domestic credit growth are fixed; neither is altered in response to the short-term shocks. Given transitory shocks, this is arguably a well-thought-out policy alternative.

(2) In the second regime, domestic credit is adjusted to reduce excess demand, but the exchange rate is fixed. Given the information lag and uncertainty about the duration of the shock, domestic credit is not adjusted to offset excess demand pressures entirely, but only to reduce them—that is, credit policy is to lean against the wind. The coefficient on the change in the trade balance ($\omega_1$) is set at 0.5, that on the acceleration of inflation ($\omega_2$) at −0.5. The effect is cumulative: because excess demand is likely to affect both the trade balance and the inflation rate, domestic credit expansion will be reduced by both terms. Nevertheless, this is a rather gentle leaning against the wind—for example, a rise of 10 percentage points in the growth of exports minus the growth of imports coupled with an increase of 10 percentage points in the rate of inflation would elicit a reduction of 10 percentage points in the growth rate of domestic credit. Within three periods, this would lower price inflation by only about 1 percentage point and would reduce the trade gap by about 1½ percentage points.

(3) In the third regime, domestic credit expansion is fixed, but the exchange rate is adjusted to contain excess demand. In equation (14), $\pi_1$ is set at −0.5, $\pi_2$ at 0.5. As in the second regime, the effects are cumulative, and the coefficients of the reaction function constitute a very gentle leaning against the wind. Following a deterioration of 10 percentage points in the trade balance and a deterioration in relative inflation rates of the same magnitude, the exchange rate depreciates by 10 percent. In response to this depreciation, prices rise sharply (by almost 3 percent) on impact, but only by 1½ percent over two periods; the correction of the trade balance brought about over the same time span by the depreciation amounts to 1½ percentage points—that is, substantially less than the deviation that precipitated the exchange rate change. As in the second policy regime, the objective of stabilization policy is to help the system

16 Ideally, the parameter $\pi_1$ should in this case be derived from the equilibrium condition of the trade balance. This would give $\pi_1$ an enormously large value. Any large value for $\pi_1$, however, will suffice to characterize the floating system compared with the other policy alternatives.
back to equilibrium without sharp changes in policy that could themselves be disequilibrating.

(4) The fourth regime combines the second and the third. Both the exchange rate and domestic credit are endogenized by the reaction functions with the same coefficients as in the two other regimes. This represents a sharper overall policy response to excess demand and a response on both fronts simultaneously.

(5) In the fifth policy regime, a real exchange rate system, or a (rather rapidly) crawling peg, is examined (see Williamson (1965)). Domestic credit is not allowed to react to disequilibria (that is, \( \omega_1 = \omega_2 = 0 \)), but, in the exchange rate reaction function, coefficients are set so as to keep domestic prices in line with those abroad; that is, \( \pi_1 = 0 \), but \( \pi_2 = 1 \).

(6) Finally, in the sixth policy regime, domestic credit is again unresponsive, but the exchange rate is allowed to approximate a free float. In the second variant of the exchange rate reaction function (equation (15)), \( \pi_1 \) is set at a large number, in this case \(-3.0\). This number is large enough to elicit a rather dramatic price and demand response to a trade balance deviation.

**Simulation Experiments**

The program for the simulation experiments is set up to produce percentage deviations from the base run—that is, the run without any shocks and with exchange rates and domestic credit given exogenously—for each of the shocks under each of the policy regimes.

The six enlarged models, one for each policy regime, are each subjected to the three different shocks. First, an output shock is produced by a one-quarter, 30 percent reduction in capacity (that is, in potential output) so that capacity utilization increases sharply and demand exceeds potential output. Second, a monetary shock is effected by a one-quarter, one-unit reduction of the constant term in the implicit money demand function. This reduction depresses the demand for money relative to the supply and thereby creates excess demand for goods. Third, a terms of trade shock is given by a one-quarter, 30 percent rise in the foreign currency price of imports.\(^{17}\)

\(^{17}\) It is, of course, significant that import prices rather than export prices change, and that one of the policy regimes is specifically set up to maintain parity between import prices in domestic currency and home prices. This terms of trade shock and that policy regime are obviously chosen to illustrate potential dangers of a crawling peg.
Results for Temporary Shocks to the System

In general, these experiments tend to confirm the view that financial policies do better at stabilizing the economy in response to financial disturbances than in response to real disturbances (Boyer (1978), Fischer (1977), and Lipschitz (1978)). Some results that seem to contradict this principle—for example, the relatively good performance of a policy to fix the real exchange rate in response to a terms of trade shock—derive essentially from the short duration of the shock and from the particular lag structure of the model. Rigorous and quick-reacting financial policies—best characterized in this analysis by the pure flexible exchange rate regime—do best at containing the external payments deficit under all circumstances. When the economy is buffeted by real shocks, however, this external payments stability is won at a substantial cost in absorption. In all cases, the more reactive is the exchange rate, the more volatile are prices. Insofar as price stability is an important component of the authorities’ objective function, it is unlikely that a high degree of nominal exchange rate variability will be allowed, even in response to financial shocks, unless there is a binding foreign exchange constraint.

If the authorities were constrained to choose one policy regime in response to all transitory shocks, the hands-off regime would probably be the best. This is an important consideration given the perennial difficulty of determining the origin of the principal shock to the economy at any time. The even more chronic difficulty of determining the duration of the disturbance is shown to be of critical importance. This difficulty leads to the examination of longer-term changes in the economic environment (see the subsection “Results for Permanent Changes,” below).

The Output Shock

As may be expected, the optimal policy regime depends on the objective function of the authorities: that is, no one regime is better in all respects than all the others. Insofar as the authorities seek to stabilize absorption and inflation, the hands-off regime is clearly best (Table 3 and Chart 1). The trade balance is allowed to play its normal role, under fixed exchange rates, of cushioning shocks to domestic absorption. It bears the brunt of the real shock, with exports in particular reacting sharply to the reduced output capacity. The natural tendency to return to equilibrium—through both the relative price effect and the monetary squeeze—is allowed to operate smoothly. In all of the other managed regimes, continuing trade imbalances and price changes elicit policy responses that interfere with this tendency. The free-floating exchange rate regime is at
Table 3. Output Shock: Mean-Squared Deviations from Base Run Under Different Policy Regimes  
(In percent)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fixed Exchange Rate and Fixed Domestic Credit</th>
<th>Fixed Exchange Rate and Reactive Domestic Credit</th>
<th>Reactive Exchange Rate and Fixed Domestic Credit</th>
<th>Reactive Exchange Rate and Domestic Credit</th>
<th>Fixed Real Exchange Rate and Fixed Domestic Credit</th>
<th>Flexible Exchange Rate and Fixed Domestic Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices</td>
<td>0.70</td>
<td>0.88</td>
<td>2.32</td>
<td>1.69</td>
<td>6.33</td>
<td>31.46</td>
</tr>
<tr>
<td>Export volume</td>
<td>69.68</td>
<td>67.95</td>
<td>66.62</td>
<td>65.46</td>
<td>69.86</td>
<td>53.45</td>
</tr>
<tr>
<td>Import volume</td>
<td>14.47</td>
<td>17.46</td>
<td>17.69</td>
<td>20.75</td>
<td>14.13</td>
<td>26.28</td>
</tr>
<tr>
<td>Trade balance</td>
<td>47.65</td>
<td>47.27</td>
<td>46.01</td>
<td>46.70</td>
<td>47.40</td>
<td>28.43</td>
</tr>
<tr>
<td>Money stock</td>
<td>19.86</td>
<td>44.00</td>
<td>17.87</td>
<td>45.10</td>
<td>20.92</td>
<td>12.93</td>
</tr>
<tr>
<td>Exchange rate</td>
<td></td>
<td>14.27</td>
<td>14.13</td>
<td>6.29</td>
<td>255.86</td>
<td></td>
</tr>
<tr>
<td>Real absorption</td>
<td>0.20</td>
<td>0.37</td>
<td>0.33</td>
<td>0.54</td>
<td>0.20</td>
<td>0.73</td>
</tr>
<tr>
<td>Domestic credit</td>
<td></td>
<td>12.29</td>
<td>13.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real income</td>
<td>3.25</td>
<td>3.34</td>
<td>3.13</td>
<td>3.22</td>
<td>3.25</td>
<td>2.26</td>
</tr>
</tbody>
</table>

the opposite end of the continuum to the hands-off regime. Greater stability in the trade balance is obtained at the cost of much sharper changes in the exchange rate and, consequently, in prices. The price changes, through their effect on the demand for money, destabilize absorption. In practice, the choice of regime might well depend on the financing ability of the country. A country with sizable foreign exchange reserves or easy access to capital markets might well opt for the hands-off policy, thereby choosing relatively stable absorption and prices at the cost of external current account volatility. A country with a binding external financial constraint might be forced to adopt flexible exchange rates.

In general, the more reactive is the exchange rate, the more stable are income and the trade balance and the less stable are prices. The exception to this generalization is the fixed real exchange rate regime, in which absorption is stabilized—as the lagged response of the exchange rate allows for greater price movements in the aftermath of the shock to restore absorption to its initial level—but the trade balance is allowed to swing in response to the real shock. In the other regimes, reactive exchange rates are a more effective stabilization tool than reactive domestic credit with respect to all variables except the price level.

The Monetary Shock

The three essential elements in this set of simulations are the short duration of the disturbance, the information lag that impedes all but two of the policy regimes, and the financial nature of the shock. The first two of these characteristics are shared by the other experiments with tempo-
Chart 1. Responses to Temporary Output Shock
Under Four Policy Regimes
(In percentage deviation from base run)

A. Prices
- Hands-off regime
- Reactive domestic credit only
- Reactive exchange rate only
- Pure floating exchange rate

B. Trade balance

C. Absorption
Table 4. Monetary Shock: Mean-Squared Deviations from Base Run Under Different Policy Regimes

(in percent)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fixed Exchange Rate and Fixed Domestic Credit</th>
<th>Fixed Exchange Rate and Reactive Domestic Credit</th>
<th>Reactive Exchange Rate and Fixed Domestic Credit</th>
<th>Reactive Exchange Rate and Fixed Domestic Credit</th>
<th>Fixed Real Exchange Rate and Fixed Domestic Credit</th>
<th>Flexible Exchange Rate and Fixed Domestic Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices</td>
<td>1.14</td>
<td>1.04</td>
<td>3.17</td>
<td>2.65</td>
<td>2.96</td>
<td>12.08</td>
</tr>
<tr>
<td>Export volume</td>
<td>2.14</td>
<td>2.20</td>
<td>2.19</td>
<td>2.31</td>
<td>2.23</td>
<td>1.37</td>
</tr>
<tr>
<td>Import volume</td>
<td>6.10</td>
<td>6.05</td>
<td>6.13</td>
<td>6.21</td>
<td>6.32</td>
<td>4.64</td>
</tr>
<tr>
<td>Trade balance</td>
<td>10.09</td>
<td>9.97</td>
<td>9.73</td>
<td>9.87</td>
<td>10.31</td>
<td>5.40</td>
</tr>
<tr>
<td>Money stock</td>
<td>5.63</td>
<td>11.43</td>
<td>5.04</td>
<td>12.01</td>
<td>5.19</td>
<td>3.96</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>—</td>
<td>—</td>
<td>4.86</td>
<td>4.67</td>
<td>2.95</td>
<td>48.57</td>
</tr>
<tr>
<td>Real absorption</td>
<td>1.00</td>
<td>1.01</td>
<td>1.05</td>
<td>1.05</td>
<td>1.05</td>
<td>1.01</td>
</tr>
<tr>
<td>Domestic credit</td>
<td>—</td>
<td>2.85</td>
<td>—</td>
<td>3.52</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Real income</td>
<td>0.54</td>
<td>0.56</td>
<td>0.50</td>
<td>0.52</td>
<td>0.51</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Primary shocks but are well illustrated in this case by the policy regime that attempts to fix the real exchange rate. Although the system does eventually settle back to the same real exchange rate, attempts to fix the real exchange rate are counterproductive. The lagged effects of the exchange rate changes on trade exacerbate the information lag and undermine stabilization policy.

Because the shock to the system is financial, it is amenable to financial remedies. The pure floating exchange rate provides the quickest acting financial remedy in that it does best at stabilizing the trade balance and not badly with respect to income and absorption (Table 4 and Chart 2). These results, however, are achieved at the cost of substantially increased price volatility.

Of the other policy regimes, in general the hands-off policy does best at stabilizing absorption and prices (although the reactive domestic credit policy does slightly better with respect to prices), and the reactive exchange rate policy does best at stabilizing income and the trade balance. Once again the choice of policy regime depends on the relative importance assigned to each of the endogenous variables and on the extent to which the country's financial resources allow it to shun adjustment.

The Terms of Trade Shock

Here again the hands-off regime is arguably the one that imparts most stability to the system as a whole. The fixed real exchange rate policy...
Chart 2. Responses to Temporary Monetary Shock Under Four Policy Regimes
(In percentage deviation from base run)

A. Prices
- Hands-off regime
- Reactive domestic credit only
- Reactive exchange rate only
- Pure flexible exchange rate

B. Trade balance

C. Absorption
option, however, does significantly reduce the variance of import volume; as a result, the variance of absorption, income, and the trade balance is slightly lower under this regime than under the hands-off regime (Table 5 and Chart 3). The extra stability in these variables is obtained at a cost of an enormous increase in the variance of the nominal exchange rate and, more important, of the domestic price level.

The result that an attempt to fix the real exchange rate in response to a real terms of trade shock might be optimal, in the sense of minimizing fluctuations in income and absorption, seems counterintuitive. In fact, this result derives entirely from the transitory nature of the shock. Under the hands-off regime, because of the lags in the system and the secondary effects of the shock, the initial reduction in import volume is corrected only slowly. Under the fixed real rate regime, however, with the lagged adjustment of the exchange rate to deviations between domestic and import price inflation, imports are boosted sharply after the shock by an appreciation of the domestic currency that coincides with the return to the base value of the import price index. This process hastens the return to base-run equilibrium. Clearly, if the shock were of a more permanent nature, the appreciation of the exchange rate would tend to delay necessary adjustment and to maintain absorption at an unsustainable level.

This result underscores the importance of the chronic difficulty of trying to determine the likely duration of any change in the economic environment. Obviously, at the extreme, temporary real changes may be financed, whereas permanent ones require adjustment. But a host of other questions about the efficacy of various policies and the best way to treat changes of a purely financial nature remain. Although the model is not strictly set up to examine permanent shifts—because they lead to much larger cumulative changes over time that may not be accurately represented in the linearized identities—some rough results may be instructive.

**Results for Permanent Changes in Economic Environment**

In general, the model's simulations of the various policy reactions to permanent changes in the economic environment produce reasonable results but no surprises. As expected, the simulations illustrate the long-run neutrality of money (but underscore the fact that the long run is well beyond the time horizon of most policymakers), the differences between real and monetary phenomena (and the folly of confusing the two), and the necessity of adjusting to sustained real changes.
Table 5. Terms of Trade Shock: Mean-Squared Deviations from Base Run Under Different Policy Regimes
(In percent)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fixed Exchange Rate and Fixed Domestic Credit</th>
<th>Fixed Exchange Rate and Reactive Domestic Credit</th>
<th>Reactive Exchange Rate and Fixed Domestic Credit</th>
<th>Reactive Exchange Rate and Fixed Domestic Credit</th>
<th>Fixed Real Exchange Rate and Fixed Domestic Credit</th>
<th>Flexible Exchange Rate and Fixed Domestic Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices</td>
<td>1.55</td>
<td>1.49</td>
<td>1.74</td>
<td>1.63</td>
<td>2.65</td>
<td>16.63</td>
</tr>
<tr>
<td>Export volume</td>
<td>0.83</td>
<td>0.83</td>
<td>0.82</td>
<td>0.86</td>
<td>1.20</td>
<td>1.65</td>
</tr>
<tr>
<td>Import volume</td>
<td>3.36</td>
<td>3.98</td>
<td>3.45</td>
<td>4.08</td>
<td>2.52</td>
<td>5.52</td>
</tr>
<tr>
<td>Trade balance</td>
<td>17.93</td>
<td>18.62</td>
<td>18.04</td>
<td>18.78</td>
<td>17.33</td>
<td>13.85</td>
</tr>
<tr>
<td>Money stock</td>
<td>2.49</td>
<td>14.36</td>
<td>2.47</td>
<td>14.59</td>
<td>3.03</td>
<td>2.24</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>—</td>
<td>—</td>
<td>0.43</td>
<td>0.64</td>
<td>9.61</td>
<td>124.67</td>
</tr>
<tr>
<td>Real absorption</td>
<td>0.07</td>
<td>0.13</td>
<td>0.08</td>
<td>0.14</td>
<td>0.04</td>
<td>0.18</td>
</tr>
<tr>
<td>Domestic credit</td>
<td>—</td>
<td>7.85</td>
<td>—</td>
<td>7.91</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Real income</td>
<td>0.01</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
<td>—</td>
<td>0.04</td>
</tr>
</tbody>
</table>

A Permanent Reduction in Capacity

In the case of a 30 percent reduction in capacity that occurs in the fifth quarter and is sustained for the remaining 13 years of the simulation period, absorption adjusts downward rapidly under all regimes but most rapidly under the pure flexible exchange rate regime and least rapidly under the hands-off regime (panel A of Chart 4). Not unexpectedly, of the managed regimes, that in which both domestic credit and the exchange rate are allowed to react to disequilibria exhibits the fastest adjustment. After two years of reduced capacity, absorption has been reduced by 28.0 percent under the hands-off regime and by 29.8 percent under the flexible exchange rate regime. The other regimes fall within this range. Adjustment is not entirely completed even after the full 13 years of postshock simulation. In the case of a flexible exchange rate, adjustment is virtually complete, with absorption some 29.9 percent below the initial level. In the hands-off case, absorption still has about 1½ percentage points to drop. Cumulated losses in the trade balance are almost 75 percent larger under the hands-off regime than under the flexible exchange rate regime.18

18 Cumulative losses in the trade balance are measured, for each regime, simply as

\[ \Sigma [tb(i) - tb(i,0)] \]

where \( i \) is the period from the first quarter of 1966 through the fourth quarter of 1978 and where 0 indicates the base-run value. Note that a deterioration in \( tb \) in any period might not have a negative effect on the money supply and that a
The nature of the shock—that is, a once-and-for-all reduction in capacity—requires that the adjustment be a reduction in expenditure rather than a switching of expenditure. Changes in relative price play virtually no role in the adjustment, which relies chiefly on reduced real money balances (panel B of Chart 4) together with a change in the perception of permanent income (or absorption). This is a rather unusual case in the sense that a depreciation of the real exchange rate—defined as \( p - e \) because traded goods prices in foreign currency are fixed—does not increase production or capacity by improving profit margins in the traded goods sector.

In a richer model, changes in the real exchange rate would presumably either facilitate or impede adjustment, so it is worth observing the behavior of the real exchange rate in the different regimes. In all of the fixed exchange rate regimes, the real exchange rate appreciates with the rise in domestic prices in response to supply shortages. In the regime that attempts to offset changes in the real exchange rate, the rate also appreciates, albeit by somewhat less, because there is a lag between price changes and offsetting exchange rate changes. Because price inflation is checked by the decline in the money supply, however, in all of these cases the appreciation is modest, reaching a maximum of 2.8 percent (in the hands-off regime) and in no case exceeding 2 percent by the end of the simulation period.

In the regimes where the exchange rate is allowed to react to lagged changes in prices and the trade balance, there is a depreciation of the real rate by 8–9 percent immediately after the cut in capacity, but the rate subsequently returns to the initial level. In the pure floating regime, there is a sharp—almost 50 percent—initial real depreciation that is eroded within one year; for the last seven years of the simulation period, the real rate is about 1.7 percent below its initial level.

Within the limitations of the present model, the differences in adjustment speeds between regimes are due to different real balance effects.

---

constant \( tb \) could be consistent with a positive external influence on the money supply. This is because \( tb \) is measured as the logarithm of the ratio of exports to imports relative to its value in the base period. For example, assume that domestic credit is fixed, the external net capital inflow is unchanged at a base-period value of 50, exports fall from 100 in the base period to 80, and imports fall from 150 in the base period to 120. Because both exports and imports have fallen by the same proportion, \( tb \) is unchanged:

\[
tb = \ln(\frac{100}{150}) = \ln(\frac{80}{120}) = -0.4055.
\]

However, the monetary effect of external transactions has changed. In the base period, the external accounts were balanced and, consequently, had no effect on the money supply. In the new period, there is a surplus of 10 on external transactions—that is, exports (80) plus the net capital inflow (50) minus imports (120)—that adds to the money supply.
Chart 3. Responses to Temporary Terms of Trade Shock Under Four Policy Regimes
(In percentage deviation from base run)

A. Prices
- Hands-off regime
- Reactive exchange rate and domestic credit
- Fixed real exchange rate
- Pure flexible exchange rate

B. Trade balance

C. Absorption
Chart 4. Responses to Sustained Reduction in Capacity Under Three Policy Regimes
(In percentage deviation from base run)

A. Absorption

- Hands-off regime
- Reactive exchange rate and domestic credit
- Pure floating exchange rate

B. Real money balances
In the first year of reduced capacity, real balances are only 15 percent lower on average in the hands-off regime but are 37 percent lower on average in the flexible exchange rate regime. The other regimes fall within these limits. Reactive domestic credit policy substantially increases the initial fall in real balances, but reactive exchange rates lead to a larger fall over the entire period.

**A Permanent Reduction in Money Demand**

In theory, when subjected to a permanent monetary shock, the model should exhibit long-run neutrality with respect to relative prices (or the real exchange rate) and all other real flow variables. On this basis, the policy option of the fixed real exchange rate should be particularly effective in promoting adjustment. In the simulation results, these a priori notions are by and large borne out, but the long run proves to be much longer than the time horizon of most policymakers.

The hands-off regime and the fixed real exchange rate regime are the two extremes in terms of speed of adjustment (Chart 5). In the hands-off regime, by the end of the simulation period, 13 years after the initial shock, only two thirds of the excess real balances have been dissipated, absorption is still 4½ percent above the base-run level (although real income is only half a percent higher), and the real exchange rate is 10½ percent higher than its full equilibrium level. Although all variables are still moving in the right direction, they are moving very slowly. At the other end of the spectrum, the fixed real exchange rate regime shows almost complete adjustment: 95 percent of the excess real money balances have been dissipated, and absorption, income, and the real exchange rate are all less than 1 percent away from their full equilibrium levels and are moving in the right direction.

The second most complete adjustment occurs under the free-floating exchange rate regime and, after that, under the regime in which both the exchange rate and domestic credit are allowed to react to disequilibria. The fixed real exchange rate regime, however, shows considerably more complete adjustment than either of these. Properly characterized, of course, a pure flexible exchange rate regime would adjust more rapidly than the fixed real exchange rate regime, insofar as the latter is subject to information lags. Given capital flows and initial overall external balance, the exchange rate would have to adjust to ensure that the gap between absorption and income did not exceed the initial current account deficit. For the estimated model, however, this would require even larger fluctuations in the nominal and real exchange rates than those that occur in our characterization of the pure float—movements that would proba-
Chart 5. Responses to Sustained Fall in Money Demand Under Three Policy Regimes
(In percentage deviation from base run)

A. Absorption

- Hands-off regime
- Reactive exchange rate and domestic credit
- Fixed real exchange rate

B. Real money balances

Percentage changes are measured as first differences in logarithms. A fall in real balances from 100 to 35 would therefore be recorded as a change of 105 percent; by the more conventional measurement of percentage change, this fall would be recorded as a change of only 65 percent.
bly not be acceptable to policymakers insofar as large price and exchange rate fluctuations are generally thought to be costly. More simply, in theory a domestic credit policy capable of immediately reducing the money supply by the full extent of the reduction in money demand would ensure costless continuous equilibrium. This, however, would require perfect information on the source, size, and duration of the shock.

Although the simulation results show fastest adjustment in the fixed real exchange rate regime, this is at the cost of higher inflation. The annual inflation rate is, on average, almost 5 percentage points above the base run in the postshock sample under this policy regime, compared with 3 percentage points in the flexible exchange rate regime and less than 1 percentage point in the hands-off regime. However, whereas the fixed real rate policy leads to a fairly steady increase in prices over the sample period, in the hands-off regime prices rise by 14 percent in the first year after the shock before declining, and in the flexible exchange rate regime prices rise by almost 50 percent in the first 18 months before embarking on a steady decline. Also, whereas the real exchange rate oscillates in the pure flexible exchange rate regime and in the other reactive exchange rate regimes, it rises and then declines steadily in the fixed real rate regime. Unless higher prices per se are negatively weighted in the authorities' objective function, the fixed real rate policy would seem to be best. In general, these simulations tend to confirm the view that sustained financial shocks can effectively be offset by financial policies even if the policymaking authorities have limited information about the size of the shock.

A Permanent Change in Terms of Trade

It is interesting to juxtapose the case of a permanent downward shift in the money demand function with that of a permanent deterioration in the terms of trade. In the former, the shock is financial, the resultant inflation is of domestic origin, and the long-term effect on real flows is negligible. In the latter, the shock is real, the resultant inflation originates abroad, and the change exerts a substantial long-run effect on real flow variables. Moreover, the juxtaposition of the two different shocks underscores the enormity of the policy error of treating them in the same way.

19 In the floating rate regime as characterized in the model, the nominal exchange rate depreciates by 68 percent in the first three quarters after the shock, whereas the real rate depreciates by 30 percent. Nevertheless, the trade balance deteriorates by 23 percent over this period. A substantially larger adjustment coefficient ($\pi_t$) in equation (15) could stabilize the external accounts, but at the cost of much greater price and exchange rate volatility.
Although the policy of trying to fix the real exchange rate is most effective in response to the domestic monetary disturbance, it is near disastrous after a terms of trade deterioration. In trying to fix the import-related real exchange rate, the authorities are forced to appreciate the domestic currency in response to the deterioration in the terms of trade. This appreciation lowers domestic prices and leads to a vicious circle of further currency appreciation and falling domestic prices. The process exacerbates the increase in the trade deficit and undermines the monetary squeeze that would normally curtail domestic expenditure. By the end of the simulation period, the deterioration in the trade ratio is four times as large as that under the flexible exchange rate regime and more than twice as large as those under any of the other regimes; there has been virtually no reduction in real absorption; and prices have fallen by about 50 percent (Chart 6). Clearly, a country following such a strategy would soon run out of foreign reserves and would create relative price distortions bound to hinder its export sector severely and to prevent its import-competing sector from capitalizing on a relative price advantage.

Of the other policy regimes, the flexible exchange rate produces the largest increase in domestic prices and reduction in real balances and, as a result, does best at containing the trade deficit. It also leads to the smallest increase in the real exchange rate for exports. All of the other regimes produce similar movements in prices, absorption, and the trade balance. Restrictive domestic credit alone does slightly better at hastening adjustment and containing the trade balance than the other reactive exchange rate regimes, since these regimes contain exchange rate reaction functions (equation (14)) with two terms that work against one another. The exchange rate adjusts to both the worsening trade balance and the deviations of the import-based real exchange rate from equilibrium. The former pushes the domestic currency down in value, the latter pushes it up; because they counterbalance each other, the exchange rate sees very little movement. Consequently, the real exchange rate for exports appreciates with domestic price inflation.

IV. Conclusions

Rather than summarize the results of the analysis, it may be worth ending with three observations culled from the experiments conducted. These generalizations must be subject to all of the caveats that are

20 The problem of trying to fix real wage rates in the face of a deterioration of the terms of trade is strictly analogous and has been well researched; see, for example, Gray (1978). The particular reaction function here (which focuses on the import price rather than on the export price), coupled with an import price shock, is of course set up to illustrate the problem.
Chart 6. Responses to Sustained Deterioration in Terms of Trade Under Three Policy Regimes
(In percentage deviation from base run)

A. Absorption

- Hands-off regime
- Reactive exchange rate and domestic credit
- Fixed real exchange rate

B. Real money balances
attached to the particular model employed and to policy experiments in general, but they are likely to be more generally applicable, especially because they are of a cautionary nature.

First, confusing real shocks with financial shocks may be very costly. Thus, a crawling peg exchange rate system, albeit well-suited to dealing with fluctuations in domestically generated monetary inflation, may be disastrous in the face of sustained changes in the terms of trade.

Second, the particular objective function of policymakers in developing countries is rarely well defined. Clearly, in many situations it might be possible to stabilize absorption, income, or the trade balance by the selection of an appropriate set of policies. The fluctuations in prices and exchange rates required to do this, however, might in themselves be considered to be unacceptably costly in the uncertainty that they produce and in their effects on confidence, investment, and saving.

Finally, it may be costly to treat short-run, reversible shocks as if they are permanent by adopting policy measures to achieve rapid adjustment. The effects of discretionary policy changes often persist long after the shocks that elicited them. Moreover, the difficulties of fine-tuning for disturbances of very short duration are greatly exacerbated by the information lag that inevitably reduces the speed of policy adjustment. In a certain world, there would usually be a strong case for financing short-run external payments imbalances rather than adjusting domestic demand to eliminate them. The weakness of this prescription is that uncertainty about the duration of any disturbance is fundamental to the problem of policy formulation. The benefits of avoiding excessive early adjustment, therefore, have to be set against the costs of a probable greater, and more painful, adjustment at a later stage. A prudent government might well decide that some modest adjustment at an early stage is the safest route.

**APPENDIX I**

**Data Sources**

The quarterly national accounts data were taken from The Quarterly GNP of Korea (Seoul: The Bank of Korea, various issues). Most of the other data used were taken from the International Monetary Fund's Data Fund tapes, much of which are published in the Fund's International Financial Statistics (Washington, various issues). These data are either reported directly to the Fund by the Korean authorities or are taken from the Bank of Korea's Monthly Economic Statistics (Seoul, various issues). Seasonally adjusted series were used whenever the unadjusted series showed evidence of seasonality. Interest rates (I) in the unofficial money market are from unpublished survey data collected by the Bank of Korea.

In most cases, the series are fully described in the text; in what follows, therefore, only those series requiring further description are discussed.
Domestic credit (DC) is defined residually, from the consolidated balance sheet of the banking system, as money minus net foreign assets valued in local currency.

Net nontrade receipts in the external accounts (K) are defined residually from the balance of payments identity as the change in net foreign assets minus export receipts plus import payments. This flow variable—which consists largely of the net capital inflow—is cumulated into a stock variable (KS) in the linearization of the identities in Appendix II.

The overall price index used (P) is the wholesale price index. The import and export price indices used (PX and PM) are unit-value indices.

The desired stock of reserves (R*) is determined by running a trend through peaks of imports, multiplying the resultant peak import series by the average reserve-import ratio over the sample period, and deflating by import prices. Initially, all these series are valued in U.S. dollars, but both the desired reserve figure and the import price index are converted into domestic currency. Because the dollar-won exchange rate enters both the numerator and the denominator, this variable is impervious to exchange rate changes.

Real trade data are the nominal domestic currency series, based on customs data and deflated by the unit-value indices. Exports are measured f.o.b. and imports c.i.f.

Trade in services (TS) is defined as the difference between the trade data as described above and the trade data for goods and services as measured in the national income statistics.

**APPENDIX II**

**Linearizing the Identities**

The two identities—that is, the real income and the money identities—are not in log-linear form. For estimation and simulation purposes they are linearized by means of a Taylor’s series expansion. Second and higher-order terms are omitted from the expansion. The identities are linearized about trend values of the variables, with the time trend (t) set at zero in the third quarter of 1975 and changed by increments of 1 in both directions for each quarter deviation from the base date.

The Real Income Identity

As given in the text, this identity may be written

\[ YR_t = \text{ABS}_t + \text{XV}_t - \text{IMP}_t + \text{TS}_t. \]  

(11)

Trend growth rates for variables are denoted by \( \lambda \), such that the trend value of \( \text{ABS} \) at time \( t \) is \( \lambda_{\text{ABS}} t + \text{ABS}_0 \). The subscript zero denotes the base period value of the relevant variable. Linearizing equation (11) about the trend yields

\[
yr = yr_0 + \lambda_y t + \left(\frac{\text{ABS}}{YR}\right)_0 \left[\text{ABS}_t - \text{ABS}_0 - \lambda_{\text{ABS}} t\right]
+ \left(\frac{\text{XV}}{YR}\right)_0 \left[\text{XV}_t - \text{XV}_0 - \lambda_{\text{XV}} t\right]
- \left(\frac{\text{IMP}}{YR}\right)_0 \left[\text{IMP}_t - \text{IMP}_0 - \lambda_{\text{IMP}} t\right]
+ \left(\frac{\text{TS}}{YR}\right)_0 \left[\text{TS}_t - \text{TS}_0 - \lambda_{\text{TS}} t\right].
\]  

(11a)
Letting
\[ c_1 = (ABS/YR)_0 \]
\[ c_2 = (XVI/YR)_0 \]
\[ c_3 = (IMP/YR)_0 \]
\[ c_4 = (TS/YR)_0 \]
\[ c_5 = \lambda_y - c_1 \lambda_{abs} - c_2 \lambda_{sv} + c_3 \lambda_{imp} - c_4 \lambda_u \]
\[ q = \text{the error due to the linearization,} \]
substituting these definitions into equation (11a) gives
\[ yr = c_1 abs, + c_2 xv, - c_3 imp, + c_4 ts, + c_5 t \]
\[ + \text{constant} + q. \]

(11b)

The Money Identity

As given in the text, this identity is written
\[ M_t = DC_t + NFA_{t-1} + (XV, PX,)_t - (IMP, PM,)_t + K_t. \]

(12)

In terms of changes in the money stock, this may be written as
\[ \Delta M_t = \Delta DC_t + (XV, PX,)_t - (IMP, PM,)_t + \Delta K_t, \]

(12a)

where \( \Delta \) is the first difference operator and \( KS \) is the stock of indebtedness. This interpretation of \( KS \) is approximate because \( K \) represents the flow of both capital and nontrade current account receipts; however, \( KS \) should simply be interpreted as the summation of \( K \) over time. This is merely a device to eliminate negative values of \( K \) that would complicate the linearization. Dividing equation (12a) by \( M_{t-1} \) yields
\[ \Delta m_t = \Delta dc, (DC/M)_{t-1} + (XV, PX,)/M_{t-1} - (IMP, PM,)/M_{t-1} + \Delta ks, (KS/M),_{t-1}. \]

(12b)

Linearizing equation (12b) term by term by means of a Taylor's series expansion yields
\[ \Delta m_t = (DC/M)_0 [dc_t - dc_{t-1}] + (\Delta dc_0)(DC/M)_0 \]
\[ \cdot [dc_{t-1} - dc_0 - \lambda_{det} - m_{t-1} + m_0 + \lambda_{mt}] + [(XV \cdot PX)/M]_0 \]
\[ \cdot [1 + xv_t + px_t - xv_0 - px_0 - \lambda_{sv}t - \lambda_{pt}t - m_{t-1} + m_0 + \lambda_{mt}] \]
\[ - [(IMP \cdot PM)/M]_0 \]
\[ \cdot [1 + imp, + pm, - imp_0 - pm_0 - \lambda_{mt} - \lambda_{pm}t - m_{t-1} + m_0 + \lambda_{mt}] \]
\[ + (KS/M)_0 [ks_t - ks_{t-1}] + (\Delta ks_0)(KS/M)_0 \]
\[ \cdot [ks_{t-1} - ks_0 - \lambda_{st}t - m_{t-1} + m_0 + \lambda_{mt}]. \]

(12c)

Letting
\[ k_1 = (DC/M)_0 \]
\[ k_2 = \Delta dc_0 \]
\[ k3 = [(XV \cdot PX) / M]_0 \]
\[ k4 = [(IMP \cdot PM) / M]_0 \]
\[ k5 = (KS / M)_0 \]
\[ k6 = \Delta k s_o \]

\( \nu = \) the error due to the linearization,
equation (12c) may be rewritten as
\[
m_t = (1 - k1 k2 - k3 + k4 - k5 k6) m_{t-1} + k1 d c_t + k1 (k2 - 1) d c_{t-1} + k3 (x v_t + p x_t) - k4 (i m p_t + p m_t) + k5 k s_t + k5 (k6 - 1) k s_{t-1} + [(k1 k2 + k3 - k4 + k5 k6) \lambda_m - k1 k2 \lambda d c - k3 (\lambda x v + \lambda p s) + k4 (\lambda i m p + \lambda p m) - k5 k6 \lambda k s_t] t + \text{constant} + \nu_t. \]  
(12d)

It is arguable that \( k1 \) and \( k5 \) should be evaluated at the period before the base period to be consistent with equation (12b). However, because these ratios were relatively constant, all were simply evaluated at the base period.

**APPENDIX III**

**Structure of the Model**

It is difficult to test the validity of the structure of the full model by means of any simple statistic.\(^{21}\) The likelihood-ratio statistic, which is distributed asymptotically as a chi-square distribution, allows a large sample test of whether the overidentifying restrictions are consistent with the data for the FIML (full-information maximum-likelihood) estimator. But recent work suggests that, even for samples of over 100 observations, the likelihood ratio may not be a good approximation to the asymptotic chi-square distribution. For whatever it is worth, the chi-square value of the log-likelihood ratio is 334.89, with 111 degrees of freedom. The critical value of the distribution at the 5 percent level with 111 degrees of freedom is approximately 136.6. Thus, if one were to regard the likelihood ratio as a reasonable approximation to the asymptotic chi-square distribution, one would have to reject the hypothesis that the overidentifying restrictions are consistent with the sample data.\(^{22}\)

\(^{21}\) Tests of the individual parameters do not present as great a problem. Parameter estimates are asymptotically normally distributed, but work by Phillips (1978) suggests that for small samples—20 to 30 observations in his case—the accuracy of the approximation depends critically on the stability of the model. If the model is unstable, the small-sample parameter distribution will be slow to converge to the asymptotic distribution as the number of observations is increased. The sample used in this model (56 observations) is about twice as large as those in Phillips' Monte Carlo studies, so that we have proceeded to test the parameter estimates with a normal distribution with the standard deviation given by the estimates' standard errors.

\(^{22}\) Most other models using the same or similar estimation programs have arrived at a similar rejection of the overidentifying restrictions; see, for example, Jonson, Moses, and Wymer (1976), Knight and Wymer (1978), and Brillembourg and Schadler (1979).
Table 6. Estimation Errors
(Sample period: first quarter of 1965 through fourth quarter of 1978)

<table>
<thead>
<tr>
<th>Endogenous Variable</th>
<th>Variance</th>
<th>Mean-Squared Error of Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p )</td>
<td>0.2753</td>
<td>0.0003</td>
</tr>
<tr>
<td>( x_v )</td>
<td>1.2876</td>
<td>0.0038</td>
</tr>
<tr>
<td>( imp )</td>
<td>0.5336</td>
<td>0.0062</td>
</tr>
<tr>
<td>( obs )</td>
<td>0.1457</td>
<td>0.0013</td>
</tr>
<tr>
<td>( yr )</td>
<td>0.1500</td>
<td>0.0007</td>
</tr>
<tr>
<td>( m )</td>
<td>1.7585</td>
<td>0.0004</td>
</tr>
</tbody>
</table>

In testing the hypothesis that the model is not consistent with the data, the opposite problem occurs. With a small sample, it is difficult not to reject the hypothesis. The Carter-Nagar statistic for the overidentified model, which has an asymptotic chi-square distribution with 21 degrees of freedom, is 72,110. The critical value of the chi-square distribution with 21 degrees of freedom at the 5 percent level is 32.7. Thus, if the difficulties related to small samples were ignored, the hypothesis that the model is not consistent with the data would be resoundingly rejected. This result is reflected in the Carter-Nagar \( R^2 \) statistic of 0.9969.

Although these formal tests are not of much use because of the inadequacy of the sample size, it may be of interest to examine the mean-squared errors of the estimated endogenous variables (Table 6). As is clear from the results in the table, the in-sample tracking performance of the model is good, and the mean-squared errors of estimates are very small relative to the original variances of the endogenous variables.

The simulation results go only one year beyond the sample period and therefore track actual performance rather well (Table 7). In the postsample period, however, the divergence between actual and simulated values does widen.

In general, it is somewhat surprising that the model specified fits the data as well as it does. In specifying the model, a demand-driven structure was chosen chiefly because of its familiarity. There are, of course, persuasive arguments against this sort of model structure in light of the real—that is, relative price or terms of trade—shocks that occurred in 1973 and again soon after the end of the sample period (see, for example, van Wijnbergen (1981) and (1982)). The structure chosen does, however, facilitate the concentration on typical instruments of demand management in the policy analysis undertaken in Section III.

Table 7. Simulation Errors
(Third quarter of 1965 through fourth quarter of 1979)

<table>
<thead>
<tr>
<th>Endogenous Variable</th>
<th>Variance</th>
<th>Mean-Squared Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Static simulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dynamic simulation</td>
</tr>
<tr>
<td>( p )</td>
<td>0.3164</td>
<td>0.0004</td>
</tr>
<tr>
<td>( x_v )</td>
<td>1.2524</td>
<td>0.0044</td>
</tr>
<tr>
<td>( imp )</td>
<td>0.4992</td>
<td>0.0061</td>
</tr>
<tr>
<td>( obs )</td>
<td>0.1586</td>
<td>0.0015</td>
</tr>
<tr>
<td>( yr )</td>
<td>0.1606</td>
<td>0.0008</td>
</tr>
<tr>
<td>( m )</td>
<td>1.7373</td>
<td>0.0004</td>
</tr>
</tbody>
</table>

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Stabilization Policies in Developing Countries with a Parallel Market for Foreign Exchange

A Formal Framework

Pierre-Richard Agénor*

WIDESPREAD TRADE restrictions and foreign exchange controls have resulted in inefficient patterns of resource use and led to the emergence of parallel markets in goods and foreign currency in many developing countries. The evidence collected over the past few years has shown that current account restrictions (including import licenses, foreign exchange allocations, and import deposit requirements) create incentives for illegal transactions, such as smuggling and fake invoicing, as well as for capital flight and capital inflows via unofficial channels.

Although official data on the volume of transactions in parallel currency markets1 are usually not available on a systematic basis, formal and informal evidence suggests that the major sources of foreign exchange supply are smuggling, overinvoicing of imports and underinvoicing of exports, workers' remittances from abroad (as in Turkey, for example), and tourism (as in Argentina and Brazil). The relative importance of various sources in total supply is, however, generally unknown.2 Simi-

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1By definition, a parallel currency market is one in which foreign exchange transactions are conducted outside official channels (including officially recognized financial institutions and authorized foreign exchange dealers). Such a market is often illegal, albeit officially tolerated in many countries.

2Researchers have usually had to resort to "indirect" techniques to measure the importance of parallel market transactions. For example, the extent to which traders engage in fake invoicing can, in principle, be measured by using techniques that compare partner country trade data. To investigate the scale of

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larly, no direct information on the composition of foreign exchange demand in parallel currency markets is generally available. The existence of rationing in the official foreign exchange market in many developing countries suggests, however, that in most countries the illegal demand for foreign currency arises for both current and capital account transactions. Unsatisfied demand at the official rate spills into the parallel market.³

The parallel market rate usually includes a scarcity premium that reflects the underlying excess demand pressures that the restrictions are intended to contain. Parallel exchange rates, being market determined, have tended to show large fluctuations, reflecting short-run changes in the underlying supply and demand curves. Table 1 presents estimates of the degree of variability of official and parallel exchange rates in a group of 11 developing countries over the period 1974–86. The table shows that parallel market rates have in general exhibited a substantially higher degree of volatility than official rates. This is partly due to the important role of noneconomic factors (political risk, domestic crises, international tensions) in the short-run behavior of parallel exchange rates, as well as to the fundamentally forward-looking nature of expectations on illegal currency markets.

This paper examines the implications of the existence of illegal trade transactions and parallel currency markets for short-run policymaking in developing countries, using a macroeconomic model that incorporates currency substitution features and forward-looking rational expectations. Most macroeconomic models for developing countries have used backward-looking expectational schemes.⁴ Developments in macroeconomic theory since the early 1970s have, however, repeatedly stressed the role of forward-looking expectations in the conduct of

underinvoicing or overinvoicing of exports, for instance, one would need to look at the ratio of exports to major partner countries, as shown by domestic data, to the corresponding imports, as recorded in partner country data. When this ratio is less than unity, the evidence points to capital flight. To be able to make these comparisons between partner countries, however, it is important to adjust the trade data for transport costs, timing of transactions, and classification of transactions. See Gupta (1984) and McDonald (1985) for recent attempts to use these procedures.

³However, Pitt (1984) has shown that foreign exchange controls and current account restrictions are not a necessary condition for the existence of a parallel currency market. If legal trade requires the sale or purchase of legal foreign exchange, the existence of a positive tariff is sufficient to induce illegal trade activities and foreign currency transactions.

⁴A notable exception is the simulation model recently developed by Haque, Montiel, and Symansky (1989), but the specification of their model differs substantially from the one adopted here.
Table I. Variability in Official and Parallel Exchange Rates, 1974–86

<table>
<thead>
<tr>
<th>Country</th>
<th>Official Rate</th>
<th>Parallel Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>7.56</td>
<td>22.01</td>
</tr>
<tr>
<td>Greece</td>
<td>38.15</td>
<td>41.64</td>
</tr>
<tr>
<td>India</td>
<td>1.64</td>
<td>1.94</td>
</tr>
<tr>
<td>Korea, Republic of</td>
<td>184.15</td>
<td>189.49</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.26</td>
<td>0.37</td>
</tr>
<tr>
<td>Morocco</td>
<td>1.97</td>
<td>1.98</td>
</tr>
<tr>
<td>Nigeria</td>
<td>0.27</td>
<td>0.53</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2.11</td>
<td>3.20</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.14</td>
<td>0.15</td>
</tr>
<tr>
<td>Tunisia</td>
<td>0.15</td>
<td>0.17</td>
</tr>
<tr>
<td>Zambia</td>
<td>2.04</td>
<td>2.58</td>
</tr>
</tbody>
</table>

Source: Appendix I.
Note: Standard deviation of the quarter-to-quarter rate of change of the official and parallel exchange rates.

stabilization policy. To the extent that expectations of future outcomes are altered when a stabilization package is adopted, its effects would not depend solely on the magnitude of the announced policy changes and the coefficients relating policies to ultimate objectives based on past historical experience. For example, an announced reduction in the rate of growth of the money stock could lead to an immediate fall in inflation if it caused agents to revise downward their expectations of the future rate of inflation. Conversely, if the policy change is not viewed as credible, inflation could persist much longer than the underlying estimated relationship would indicate, and the adverse effects of a stabilization policy on output and employment would be correspondingly larger.

The model developed in this paper is "monetary," in the sense that it emphasizes the role of monetary disequilibria in explaining movements in output, prices, the parallel market exchange rate, and changes in net foreign assets. However, in contrast to the "standard" monetary approach to the balance of payments, foreign reserves do not move instantaneously to adjust supply and demand, consequently creating disequilibrium in the official market for foreign exchange. Excess demand at the official exchange rate spills over to the parallel market, which

5 See Fischer (1988) for a concise discussion, and Minford and Peel (1983) and Hoover (1988) for a broader perspective. Although the Muthian concept of rational expectations remains controversial (see, for example, the discussion by Akerlof and Yellen (1987)), recent developments in macroeconomics for developing countries have in general adopted it—or its deterministic equivalent, perfect foresight.
therefore plays a crucial role in the determination of macroeconomic equilibrium.

An early study by Blejer (1978) emphasized the role of monetary factors in the determination of the parallel market exchange rate. Blejer’s assumption that foreign exchange is demanded in the parallel market for capital transactions only seems too constraining for most developing countries, which use quantitative restrictions on imports as an instrument of control. More recently, Olgun (1984) developed and estimated a short-run macroeconomic model for Turkey that explicitly considered the impact of fluctuations in parallel market exchange rates on output, prices, and portfolio decisions in the private sector. Olgun’s model, however, is based on restrictive assumptions—he assumes, in particular, that the money stock is demand determined. Moreover, his model is not sufficiently detailed to analyze the impact of fiscal and credit policies on the economy.

Section I of the paper discusses the specification of the model. Section II presents econometric estimates of the behavioral equations, and Section III analyzes the simulation results based on alternative policy scenarios. The policy shocks considered are those most often discussed in stabilization programs: changes in domestic credit, changes in government spending, and devaluation of the official exchange rate. Section IV offers some concluding remarks and draws policy implications for macroeconomic management in developing countries with a large parallel currency market. Data sources and definitions are given in Appendix I, and the solution procedure of the model is presented in Appendix II.

I. A Macroeconomic Model with a Parallel Currency Market

This section describes a macroeconomic model for a small open economy with a sizable parallel market for foreign exchange. In many respects, the model can be seen as an extension of the monetary framework developed by Khan and Knight (1981), which provides an essential reference for the analysis of stabilization policies in developing countries.

Consider a small open economy producing both traded and nontraded goods. The exchange rate system consists of a dual rate regime in which an official pegged nominal exchange rate coexists with an illegal or quasi-illegal parallel market for foreign exchange. Commercial transactions are settled partly in the official market at the exchange rate \( e \), which is set by the monetary authorities and is treated as a policy instrument. The remainder of commercial transactions and all capital trans-
actions are settled in the parallel market at the free exchange rate $b$, which is determined by the interactions between supply and demand for foreign exchange.

Only two financial assets are available, domestic money and foreign money, both being non-interest-bearing assets. Desired holdings of domestic and foreign currencies depend on both transaction motives and portfolio considerations. Markets for government securities do not exist, so that public budget deficits are financed either by borrowing abroad or by the domestic banking system.

**The Inflation Process**

The price level, $P_t$, is defined as a geometric average of the price of nontraded goods, $P^N$, and the price of traded goods, $P^T$:

$$P_t = (P^T_t)^{\delta} (P^N_t)^{1-\delta}, \quad 0 < \delta < 1,$$  

with $\delta$ measuring the share of traded goods in total expenditure. Taking log differences of equation (1) yields

$$\Delta \log P_t = \delta \Delta \log P^T_t + (1 - \delta) \Delta \log P^N_t,$$  

with $\Delta$ denoting the first-difference operator.

Since the economy considered is “small,” the world price of traded goods, $Q$, is exogenously given, and its rate of change in domestic currency is determined by the world rate of inflation, $\Delta \log Q$, a weighted average of the rate of change of the official exchange rate, $\Delta \log e_t$, and the rate of change of the parallel rate, $\Delta \log b_t$:

$$\Delta \log P^T_t = \theta \Delta \log e_t + (1 - \theta) \Delta \log b_t + \Delta \log Q_t, \quad 0 \leq \theta \leq 1,$$  

where $\theta$, assumed constant in the short run, denotes the proportion of trade carried through official channels. The rationale for considering a weighted average of both exchange rates to determine the domestic price of tradable goods is that trade takes place at both the official exchange rate (through official channels) and the parallel market rate (through smuggling). However, in most countries where foreign exchange rationing by the banking system is prevalent, the officially fixed exchange rate is not relevant for the determination of market prices of traded goods. It only measures the rents captured by those (usually the government and

---

6 In the medium and long run, $\theta$ is likely to depend on the spread between the official and parallel exchange rates, the degree of restrictions on trade and capital movements, as well as the degree of law enforcement at the borders.
a small group of importers) to whom foreign exchange is made available at the official rate. This suggests that the weight attached to the parallel market rate in equation (2) above should be significantly greater than the share of smuggling in total trade, and that econometric estimates of $\theta$ should be close to zero and not statistically significant. As shown below, the latter implication is indeed supported by the empirical results.

Since an excess supply of money implies an excess demand for both traded and nontraded goods, by assuming that the excess demand for nontraded goods varies with excess demand throughout the economy, one can postulate the following equation for the rate of change of the prices of nontraded goods:

$$\Delta \log P^N_t = \phi_1 \pi_{t+1/t} + \phi_2 [\log m_{t-1} - \log m^d],$$

$$0 \leq \phi_1 \leq 1, \quad \phi_2 > 0,$$

(3)

where $m = M/P$ denotes the real money stock ($M$ denoting the nominal stock of money), $m^d$ is the demand for real cash balances (explained below), and $\pi_{t+1/t} = \Delta \log P^d_{t+1/t}$ is the expectation of the rate of inflation for period $t + 1$ formed at period $t$. The coefficient $\phi_1$ measures the degree to which the prices of nontradable goods move with the expected future level of domestic inflation, and $\phi$ denotes the elasticity of nontraded goods prices to the excess supply of real money balances. Firms adjust the price of nontradable goods with respect to the price of all goods sold and exchanged in the economy. Accordingly, expected general inflation rather than the expected percentage change in the price index for home goods appears on the right-hand side of equation (3).

Substituting equations (2) and (3) in equation (1') yields an expression for the rate of domestic inflation as a function of world inflation, changes in the official and parallel exchange rates, expected inflation, and the rate of ex ante disequilibrium in the money market:

$$\Delta \log P_t = \delta \delta \Delta \log e_t + (1 - \tau) \delta \Delta \log b + \delta \Delta \log Q_t$$

$$+ (1 - \delta) \phi_1 \pi_{t+1/t} + (1 - \delta) \phi_2 [\log m_{t-1} - \log m^d].$$

(4)

If all goods are traded—that is, $\delta = 1$—then the last two terms in equation (4) disappear, so that the domestic rate of inflation is pegged to the world rate at a composite exchange rate. Also, in the long run the

---

Footnote 7: Monetary disequilibrium in equation (3) is measured in terms of the deviation of the beginning-of-period actual stock of real balances from demand, a quantity that can be viewed as the “flow” supply of real balances. This concept ignores, however, the role that domestic credit expansion during the period plays in closing the real balance gap. An alternative measure that incorporates this last element is discussed by Blejer (1977) and Sundararajan (1986).
money market is in equilibrium and expected and actual rates of price increase are equal, so that domestic prices grow at the same rate as the rate of change in prices of traded goods (expressed in domestic currency at a composite exchange rate) only if \( \delta/[1 - (1 - \delta)\phi_t] = 1 \); that is, if \( \phi_t = 1 \).

**Parallel Market for Foreign Exchange**

The parallel market exchange rate is determined by the interactions between the supply of and the demand for foreign currency in that market. Following Lizondo (1987) and Kharas and Pinto (1989), the model provides a proper distinction between the role of stocks and flows in the behavior of the parallel market exchange rate. The flow market for foreign currency arises out of illegal cross-border transactions in goods and services. The stock of foreign currency is held as part of a diversified portfolio, and is determined by an equilibrium condition akin to that in an asset market.

The flow supply of foreign currency in the parallel market results from the overinvoicing of imports and underinvoicing of exports, the degree of which is assumed to depend on the level of the spread between the official and parallel exchange rates. Formally, the flow supply function can be written as\(^8\)

\[
\Delta \log C_t^f = c_0 + c_1 \log (b_t/e_t), \quad c_1 > 0.
\]  

The flow demand for foreign currency in the parallel market—that is, the demand for foreign currency as a medium of exchange for current account transactions—arises because the monetary authorities cannot satisfy total demand (for legal and illegal transactions) at the official exchange rate. Such demand, denoted by \( \Delta \log C_t^d \), is positively correlated with overall economic activity (measured by the level of real income) and the deviation of domestic prices from foreign prices, valued at the parallel exchange rate:

\[
\Delta \log C_t^d = \gamma_0 + \gamma_1 \log y_t + \gamma_2 \log (P_t/b_tQ_t), \quad \gamma_1, \gamma_2 > 0.
\]  

The net rate of addition to the stock of foreign currency in private agents' portfolios, \( \Delta \log F_t \), is therefore given by

---

\(^8\) The supply function (5) should, in principle, include a risk factor, given the illegal nature of parallel market activities. The exclusion of a risk coefficient can be rationalized by the assumption either that parallel market operations, although illegal, are tolerated by the authorities, or that the probability of being caught, although nonnegligible, is small.
\[ \Delta \log F_t = \Delta \log C_t^f - \Delta \log C_t^d, \] (7)

where \( F \) denotes total foreign currency holdings by the public.

The portfolio component of foreign currency demand in the parallel market is, as emphasized in the currency substitution literature (see Calvo and Rodriguez (1977) and Ramirez-Rojas (1985)), positively related to the expected rate of return derived by holding this asset and negatively related to the expected rate of return derived from holding alternative assets (domestic currency in this context). The opportunity cost of holding foreign currency is given by the rate of return on domestic money, which is equal to minus the expected domestic inflation rate, \( \pi_{t-1} = \Delta \log P_{t-1}^d \), assuming that expectations are formed at period \( t-1 \) for period \( t \). The return from holding foreign money as an asset can be written as the difference between the expected rate of depreciation in the parallel market, \( \Delta \log b_{t-1}^p \), and the expected rate of world inflation, \( \Delta \log Q_{t-1}^w \), assuming that agents are concerned about the external purchasing power of their holdings of foreign currency. Assuming homogeneity in wealth, equilibrium in the stock market for foreign currency is given by

\[ \log [b_t F_t (M_t + b_t F_t)] = \mu_0 + \mu_1 \pi_{t-1} + \mu_2 \rho_{t-1}, \quad \mu_1, \mu_2 > 0, \] (8)

where
\[ \rho_{t-1} = \Delta \log b_{t-1}^p - \Delta \log Q_{t-1}^w. \]

The quantity \( M_t + b_t F_t \) measures nominal financial wealth of the public, with foreign currency holdings valued at the parallel market exchange rate.

Using, as an approximation
\[ \log (M_t + b_t F_t) = \tau_0 + (1 - \tau) \log M_t + \tau \log b_t F_t, \]

where \( 0 < \tau < 1 \), equation (8) can be rewritten as

\[ \log F_t = \frac{\tau_0 + \mu_0}{1 - \tau} + \frac{\mu_1}{1 - \tau} \pi_{t-1} + \frac{\mu_2}{1 - \tau} \rho_{t-1} + (\log M_t - \log b_t). \] (9)

Taking first differences of (9), substituting in (7), and using (5) and (6) yields the following solution for the parallel market exchange rate:

9 The stock equilibrium condition in the parallel exchange market is expressed in terms of flows for estimation purposes, since reliable data on stocks of foreign currency held by domestic agents in developing countries do not exist. The asymmetric treatment between stocks (of domestic currency) and flows (of foreign currency) implies that in the sense of Foley (1975) and Buitter (1980), the model is neither a pure stock (beginning-of-period) model nor a pure flow (end-of-period) model.
\[
\log b_t = \frac{1}{\Omega} \left[ (\gamma_0 - c_0) + \log b_{t-1} + \Delta \log M_t + \frac{\mu_1}{1 - \tau} \Delta \pi_{t-1} + \frac{\mu_2}{1 - \tau} \Delta \rho_{t-1} + \gamma_1 \log y_t + c_1 \log e_t + \gamma_2 \log (P_t/Q_t) \right],
\]

where \( \Omega = 1 + c_1 + \gamma_2 > 0 \).

Equation (7) indicates that the parallel market rate is positively related to the rate of growth of domestic money supply, the official exchange rate, real output, relative prices, and changes in the expected rates of return on foreign and domestic currencies. The coefficient of the official exchange rate variable will be higher, the higher is the elasticity of (flow) supply of foreign exchange in the parallel market and the lower is the elasticity of (flow) demand for foreign currency in that market.

A higher level of economic activity, a rise in the level of domestic prices relative to foreign prices, or an increase in the rate of change of the expected rate of return on foreign currency holdings will increase the unofficial demand for foreign currency, and this will entail a depreciation of the parallel market exchange rate. A rise in the stock of domestic currency at \( t \), for given expectations, implies a depreciation of the parallel market rate in order to restore portfolio equilibrium.

For given prices and expectations, a devaluation of the official rate reduces on impact the exchange rate differential and therefore the incentive to underinvoice exports and overinvoice imports. The fall in (flow) supply of foreign exchange requires a depreciation of the parallel rate to maintain equilibrium, and this, in turn, reduces (flow) demand, offsetting, in part, the initial upward effect on the free exchange rate. In the short run the parallel rate always depreciates by less than the official rate (since \( c_1/\Omega < 1 \)), so that the exchange rate differential falls. In the long run, however, with \( \Delta \pi_{t-1} = \Delta \rho_{t-1} = 0 \), the parallel rate depreciates in the same proportion as the official exchange rate, if \( \gamma_2 \to 0 \).

The model thus predicts that if relative prices have a negligible effect on the flow demand for foreign currency, there will be an initial fall in the parallel market premium\(^{10}\) following a devaluation of the official exchange rate and a gradual increase thereafter, leading ultimately to a one-to-one correspondence between the increase in the official and parallel exchange rates. For this long-run neutrality to hold, the statistical estimate of \( \gamma_2 \) must be close to zero and the sum of the estimated coefficients on \( \log b_{t-1} \) and \( \log e_t \) must be close to unity, a restriction whose validity will be examined in the next section.

\(^{10}\) The parallel market premium is defined here as \( \log(b_t/e_t) \).
The Money Market and Official Reserves

Actual holdings of real money balances $m = M/P$ are assumed to adjust with a lag to the difference between (the logarithm of) desired holdings, $m^d$, in the current period and (the logarithm of) actual holdings at the end of the previous period. This partial adjustment mechanism can be described as

$$\Delta \log m_t = \nu [\log m^d_t - \log m_{t-1}], \quad 0 < \nu < 1,$$

(11)

where $\nu$ denotes the speed of adjustment.

The demand for real balances is specified as a function of real output, the expected rate of inflation, and the difference between the expected rate of depreciation of the domestic currency in the parallel market and expected world inflation, expectations being formed for period $t$ conditional on information available at $t-1$:

$$\log m^d_t = \alpha_0 + \alpha_1 \log y_t - \alpha_2 \pi^\text{pr}_t - \alpha_3 \pi^\text{exp}_t.$$

(12)

The expected inflation rate measures the opportunity cost of money holdings in terms of domestic real assets. As discussed above, foreign exchange is bought and sold in the unofficial market, in part because the public desires to alter the composition of its money holdings. This implies that the expected rate of depreciation of the domestic currency in the parallel market, net of foreign inflation, influences the demand for domestic money. The coefficient of the variable $\rho^\text{pr}_{t-1}$ is expected to be negative. When expectations of a depreciation of the parallel exchange rate are revised upward, for example, the expected return from holding foreign currency increases and agents tend to substitute foreign money for domestic cash balances as the opportunity cost of holding domestic money rises. This leads to a reduction in the demand for domestic currency in real terms.

From the money supply identity, changes in the stock of money—broadly defined to include currency in circulation, demand deposits, and savings and time deposits—are equal to the sum of changes in net foreign assets of the consolidated banking system, $R$, and changes in net domestic assets, $L$:

$$\Delta M_t = \Delta R_t + \Delta L_t.$$

(13)

This relationship can be log-linearized around the sample means and expressed in terms of the rate of change of variables in real terms as

$$\Delta \log m_t = k_1 + k_2 \Delta \log (R/P)_t + k_3 \Delta \log (L/P)_t,$$

(14)

where $k_2 = (R/M)$ and $k_3 = (L/M)$ are, respectively, ratios of the sample
means of net foreign assets and net domestic assets to the money supply, lagged by one period.

Substituting equation (11) in (14) and rearranging terms yields an equation that expresses the "required" rate of change of net foreign assets in real terms as a function of monetary imbalances and the rate of change of the real stock of domestic assets:

\[
\Delta \log \left( \frac{R}{P} \right) = \frac{k_1}{k_2} + \frac{\nu}{k_2} \left[ \log m^d_t - \log m_{t-1} \right] - k_3 \frac{\Delta \log \left( \frac{L}{P} \right)}{k_2},
\]

For a given rate of growth of domestic credit in real terms, equation (15) indicates that in a fixed exchange rate economy, changes in the stock of net foreign assets should occur as long as there is an ex ante disequilibrium between supply and demand in the money market, as emphasized in the monetary approach to the balance of payments (see Frenkel and Mussa (1985) and Wilford (1986)). However, if foreign exchange controls are in place, equation (15) cannot be used to explain actual changes in foreign reserves. To do so, the mechanism by which exchange restrictions are enforced must first be specified. A sensible approach is to modify the model of import restrictions developed by Hemp­hill (1974), and used subsequently by Lipschitz (1984) and Sundararajan (1986). The authorities are assumed to choose the rate at which the banking system can allocate changes in the real stock of foreign exchange, \(\Delta \log \left( \frac{R}{P} \right)_f\), so as to minimize the cost of deviations from the "required" rate of change, \(\Delta \log \left( \frac{R}{P} \right)_r\), as well as the cost of deviations from a "targeted" rate of change of net reserves, \(\Delta \log \left( \frac{R}{P} \right)_t\). A compromise between these potentially conflictive objectives is reached through a linear allocation scheme:

\[
\Delta \log \left( \frac{R}{P} \right)_f = (1 - \omega)\Delta \log \left( \frac{R}{P} \right)_r + \omega\Delta \log \left( \frac{R}{P} \right)_t,
\]

where \(0 \leq \omega \leq 1\) denotes the trade-off parameter. In the standard monetary model, reserves adjust fully to equilibrate current supply and demand in the official exchange market, so that \(\omega = 0\). If, on the contrary, it is assumed that the authorities are only concerned about their reserve growth target, then \(\omega = 1\). More generally, the above equation indicates that the higher the targeted value of the rate of change of net reserves is, the higher is the allowed increase in reserves by the banking system.

\[11\] The approach outlined by these authors to model an import licensing scheme cannot be strictly applied in the framework used here, because it is based on an exportable/importable distinction rather than on a tradable/nontradable dichotomy. Nevertheless, the procedures are conceptually similar.
Similarly, a rise in the required rate of change of international reserves for balance of payments equilibrium translates into an increase proportional to \(1 - \omega\) in the rate of change of net foreign assets held by the banking system. Therefore, in the general case where \(0 < \omega < 1\), the assumed behavior of the authorities prevents full equilibrium through reserves adjustment in the official foreign exchange market. The coefficient \(\omega\) can be conveniently regarded as an implicit measure of the degree of rationing.

In the context of an annual model, changes in the actual rate of growth of international reserves can be assumed to adjust rapidly (within a year) to changes in the rate of growth of allocated external assets, so that \(\Delta \log (R/P)_t = \Delta \log (R/P)_t^a\). The targeted rate of growth of net external reserves in real terms is assumed to depend linearly on the level of net foreign assets at \(t - 1\):

\[
\Delta \log (R/P)_t^a = k_0 - \lambda \log (R/P)_{t-1}, \quad \lambda > 0.
\] (17)

Equation (17) indicates that the higher is the real level of reserves at \(t - 1\), the lower the desired rate of increase for period \(t\). Substituting equations (15) and (17) in equation (16) yields

\[
\Delta \log (R/P)_t = [(1 - \omega)k_1/k_2 - \omega k_0] + (1 - \omega)v/k_2[\log m^d - \log m_{t-1}] - (1 - \omega)k_3/k_2 \Delta \log (L/P)_t - \omega \lambda \log (R/P)_{t-1}.
\] (18)

Since \(k_2\) and \(k_3\) are determined from the sample, and since the coefficient \(v\) can be estimated separately (see below), a simple test of the foreign exchange rationing scheme outlined above can be implemented by recovering the parameter \(\omega\) from the regression coefficients in equation (18). The higher this estimate is, the higher the emphasis the authorities put on their reserve target. Conversely, the lower this estimate is, the lower the degree of rationing, or the higher the degree of adjustment between current supply and demand in the official market for foreign exchange.

**Real Output**

The growth rate of real output is assumed to depend on the lagged deviation of actual output from normal capacity level (treated as exogenous), on the excess stock of real money balances, and on the budget deficit:

\[
\Delta \log \bar{y}_t = \delta_1 - \delta_2 \log (y_{t-1}/\bar{y}_{t-1}) + \delta_3[\log m_{t-1} - \log m^d_t] + \delta_4 \log (G_t/T_t),
\] (19)
with $G$ denoting nominal government expenditure, and $T$, nominal fiscal revenues. The first term on the right-hand side of equation (19)—the so-called output gap—represents the extent to which producers adjust output to changes in their desired supply. This term implies that when actual output is low relative to normal production capacity, $\bar{Y}$, its growth rate tends to rise. The second term captures the spillover effects of monetary disequilibrium on output. An excess supply of money induces output effects in the short run, as agents in their attempt to adjust money balances to equilibrium level change their spending and their holdings of financial assets. The third term reflects the effects of fiscal policy on activity. Budget deficits are assumed to have a positive effect on output behavior. In the long run output is equal to its capacity level, the money market is in equilibrium, and government spending equals fiscal revenues, so that the steady-state growth rate of output is equal to $\delta_i$.

**Government Sector**

Nominal government expenditure, $G$, is assumed to be exogenous. Nominal government revenues, $T$, are specified as a log-linear function of nominal income:

$$\log T_i = \beta_0 + \beta_1[\log y_i + \log P_i]. \quad \beta_i > 0. \tag{20}$$

Finally, since money is the only domestic financial asset, the government budget deficit cannot be financed by the public. Rather, it is financed by external borrowing and by domestic borrowing from the central bank. The change in net domestic assets of the banking system is therefore equal to changes in the stock of credit to the private sector, $\Delta L^p$—assumed to be exogenous—plus changes in net credit to the government, which are determined by the budget deficit net of foreign financing (consisting of loans and grants), $\Delta F^*$:

$$\Delta L_i = \Delta L^p + (G_i - T_i + \Delta F^*). \tag{21}$$

The complete structural model is shown in summary form in Table 2; the variables are defined in Table 3.

---

12 Clements and Jonson (1979) have shown that under certain circumstances, the use of the term for excess cash balances in equation (19) is equivalent to using unanticipated changes in the money stock.

13 More precisely, real output is assumed to depend on the difference between the actual and desired levels of government expenditure, the latter being a function of tax revenues.
Table 2. Equations of the Model

Money demand
\[ \log m_t = \alpha_0 + \alpha_1 \log y_t - \alpha_2 \pi_{t-1} - \alpha_3 \rho_{t-1} \]

Real output
\[ \Delta \log y = \delta_1 - \delta_2 \log (y_{t-1}/y_{t-1}) + \delta_3 \log m_{t-1} - \log m_{t-1} + \delta_4 \Delta \log (G/T_i) \]

Inflation rate
\[ \Delta \log P_t = \delta_6 \Delta \log e_t + (1 - \tau) \delta_7 \Delta \log b_t + \delta_8 \Delta \log Q_t \]
\[ + (1 - \delta) \phi_1 \pi_{t-1} + (1 - \delta) \phi_2 \log m_{t-1} - \log m_{t-1} \]

Net foreign assets
\[ \Delta \log (R/P)_t = [(1 - \omega)k_1/k_2 - \omega k_0] + (1 - \omega) \gamma/k_2 \log m_{t-1} - \log m_{t-1} \]
\[ - (1 - \delta) \gamma/k_2 \Delta \log (L/P)_t - \omega \log (R/P)_t - 1 \]

Parallel market exchange rate
\[ \log b_t = (1/1 - \tau)(\gamma_0 - c_0) + \log b_{t-1} + \Delta \log M_t + \mu_1 (1 - \tau) \pi_{t-1} \]
\[ + \mu_2 (1 - \tau) \Delta \pi_{t-1} + \gamma_1 \log y_t + c_1 \log e_t + c_2 \log \log (P_t/Q_t) \]

Government revenues
\[ \log T_t = \beta_0 + \beta_1 \log y_t + \log P_t \]

Money supply
\[ M_t = L_t + R_t \]

Domestic credit
\[ L_t = L_{t-1} + \Delta L^p_t + G_t - T_t - \Delta P_t \]

Real money balances
\[ m_t = M_t / P_t \]

Table 3. Definition of Variables

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta )</td>
<td>First-difference operator</td>
</tr>
<tr>
<td>( b )</td>
<td>Parallel market exchange rate</td>
</tr>
<tr>
<td>( \Delta \log b_{t-1}^e )</td>
<td>Expected rate of depreciation of the parallel market exchange rate, formed at period ( t - 1 ) for period ( t )</td>
</tr>
<tr>
<td>( e )</td>
<td>Official exchange rate (exogenous)</td>
</tr>
<tr>
<td>( \Delta F^e )</td>
<td>Foreign financing (including loans and grants) of the budget deficit (exogenous)</td>
</tr>
<tr>
<td>( G )</td>
<td>Nominal government expenditure (exogenous)</td>
</tr>
<tr>
<td>( L )</td>
<td>Domestic credit of the consolidated banking system</td>
</tr>
<tr>
<td>( L^p )</td>
<td>Domestic credit to the private sector (exogenous)</td>
</tr>
<tr>
<td>( M )</td>
<td>Nominal money stock</td>
</tr>
<tr>
<td>( m = M/P )</td>
<td>Real money balances</td>
</tr>
<tr>
<td>( P )</td>
<td>Domestic cost of living index</td>
</tr>
<tr>
<td>( P_n )</td>
<td>Price index of nontradable goods</td>
</tr>
<tr>
<td>( P_r )</td>
<td>Domestic price of tradable goods</td>
</tr>
<tr>
<td>( \pi_{t-1} )</td>
<td>Expected rate of inflation, formed at period ( t - 1 ) for period ( t )</td>
</tr>
<tr>
<td>( \pi_{t+1} )</td>
<td>Expected rate of inflation, formed at period ( t + 1 ) for period ( t )</td>
</tr>
<tr>
<td>( Q )</td>
<td>World price of tradable goods (exogenous)</td>
</tr>
<tr>
<td>( \Delta \log Q_{t-1}^e )</td>
<td>Expected rate of world inflation, formed at period ( t - 1 ) for period ( t )</td>
</tr>
<tr>
<td>( R )</td>
<td>Net foreign assets of the consolidated banking system</td>
</tr>
<tr>
<td>( \rho_{t-1} )</td>
<td>Expected rate of return on the foreign currency, formed at ( t - 1 ) for ( t )</td>
</tr>
<tr>
<td>( T )</td>
<td>Fiscal revenues</td>
</tr>
<tr>
<td>( y )</td>
<td>Real domestic output</td>
</tr>
<tr>
<td>( y^* )</td>
<td>Capacity level of real domestic output (exogenous)</td>
</tr>
</tbody>
</table>
II. Estimation Results

Estimation of a macroeconomic model such as the one described above for developing countries raises several difficult statistical problems, mostly stemming from inadequacies in, and the lack of comparability of, the data. Consistent series for long periods on aggregate data are available for only a few economies. A sensible way to proceed is therefore to consider pooled cross-sectional and time-series data for a selected group of countries. Specifically, a sample consisting of annual data covering the period 1974–86 for eight developing countries is used (see Appendix I for more details), and a fixed-effect estimation procedure is applied to the pooled sample.14

Before estimation results are discussed, however, two issues must be examined: the treatment of expectations, and the cross-equation restrictions imposed by the money demand function. Consider first the procedure used to estimate the (unobservable) expectational variables of the model (current and one-period-ahead domestic rate of inflation, current real rate of return on foreign currency holdings). Expectations are assumed “rational” or—more appropriately and perhaps less controversially—“consistent” with the underlying model. One approach to implementing this assumption empirically consists in estimating unrestricted reduced-form equations for the relevant expectational variables and using the predicted values as proxies for expectations.15 Here, however, since the model does not incorporate “surprise” terms, the alternative errors-in-variables procedure proposed by McCallum (1976) and generalized by Wickens (1982) can be used. By the assumption of rational expectations, expected values are equal to actual values plus a stochastic error term. Substituting for expectational variables in a regression equation implies, therefore, that the composite disturbance term is correlated (even asymptotically) with a regressor, so that ordinary least squares are inconsistent. Consistent estimates are obtained by an appropriate instrumental variable method.16 For the model described above,

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14 For a detailed discussion of the fixed-procedure approach to estimation of pooled time-series cross sections, see Kmenta (1986, pp. 616–35).
15 Such a procedure (known as the substitution method) has been widely used in econometric applications of the rational expectations hypothesis; see Barro (1979), Blejer and Fernandez (1980), or Leiderman (1984). Pagan (1984) provides a critical evaluation of its properties.
16 The difficulty with this method is that in the price equation—where the one-period-ahead expected rate of inflation appears—replacing expectations by actuals implies that the disturbance term will follow a moving average process of order 1. Ignoring this property of the error process—as is done here—may result in biased standard errors and invalid inference, although parameter estimates
estimation was performed according to an instrumental variable method on a fixed-effect procedure, with country-specific dummy variables and time trends included in each behavioral equation. Instruments used are the constant term, country-specific time trends, an index of industrial output in industrialized countries, all exogenous variables lagged once, and one lagged value of all endogenous variables.

The second econometric issue relates to the fact that the same demand for money function appears in the output, price, and net foreign assets equations. To ensure that cross-equation restrictions on the parameters of the money demand equation are satisfied, a two-step procedure is used here. Substituting equation (12) in equation (11) yields the following estimating equation:

$$\log m_i = a_0 v + a_1 v \log y_i - a_2 v \pi_{i,t-1} - a_3 v \rho_{i,t-1} + (1 - v) \log m_{i,t-1}. \quad (22)$$

The variable \( \log m_i \) is replaced by \((1/v) [\log m_i - (1 - v) \log m_{i,t-1}]\) in the other equations of the system, where \( \log m_i^c \) denotes the predicted value of \( \log m_i \) obtained from the estimating equation (22), and \( \hat{v} \) denotes the estimate of the speed of adjustment from the same equation. Because of the endogeneity of real output, equation (22) must also be estimated by an instrumental variable procedure to ensure consistency of the estimates.

Given the estimated value of \( v \) and the sample estimates of \( k_2 \) and \( k_3 \), the net foreign assets equation can be estimated, subject to the constraint that the sum of the coefficients of \( \hat{v}k_2(\log m^d_t - \log m_{t-1}) \) and \( k_3/k_2 \Delta \log (L/P) \), is equal to zero. This constraint is imposed by simply using the difference between these two expressions as a regressor. The estimated coefficient is therefore equal to \( 1 - \omega \), from which an estimate of the trade-off parameter can be derived.

Table 4 presents parameter estimates for the behavioral equations of the model.\(^ {17} \) Overall, the estimation results look quite satisfactory. All variables have the expected a priori sign. The estimate of the short-run income elasticity of money demand is not significantly different from

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\(^{17}\) The restriction on the coefficients of \( \Delta \log e, \Delta \log b_0, \) and \( \Delta \log Q \) in the price equation was not imposed, because preliminary testing indicated that it was strongly rejected by the data. The restriction on the coefficients of \( \log b_{i,t-1} \) and \( \Delta \log M_i \) in the parallel rate equation was imposed using their sum as a regressor. Also, in the net foreign assets equation, the variable \( \log (R/P)_{i,t-1} \) was replaced by \( (R/P)_{i,t-1} \), because \( R \) is negative for some countries for a number of periods.
Table 4. Parameter Estimates of the Model
(Two-step, instrumental variable procedure)

<table>
<thead>
<tr>
<th>Equation</th>
<th>Estimate (t-stat)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Money demand</strong></td>
<td></td>
</tr>
<tr>
<td>( \log m_t = -18.785 + 1.173 \log y_t - 0.229 \pi_{\text{tx}} )</td>
<td>(-5.907)</td>
</tr>
<tr>
<td>(- 0.073 \pi_{\text{tx}} + 0.297 \log m_{t-1} )</td>
<td>(-1.992)</td>
</tr>
<tr>
<td>(- 1.597 )</td>
<td>(3.574)</td>
</tr>
<tr>
<td>( R^2 = 0.999 ) ( \sigma = 0.050 ) ( SSR = 0.151 ) ( DW = 1.993 )</td>
<td></td>
</tr>
<tr>
<td><strong>Real output</strong></td>
<td></td>
</tr>
<tr>
<td>( \Delta \log y_t = 0.012 - 0.449 \log (y_{t-1}/y_{t-1}) )</td>
<td>(4.823) (1-567)</td>
</tr>
<tr>
<td>(+ 0.087 [\log m_{t-1} - \log m_t^*] + 0.054 \log (G/T_t) )</td>
<td>(2.596) (1.643)</td>
</tr>
<tr>
<td>( R^2 = 0.563 ) ( \sigma = 0.026 ) ( SSR = 0.041 ) ( DW = 2.046 )</td>
<td></td>
</tr>
<tr>
<td><strong>Inflation rate</strong></td>
<td></td>
</tr>
<tr>
<td>( \Delta \log P_t = 0.189 + 0.014 \Delta \log e_t + 0.132 \Delta \log b_t )</td>
<td>(0.276) (0.181)</td>
</tr>
<tr>
<td>(+ 0.421 \Delta \log Q_t + 0.527 \pi_{\text{tx}} + 0.172 [\log m_{t-1} - \log m_t^*] )</td>
<td>(1.726) (3.397)</td>
</tr>
<tr>
<td>( R^2 = 0.853 ) ( \sigma = 0.051 ) ( SSR = 0.147 ) ( DW = 1.887 )</td>
<td></td>
</tr>
<tr>
<td><strong>Net foreign assets</strong></td>
<td></td>
</tr>
<tr>
<td>( \Delta \log (R/P)<em>t = -0.003 + 0.714 [\tilde{k}/k_2(\log m_t^* - \log m</em>{t-1}) )</td>
<td>(-0.009) (1.738)</td>
</tr>
<tr>
<td>(- k_1/k_2 \Delta \log (L/P_t) ) (- 0.004 (R/P)_{t-1} )</td>
<td>(-1.837)</td>
</tr>
<tr>
<td>( R^2 = 0.531 ) ( \sigma = 0.416 ) ( SSR = 47.9 ) ( DW = 1.605 )</td>
<td></td>
</tr>
<tr>
<td><strong>Parallel market exchange rate</strong></td>
<td></td>
</tr>
<tr>
<td>( \log b_t = 0.245 + 0.763 \Delta \log e_t + 0.131 \log y_t + 0.034 \log (P/Q_t) )</td>
<td>(5.546) (5.272)</td>
</tr>
<tr>
<td>(+ 0.175 \Delta P_{\text{tx}} + 0.243 \Delta \pi_{\text{tx}} + 0.208 (\log b_{t-1} + \Delta \log M_t) )</td>
<td>(2.361) (2.956)</td>
</tr>
<tr>
<td>( R^2 = 0.997 ) ( \sigma = 0.087 ) ( SSR = 0.439 ) ( DW = 1.627 )</td>
<td></td>
</tr>
<tr>
<td><strong>Government revenues</strong></td>
<td></td>
</tr>
<tr>
<td>( \log T_t = 0.197 + 1.214 [\log y_t + \log P_t] )</td>
<td>(0.083) (1.198)</td>
</tr>
<tr>
<td>( R^2 = 0.998 ) ( \sigma = 0.067 ) ( SSR = 0.298 ) ( DW = 1.873 )</td>
<td></td>
</tr>
</tbody>
</table>

Note: Country-specific dummies and time trends are not reported. Figures in parentheses are t-ratios; \( R^2 \) denotes the coefficient of determination adjusted for degrees of freedom; \( \sigma \) is the estimated error of the regression; \( SSR \) is the sum of the squared residuals; and \( DW \) is the Durbin-Watson statistic.

unity, whereas the long-run elasticity is roughly 1.7, a result consistent with those obtained in several econometric studies on the demand for money in developing countries. Parameters measuring currency substitution effects are both highly significant, with a fairly large difference between the own- and cross-elasticity. In the output equation, changes in real activity show a limited response to monetary disequilibria, while
the ratio of government expenditure to fiscal revenue—although positive—is barely significant at the 10 percent level. The lagged value of the output gap seems, on the contrary, to have a large impact on the current rate of growth of real output.

In the inflation rate equation, the rate of change in the official exchange rate is small and not significant, whereas the rate of depreciation of the parallel exchange rate is well defined statistically, although relatively small. This suggests that, as noted earlier, prices of imports and their near-substitutes tend to reflect the marginal cost of foreign exchange given by the parallel market rate. Besides, the estimate of the parameter $\phi_1$ is $0.527/(1 - 0.421) \approx 0.91$, implying that the estimated price equation exhibits reasonable long-run properties.

The rate of change of net foreign assets in real terms shows significant response to the variable measuring the difference between excess real balances and fluctuations in the rate of growth of the real stock of domestic credit. The coefficient of the lagged value of foreign reserves is small and barely different from zero at a 5 percent tolerance level. The estimate of the trade-off parameter, $\omega$, is given by $1 - 0.714 \approx 0.28$. This coefficient is relatively small, however, implying that the monetary authorities have apparently put more emphasis during the period considered on equilibrating supply of and demand for foreign exchange in the official market than on targeting a given rate of growth of net international reserves.

The parallel exchange rate equation displays interesting properties. Although small, the coefficient of the level of real output is positive and significantly different from zero. Changes in expected rates of return on domestic and foreign currencies are also statistically significant, reflecting the importance of portfolio considerations in the determination of the demand for foreign exchange in the parallel market. The sum of the coefficients of the lagged parallel rate and official exchange rate is not significantly different from unity, while at the same time the coefficient of the relative prices variable is close to zero. As discussed above, this implies that the short-term impact of a devaluation will be a fall in the parallel market premium, while the long-term effect will be a proportional depreciation of the parallel exchange rate, a key feature of the simulation results discussed below. Finally, tax revenues seem highly elastic to nominal income for the group of countries considered.

The estimation results provide broad support for the specification of the model. However, it is difficult to infer from the data strong evi-

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18 The goodness of fit of the model as a whole is discussed in Appendix II.
ence in favor of a key assumption of the model—namely, the hypothesis that monetary authorities allow foreign reserves to adjust only by a fraction of the amount necessary to equilibrate supply and demand in the official market for foreign exchange. On the contrary, the estimate of the trade-off parameter $\omega$ suggests a fairly flexible reserve policy. This, in turn, runs contrary to the widely held view that official foreign exchange rationing is a major factor explaining the existence of a parallel currency market. At this stage, however, it is not clear how robust this result is. In particular, the relatively low estimate of $\omega$ may be the consequence of an improper specification of the rationing scheme, or it may be a feature of the particular sample of countries considered or the estimation period, or both. Nevertheless, the fact that the estimate of $\omega$ is not negligible may be taken as evidence of partial foreign exchange rationing, implying that the econometric results do not invalidate the use of the model for policy analysis. Future research will need to focus on this particular aspect of the model.

III. Policy Experiments

In this section the impact of various policy shocks on the economy is considered, using the point estimates of the parameters presented in the previous section. Model solutions are derived under the assumption of rational, or consistent, expectations, implying that expectations coincide with actual model forecasts. The procedure and the computer program used are described in Appendix II. A baseline case is first obtained, and deviations of the path of the economy from it in response to changes in policy variables are analyzed. All shocks are assumed to be fully anticipated. In what follows, graphic results for six endogenous variables are presented: real output, the domestic price level, nominal domestic credit, real money balances, the stock of net foreign assets, and the parallel exchange rate.

19 In principle, the simulations discussed here are not immune to the Lucas (1976) critique, according to which a policy change sufficiently atypical to amount to a change in "policy regime" could well induce behavioral responses by private sector agents that would shift the parameters of the model's equations. However, since the analysis in this paper focuses on policy changes that lie within the range of policy variations observed during the model's estimation period, the Lucas critique may not be especially relevant.

20 The experiments were also carried out with unexpected shocks. The major difference with the results reported below is that real effects are higher—and price effects lower—in the short run; qualitatively, however, the results are basically identical to those discussed in the text.
Changes in Domestic Credit

Consider first a temporary (one period only), fully anticipated increase of 10 percent from the base value of net credit to the private sector. Chart 1 depicts the time path of major macroeconomic variables following the credit expansion. To permit a better understanding of the transmission process of monetary shocks in this model, the case in which the authorities allow net foreign assets to adjust fully to equilibrate supply and demand in the official exchange market—that is, where \( \omega = 0 \)—will also be analyzed and will be referred to as the “full-reserve-adjustment” economy.

The rise in the stock of domestic credit provides an initial monetary stimulus and creates excess real balances in the system, which, after one year—as a result of the one-period lag built into the system—stimulate output (by 0.4 percent), raise prices (by 1.2 percent), and entail a fall (by nearly 4 percent) in the rate of growth of the real stock of net foreign assets. The domestic price level rises on impact by more than it otherwise would under a backward-looking expectational scheme, since by the assumption of rationality agents foresee correctly the future impact of monetary disequilibria on the inflation rate. Through its impact on output and prices, the excess supply of real balances also translates into a depreciation of the parallel exchange rate. In addition to the effects of output and (to a small extent) changes in relative prices, the parallel exchange rate is positively affected by the initial increase in the nominal money stock and by changes in the expected rates of return of domestic and foreign currencies. Indeed, since expectations are consistent, agents anticipate correctly the effect of future inflation and future depreciation of the parallel rate on the relative rates of return of domestic and foreign currencies. The initial rise in the expected rate of depreciation of the parallel exchange rate and the expected rate of domestic inflation exert a positive impact on the free exchange rate. After its initial depreciation, the parallel exchange rate appreciates, exerting a downward effect on prices. Over time, all variables return gradually to their baseline levels, with output and domestic prices decreasing, and the real money stock increasing.

A general implication of the above results is that output and price effects associated with an increase in domestic credit are higher and last longer than in an economy where official reserves are free to adjust. This is because in the model discussed here, the rate of growth of net reserves in real terms falls by less than the amount necessary to preserve equilibrium in the official exchange market, so that the offsetting effect on the money supply coming through the balance of payments is lower than
Chart 1. Temporary Increase in Private Sector Credit of 10 Percent
(Percentage deviations from baseline)

- Real output
- Real money stock
- Price level
- Net foreign assets
- Domestic credit
- Parallel exchange rate
what would obtain if the authorities allowed net foreign assets to move freely to equilibrate supply and demand in that market. Since the rise in the rate of growth of output and in the domestic inflation rate relative to world inflation raises the demand for foreign currency in the parallel market, the free exchange rate is also higher than it would otherwise be in an economy with full reserve adjustment.21

**Changes in Government Spending**

Consider next the effects of a fully anticipated temporary increase of 10 percent in nominal government spending, with net foreign borrowing by the public sector held constant (Chart 2).

The rise in public expenditure, by increasing the initial budget deficit, has an immediate direct effect on output. This raises money demand in the current year and reduces real excess balances, offsetting in part the direct positive impact of higher government spending. Overall, output rises by 0.5 percent in the first year. This pushes the parallel exchange rate up, which, in turn, exerts a fairly small upward effect on prices. Through the government budget constraint, total credit expands, and this in turn has an immediate negative impact on the nominal stock of net foreign assets, which falls by 1 percent. As the nominal stock of money expands, real excess balances grow, and this provides an expansionary effect, which, after a year, translates mainly into higher prices and a fall in net foreign assets. Over time, the fall in net reserves reduces money supply, reversing the initial expansionary effect. Overall, the simulation results are qualitatively similar to those obtained in the case of an expansion of private domestic credit. There are, however, significant differences in both the first-year effects and in the time path of major variables, which display here a longer adjustment process.

The transmission of monetary disequilibria resulting from (fully anticipated) expansionary monetary and fiscal policies to the parallel exchange market can be summarized as follows. Excess cash balances have a positive effect on real activity and the inflation rate, as well as a negative effect on net reserves in the short run. The parallel market exchange rate depreciates for three reasons. First, the increase in output and domestic prices stimulates—to a small extent—the demand for foreign goods through both legal and illegal channels, implying a rise in the

21 In the extreme case of complete rationing at the official rate—that is, with no adjustment at all in net reserves—an increase in the rate of domestic credit creation would result in even higher domestic prices and higher output, and therefore in a more depreciated parallel market rate.
Chart 2. Temporary Increase in Government Spending of 10 Percent

(Percentage deviations from baseline)

- Real output
- Real money stock
- Price level
- Net foreign assets
- Domestic credit
- Parallel exchange rate
transactions demand for foreign currency and therefore a depreciation of the parallel rate, since the increase in demand cannot be fully accommodated in the official market for foreign exchange. Second, the initial increase in the rate of growth of the nominal money supply requires a rise in the parallel rate in order to maintain portfolio equilibrium. Third, the increase in the (actual and expected) domestic inflation rate is equivalent to a fall in the rate of return on domestic money, and this stimulates the portfolio component of the demand for foreign currency in the parallel market.

Moreover, partial rationing of the demand for foreign exchange in the official market implies longer persistence effects of policy shocks on output and prices, and this in turn implies a more prolonged impact on the parallel rate. The higher the degree of rationing in the official foreign currency market is, the lower will be the offsetting effect on the money supply coming through the balance of payments, and the higher the rate of depreciation of the parallel exchange rate generated by an expansionary credit or fiscal policy.

Devaluation of the Official Exchange Rate

Finally, consider the impact of a once-for-all fully anticipated 10 percent devaluation of the official exchange rate (Chart 3). By assumption, devaluation profits (that is, valuation effects owing to exchange rate changes) are retained by the monetary authorities.

The immediate impact of the devaluation is a rise of 1.2 percent in the domestic inflation rate and a less-than-proportional depreciation of the parallel exchange rate, which rises by about 8 percent. The inflationary impact of the devaluation is reinforced by the evolution of the parallel rate and by agents’ anticipations of the future inflationary effects. Although the upward jump in the expected inflation rate and in the expected rate of depreciation of the parallel exchange rate reduces the demand for domestic currency, the real money stock falls because of higher domestic prices, and this implies (with a one-year lag) a contraction in real excess balances. As a consequence, output and prices fall while net foreign assets rise, thereby reversing the initial effects. Overall, a devaluation has a positive effect in the short run on the inflation rate, a negative impact on real output—via the real balances effect—and is associated with a less-than-proportional depreciation of the parallel exchange rate. In the long run domestic prices rise by 1 percent, and the

These results have some interesting implications for the debate on whether or not devaluations in developing countries are “contractionary” (see Izondo and Montiel (1989)). A detailed discussion of these issues is outside the scope of this paper.
Chart 3. Devaluation of the Official Exchange Rate of 10 Percent

(Percentage deviations from baseline)

- Real output
- Real money stock
- Price level
- Net foreign assets
- Domestic credit
- Parallel exchange rate

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parallel exchange rate depreciates in about the same proportion as the official exchange rate. Since by assumption devaluation profits are not monetized, a return of the real money stock to its baseline value implies an increase (of nearly 1.6 percent) in the long-run stock of net foreign assets. Real output also returns gradually to its baseline level. As a result of the behavior of the parallel exchange rate, the parallel market premium falls on impact and returns gradually to its baseline value. The magnitude of the fall in the premium is relatively small, however, as a result of the sharp upward effect of the official exchange rate devaluation on the parallel rate. This result is consistent with the analytical prediction obtained with the perfect-foresight, currency-substitution models of the determination of the premium developed by Lizondo (1987) and Kharas and Pinto (1989).

How do the above results compare with available “stylized facts”? There is scant empirical evidence on the way in which dual markets, with legal and illegal segments, react to policy shocks. Two of the few studies available are Edwards’s (1989) analysis of 18 devaluation experiences that took place between 1962 and 1982 in Latin America, and Kamin’s (1988) study of the behavior of parallel exchange rates across 40 devaluation episodes in a larger group of developing countries. Edwards’s results show first that in the presence of a freely determined parallel market rate, expansive domestic credit policies have usually been reflected in a depreciation of the free rate, an increase in the domestic rate of inflation, and a fall in international reserves. Second, in most instances, a large nominal devaluation of the official rate tends, on impact, to reduce the spread between the freely determined parallel rate and the predetermined official rate. In the medium term, however, the premium seems largely unaffected by the parity change, typically because fiscal and monetary policies are maintained on an expansionary course. Similarly, Kamin’s study shows that the parallel exchange rate rises in most cases following an official devaluation. In the quarter during which the devaluation is effected, the premium declines unambiguously, but it seems to widen again in subsequent periods.

Although it is difficult to discern unidirectional causality effects in the studies mentioned above, the simulation exercises reported in this paper seem to corroborate to some extent the empirical regularities discussed by Edwards and Kamin. These experiments provide evidence of the crucial role played by monetary disequilibria in the transmission process of policy shocks and the behavior of major macroeconomic variables. More generally, they illustrate the importance of taking into account the role of parallel currency markets in the discussion of alternative stabilization packages in developing countries.
IV. Summary, Conclusions, and Extensions

The purpose of this paper has been to develop, estimate, and simulate a macroeconomic model for a developing country with a sizable parallel market for foreign exchange. Following early work by Khan and Knight (1981, 1985), the model has stressed the role of monetary factors in the determination of output, prices, net foreign assets, and the parallel market exchange rate.

Using a pooled time-series, cross-sectional data set, the model has been estimated by a consistent two-step procedure for a group of eight developing countries. The parameter estimates have been used to analyze the effects of alternative policy measures on the economy under the assumption of rational forward-looking expectations—namely, a rise in domestic credit to the private sector, an increase in nominal government spending, and a devaluation of the official exchange rate. The simulation results have highlighted the important role played by parallel exchange markets in the transmission process.

The key policy implications of the model can be summarized as follows. First, expansionary fiscal and credit policies are—in addition to their well-known effects on output, prices, and net foreign assets—associated with a more depreciated parallel exchange rate (through changes in both the transactions and portfolio components of the unofficial demand for foreign currency), while displaying a more persistent pattern. This is because partial rationing in the official market for foreign exchange prevents the balance of payments from playing fully its offsetting role on the money supply. The depreciation in the parallel rate helps eliminate excess real money balances and restore macroeconomic equilibrium. As a consequence, the inflationary impact of expansionary policies is larger, and the output effect is smaller, than they would be in an economy without foreign exchange rationing.

The second major implication of the model relates to exchange rate policy. An official devaluation has no long-run effect on the premium, because the parallel exchange rate depreciates proportionately. A devaluation, unless supplemented by adequate fiscal and monetary policies, is virtually powerless as an instrument to control the spread. This conclusion may have far-reaching implications for the design of stabilization programs in developing countries in which the parallel market for foreign exchange plays an important role.

Finally, although the framework developed in this paper provides many insights, there are several areas in which further work is both necessary and desirable. First, the estimation results do not provide strong support regarding the existence of policy-induced disequilibria.
between supply and demand in the official foreign exchange market, as postulated in the rationing scheme outlined in the paper. This is a feature of the results that clearly deserves more attention. Second, the treatment of the demand functions for domestic and foreign currencies may be improved by taking into account cross-equation restrictions in estimation. This can be achieved by using a procedure consisting of full information and maximum likelihood, which would also allow explicit account of the nonlinear cross-equation constraints implied by the domestic money demand function. Third, although the sample of countries considered can be regarded as reasonably representative, estimation using a larger group of developing economies may provide more reliable estimates and more general results than those obtained here, particularly with respect to the rationing process in the official foreign exchange market. Finally, supply-side effects of stabilization policies could be integrated in the model by specifying the determinants of capacity output. However, although these changes might improve the structure of the model, it is arguable whether they would affect substantially the two major policy implications described above.

APPENDIX I

Data Sources and Definitions

Annual data for the period 1974–86 were collected from the IMF’s International Financial Statistics (IFS) tapes, except data on parallel market exchange rates, which were taken from the World Currency Yearbook. Owing to data limitations, only eight countries were considered: Ecuador, India, the Republic of Korea, Malaysia, Morocco, Pakistan, Singapore, and Uruguay. The sample thus includes low- and middle-income developing countries, manufacturing and primary exporters, as well as service and remittance countries, and one heavily indebted country. This diversity makes the sample reasonably representative of developing countries in general.

The official exchange rate, \( e \), is the end-of-period domestic currency/U.S. dollar rate (IFS, line ae).

Real output, \( y \), is measured by GDP at constant 1985 prices (IFS, line 99b,p).

Capacity output, \( \tilde{y} \), is derived as the predicted value of a regression of \( y \) on country dummies and the country-specific time trends.

The price level, \( P \), is the consumer price index (IFS, line 64).

Nominal money supply, \( M \), is measured as \( M_2 \) (IFS, line 35L).

\( R \) denotes net foreign assets of the banking system (IFS, line 31n).

Total government spending in nominal terms, \( G \), is defined as the sum of government expenditure (IFS, line 82), plus lending minus repayments (IFS, line 83).

Total external financing, \( \Delta F^* \), is measured as foreign borrowing (IFS, line 85a), plus grants received (IFS, line 81z).

Net domestic financing is defined as the difference between flow credit to the
government (IFS, line 84a), minus the change in government's deposits in the banking system (IFS, line 87).

The change in total credit to the private sector, \( L^p \), is derived from the monetary identity, by subtracting from changes in the money stock net changes in foreign assets and domestic financing of the budget deficit.

The world inflation rate, \( \Delta \log Q \), is approximated by the rate of growth of consumer prices in the industrial countries.

The data used for the parallel market rate, \( b \), are those reported in the World Currency Yearbook (WCY, formerly Pick's Currency Yearbook), various issues. WCY provides end-of-month quotations, and reasonable efforts have been made to ensure that the quotations are consistently reported. WCY data have been used by most researchers in the field, although some authors have used data obtained directly from local authorities (see, for example, Canto (1985)).

APPENDIX II

Solution Procedure for the Model

The model is solved by a computer algorithm that forces the expectations entering the model's equations to be equal to the model's forecasts. For example, given information for \( t - 1 \), assumed available to all agents, the algorithm first solves the model for \( t, t + 1, \ldots, t + N \), given an initial set of (guessed) values for the expected endogenous variables. After checking for equality between expectations and the solved forecasts, the initial expectations set is gradually altered until convergence is obtained. Terminal conditions take the form of "no-change" assumptions, whereby expectations beyond \( t + N \) are assumed equal to solution values for period \( t + N \). The uniqueness of the solution path is checked by numerical sensitivity analysis of the model; that is, by the evaluation of the early parts of the solution for successive values of \( N \), until the solution values stabilize. For the results reported in this paper, the terminal date is set to 20, assuming the period of interest for the forecast is 10.

The above procedure can also be used to evaluate the goodness of fit of the model as a whole in a consistent fashion. To do this requires the use of projected—rather than actual—values for exogenous variables. Specifically, the information set available to agents is defined to include lagged values (up to \( t - 1 \)) of endogenous and exogenous variables. From period \( t \) up to the terminal date (set to 20 periods ahead), future values of exogenous variables are calculated by a simple first-order autoregressive process, the autoregressive coefficient being set to the average value observed during the three-year period preceding the current year of forecast. The solution values for period \( t \)—and period \( t + 1 \)—are used as the model predictions. The procedure is then repeated for

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23 The program was developed by the Liverpool Research Group in Macroeconomics and is based on a solution technique similar to the procedure described by Fair and Taylor (1983) and Fair (1984). The method is a special case in a general class of iterative algorithms for models that incorporate consistent forward-looking expectations discussed by Fisher and Hughes Hallet (1988). For a general discussion of alternative solution procedures for rational expectations models, see Blanchard (1985).
t + 1, t + 2, etc., until the last period of the sample. The important difference between the above procedure and a standard ex post simulation exercise for an econometric model is that in a forward-looking framework, agents are assumed to make forecasts of exogenous variables. Although, in general, the results are likely to depend on the particular forecasting procedure imputed to private agents, those reported here were fairly insensitive to the specific choice of the number of periods used to calculate the average autoregressive coefficient, as long as this number was greater than one.

In any case, the comparison between the projected and actual values provides a measure of the in-sample predictive performance of the model. The results for the major endogenous variables proved quite satisfactory, except for net international reserves. The root mean square error was 0.056 for real output, 0.087 for the domestic price level, 0.083 for the parallel market exchange rate, 0.456 for the level of net foreign assets, and 0.157 for the real money stock.

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A Macroeconometric Model for Developing Countries

Nadeem U. Haque, Kajal Lahiri, and Peter J. Montiel*

Despite the increased attention that macroeconomic management in developing countries has received during the past decade, no consensus has emerged on the appropriate analytical framework for the study of developing country macroeconomic issues. Instead, individual models suitable for different tasks have proliferated with different, and often conflicting, assumptions about a wide range of crucial aspects of these economies, such as the nature of financial markets, the degree of capital mobility, the form and functioning of the exchange rate regime, the degree of wage-price flexibility, the determination of aggregate supply, and the extent to which agents’ expectations are forward looking.

This lack of consensus on analytical macroeconomic models for developing countries is even more pronounced at the empirical level. Substantial disagreement exists over the general specification of such models, as well as over the orders of magnitude of certain key macroeconomic parameters—for example, the interest responsiveness of saving and investment, the “offset coefficient” for monetary policy, the relative price elasticity of exports and imports, and the importance of “accelerator” mechanisms in the determination of investment, all of which have important implications for economic policy. Although estimates of macroeconomic parameters such as these are indeed available for developing countries, they differ greatly with regard to countries and periods covered, specifications of estimated equations, and—possibly most important—the empirical methodology employed in producing them. Consequently, generalizations across developing countries are virtually impossible to make.

The aim of this paper is to generate “representative” developing coun-

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try estimates of a set of macroeconomic parameters that are considered important for policy, using a uniform data set for a relatively large group of countries and relying on appropriate empirical techniques to obtain these estimates. Because our interest is in providing reasonable empirical estimates of widely used parameters, we construct a fairly simple macroeconomic model using widely accepted developing country specifications for the key behavioral relationships wherever possible. The structural parameters are then estimated as a system.

Although, for the reason just explained, the behavioral relationships in our model are conventional, our work differs from existing developing country empirical macroeconomic models in two important ways. First, we assume that expectations are formed rationally by forward-looking economic agents. Second, we make explicit allowance for the presence of capital controls—a feature which, though pervasive in developing economies and often mentioned in policy discussions, is invariably neglected when it comes to empirical analysis.

The model to be estimated is described in Section I. Section II describes the estimation procedure and presents the estimation results. The model estimates are discussed in Section III. The final section provides some brief comments on the specification of the model and the estimated relationships.

I. Specification of the Model

This section develops a simple model for a small open developing country, which can be estimated using a pooled sample of time-series data from a large number of countries. In specifying the behavioral relationships as well as the structure of the economy, we have chosen to work with conventional, widely used specifications to the greatest extent possible, subject to the data limitations inherent in developing country applications. The model is of the Mundell-Fleming variety, with one domestically produced good consumed both at home and abroad and one imported good. The specification allows for the existence of capital controls, while permitting the degree of effective capital mobility to be tested empirically. The discussion is divided into descriptions of aggregate demand, aggregate supply, the money market, and the government sector. The last subsection examines the overall structure of the model.

Although a three-good (exportable-importable-nontraded) structure might be more appropriate for developing countries, data limitations make it infeasible to implement the estimation of a model with this structure across a large group of developing countries.
Aggregate Demand

Real aggregate demand for domestic output is the sum of consumption, investment, government expenditure, and the trade balance:

$$Y_t = C_t + I_t + G_t + X_t - \frac{e_t P_t^* Z_t}{P_t}.$$  

(1)

The variables in equation (1) are defined as follows: $Y_t$ is real gross domestic product (GDP); $C_t$ is real private consumption expenditure; $I_t$ is real gross domestic investment expenditure; $G_t$ is real government expenditure on the domestic good; $X_t$ denotes real exports; $e_t$ is the nominal exchange rate (price of foreign currency in domestic currency terms); $Z_t$ is real imports measured in units of the foreign good; $P_t^*$ is the foreign currency price of imports; and $P_t$ is the domestic currency price of domestic output.

Turning to the components of demand, the consumption function is specified as follows:

$$\log C_t = \alpha_0 + \alpha_1 r_t + \alpha_2 \log C_{t-1} + \alpha_3 \log Y_{t}^d + \alpha_4 \log Y_{t-1}^d,$$  

(2)

where $r_t$ is the domestic real rate of interest, $Y_{t}^d$ is real disposable income, and the $\alpha_i$'s are coefficients to be estimated.\(^2\) The short-run interest semi-elasticity of consumption is measured by the parameter $\alpha_1$.\(^3\) In this general specification are nested a number of alternative hypotheses about consumption. For example, if $\alpha_0 = \alpha_1 = \alpha_3 = \alpha_4 = 0$, and $\alpha_2 = 1$, the simplest Hall (1978) version of the permanent-income hypothesis with no liquidity constraints, in which current consumption is systematically related only to its own past value, is obtained (see Hall (1978)). If only the disposable income terms are rejected empirically, the specification would be consistent with more general Euler-equation approaches, which predict that, in the absence of new information, consumption grows from period to period at a rate that depends on the rate of interest (see Rossi (1988) and Giovannini (1985)). As a number of studies have shown, current disposable income would be important (that is, $\alpha_3 > 0$) in an equation of this type estimated with instrumental variables if liquidity constraints are binding for a significant portion of households, since in this case aggregate consumption would include a portion that is attributable to liquidity-constrained households whose consump-

\(^2\)This specification is very close to that of Blinder and Deaton (1985). See also Lahiri (1989), who estimates a similar function for several Asian economies.

\(^3\)Few studies have found reliable or significant estimates of interest elasticities of consumption in developing countries. See, for example, Rossi (1988).
tion is constrained by current income (see Flavin (1981)). Finally, the coefficient of the lagged disposable income term can also provide a test for the Blanchard hypothesis of finite horizons for private agents. As shown in Haque (1988), if the planning horizons of households that do not face liquidity constraints are effectively of infinite length, \( \alpha_4 = 0 \); otherwise, \( \alpha_4 \) will be negative (see also Haque and Montiel (1989)).

Consumer disposable income, a variable used in the consumption function above, is defined to be GDP plus the earnings on net assets held abroad, minus interest paid on domestic debt and taxes:

\[
Y_t^d = Y_t + \frac{i_t^* e_t F_{p,t-1}}{P_t} - \frac{i_t D_{C_{p,t-1}}}{P_t} - T_t,
\]

where \( i_t^* \) and \( i_t \) are the (nominal) foreign and domestic interest rates, respectively, \( F_{p,t} \) is the stock of foreign assets held by the private sector (measured in foreign currency terms), \( D_{C_{p,t}} \) is the stock of domestic bank credit held by the private sector, and \( T_t \) is real taxes. Disposable income and consumer expenditure are linked to the net change in consumer wealth by the private sector budget constraint:

\[
Y_t^d = C_t + I_t + [(M_t - M_{t-1}) + e_t(F_{p,t} - F_{p,t-1}) - (D_{C_{p,t}} - D_{C_{p,t-1}})]/P_t,
\]

where \( M_t \) denotes the money supply in period \( t \). Disposable income is thus allocated to consumption, investment, and net changes in financial assets.

Investment is specified as a function of fairly standard variables—that is, the real interest rate, real output, and the beginning-of-period capital stock.\(^4\) We adopt a linear formulation, since this permits us to avoid the problem of the absence of capital stock data by first-differencing the equation. The investment function is

\[
I_t = k_0 + k_1 Y_t + k_2 Y_{t-1} + k_3 K_{t-1},
\]

With first differences this becomes

\[
I_t = k_1 (r_t - r_{t-1}) + k_2 (Y_t - Y_{t-1}) + k_3 I_{t-1},
\]

where \( k_3 = 1 + k'_3 \). This transformation eliminates the capital stock, a variable for which no developing country data are available.

Exports are assumed to be a function of the real exchange rate \((e_t P^*_t/P_t)\) and the level of real output abroad \((Y^*)\), with positive coeffi-

\(^4\)For a discussion of investment functions in developing countries, see Blejer and Khan (1984a, 1984b) and Sundararajan and Thakur (1980).
To incorporate partial adjustment, a lagged dependent variable is included in the estimated equation. The export equation may therefore be expressed as follows:

\[ \log X_t = \tau_0 + \tau_1 \log \frac{e_t P_t^*}{P_t} + \tau_2 \log Y_t^* + \tau_3 \log X_{t-1}. \] (6)

Real imports are related negatively to the real exchange rate and positively to real domestic output. This specification is conventional.\(^7\) Again, to capture partial adjustment behavior a lagged import term is included in the estimated equation. Furthermore, since restricted foreign exchange availability frequently leads to the imposition of import controls and foreign exchange rationing, which act as a constraint on imports in developing countries, the reserve-import ratio lagged one period is often included in this regression (see Khan and Knight (1988)). The import equation can therefore be written as

\[ \log Z_t = \delta_0 + \delta_1 \log \frac{e_t P_t^*}{P_t} + \delta_2 \log Y_t + \delta_3 \log \frac{R_t}{P_t Z_{t-1}} + \delta_4 \log Z_{t-1}. \] (7)

where \(R_t\) is the foreign exchange value of international reserves.

**Aggregate Supply**

We assume a Cobb-Douglas production function relating labor and capital to output:

\[ Y_t = \theta_0 K^{\theta_1} L^{\theta_2}, \] (8)

where \(K\) and \(L\) are measures of the aggregate capital stock and employment and the \(\theta_i\)'s \((i = 0, 1, 2)\) are coefficients to be estimated. As with the investment function, estimation of the supply side of the model is hampered by the shortage of data on aggregate capital stock for developing countries. The following procedure was therefore adopted. The solution to the difference equation \(K_t = (1 - \rho) K_{t-1} + I_t\), where \(\rho\) is the rate of depreciation, can be written (after taking logs) as

\[ \log K_t = \log (1 - \rho) + \log K_{t-1} + \log I_t, \]

\[ \log K_t = \log (1 - \rho) + \log K_{t-1} + \log I_t. \]

\(^5\) See Goldstein and Khan (1985) for a discussion of empirical estimates of such an export function. See also Khan (1974) and Khan and Knight (1988) for the case of developing countries.

\(^6\) Note that the Mundell-Fleming structure of this model implies that exports and domestic output are perfect substitutes.

\(^7\) Once again, empirical applications of this specification are extensively discussed in Goldstein and Khan (1985).
\[
\begin{align*}
\log K_t &= \log \left[ \sum_{i=0}^{t-1} (1 - \rho)^i I_{t-i} + (1 - \rho)^t K_0 \right] \\
&= \log 2 + \frac{1}{2} \left[ \log \sum_{i=0}^{t-1} (1 - \rho)^i I_{t-i} + \log (1 - \rho)^t K_0 \right] \\
&= \log 2 + \frac{1}{2} \log \sum_{i=0}^{t-1} (1 - \rho)^i I_{t-i} + \frac{t}{2} \log (1 - \rho) + \frac{1}{2} \log K_0, \\
\end{align*}
\]

where \( K_0 \) is the initial stock of capital.

Thus,
\[
\begin{align*}
\log Y_t &= \log \theta_0 + \theta_1 \log K_t + \theta_2 \log L_t \\
&= \log \theta_0 + \theta_1 \left[ \log 2 + \frac{1}{2} \log \sum_{i=0}^{t-1} (1 - \rho)^i I_{t-i} \\
&+ \frac{t}{2} \log (1 - \rho) + \frac{1}{2} \log K_0 \right] + \theta_2 \log L_t, \\
&= \theta_0' + \theta_1 K_t' + \theta_2 \log L_t, \\
\end{align*}
\]

where
\[
\begin{align*}
\theta_0' &= \log \theta_0 + \frac{\theta_1}{2} \log K_0, \\
K_t' &= \log 2 + \frac{1}{2} \log \sum_{i=0}^{t-1} (1 - \rho)^i I_{t-i} + \frac{t}{2} \log (1 - \rho). \\
\end{align*}
\]

Note that equation (10) can be estimated for different values of \( \rho \) over the interval \((0,1)\), and optimal values of \( \theta_0' \), \( \theta_1 \), and \( \theta_2 \) will correspond to that value of \( \rho \) which maximizes the \( R^2 \) in equation (10). By imposing constant returns to scale (that is, \( \theta_1 + \theta_2 = 1 \)), equation (10) can be written in per capita terms as
\[
\log (Y_t/L_t) = \theta_0' + \theta_1 (K_t' - \log L_t). \\
\]

\*We used the approximation
\[
\log (x + y) = \log 2 + \frac{1}{2} (\log x + \log y) + \frac{1}{8} (\log x - \log y)^2 + \ldots ,
\]
where
\[
x = \sum_{i=0}^{t-1} (1 - \rho)^i I_{t-i} \quad \text{and} \quad y = (1 - \rho)^t K_0.
\]

In our estimation the first-order term was found to be adequate.
To allow for lagged adjustment and technical progress over time, we also included $\log (Y/L)_{t-1}$ and a time trend, $t$, as additional explanatory variables in our final specification. Thus, the empirical production function becomes

$$
\log (Y/L)_t = \theta_0 + \theta_1 (K_i - \log L_i) + \theta_2 + \theta_3 \log (Y/L)_{t-1}.
$$

(12)

The degree of wage-price flexibility in developing countries is an unsettled issue. The present model is estimated on the assumption of complete wage-price flexibility. Under these circumstances, equation (12) also represents the economy's aggregate supply function.

### Money Market

The supply of money ($M$) in the economy consists of reserves and domestic credit, with the latter denoted as $DC$:

$$
M_t = e_t R_t + DC_t.
$$

(13)

Whereas reserves are determined endogenously by the balance of payments (see below), domestic credit, both to the private sector ($DC_{p,t}$) and to the public sector ($DC_{G,t}$), is determined by policy:

$$
DC_t = DC_{p,t} + DC_{G,t}.
$$

(14)

The demand for money is, as usual, taken to be related negatively to the nominal rate of interest and positively to the level of income, with a partial adjustment mechanism introduced to capture lagged responses:

$$
\log \frac{M_t}{P_t} = \beta_0 + \beta_1 \ i_t + \beta_2 \log Y_t + \beta_3 \log Y_{t-1} + \beta_4 \log \frac{M_{t-1}}{P_{t-1}}.
$$

(15)

The lagged term in $Y$ allows for different speeds of adjustment of the demand for money to changes in interest rates and income.

The specification of the determination of the domestic nominal interest rate allows us to test for the effective degree of capital mobility in the economy. If capital is perfectly mobile, as is frequently assumed in models of small open economies, nominal interest rates are determined by the interest parity condition that equates the domestic nominal interest rate to the sum of the nominal rate prevailing abroad and the expected change in the value of the domestic currency (uncovered interest parity). In a completely closed economy, nominal interest rates have no relationship to external rates and are determined purely in domestic

*The additional lagged term in $Y$ permits the demand for money to adjust more slowly in response to changes in income than to changes in interest rates.
markets. Our formulation follows Edwards and Khan (1985) in specifying the domestic interest rate as a linear combination of these two polar cases:

\[ i_t = \phi \left( i^*_t + \frac{E_t e_{t+1} - e_t}{e_t} \right) + (1 - \phi) i^*_t. \]  

(16)

Here, \( E_t e_{t+1} \) is the expectation at time \( t \) of the exchange rate in period \( t + 1; i^*_t \) is the interest rate that would prevail if the capital account were closed; and \( \phi \) is a capital mobility index ranging between zero and unity. When \( \phi = 1 \), it is implied that the domestic interest rate is determined by the uncovered interest parity condition, and thus corresponds to perfect capital mobility, whereas \( \phi = 0 \) implies that the domestic interest rate is \( i^*_t \)—that is, the rate that would emerge under a completely closed capital account. As \( \phi \) increases from zero to unity, the degree of capital mobility increases, since \( i \) approaches its uncovered parity value. In these intermediate cases the equilibrium interest rate is determined by a combination of domestic and external factors.

The interest rate that would prevail in an economy with a closed capital account (that is, one with no private capital flows), \( i^*_t \), can be determined by equating the money supply that would be observed in this case to the demand for money. This “shadow” money supply (denoted by \( \bar{M} \)) differs from the supply of money given by equation (13), in that the effects of current private capital flows on the central bank’s stock of foreign exchange reserves are removed:

\[ \bar{M}_t = M_t + e_t \Delta F_{p,t}. \]  

(17)

Thus, the “shadow” domestic interest rate \( \bar{i} \), can be obtained by solving the following equation:

\[ \log \frac{\bar{M}_t}{P_t} = \beta_0 + \beta_1 i^*_t + \beta_2 \log Y_t + \beta_3 \log Y_{t-1} + \beta_4 \log \frac{M_{t-1}}{P_{t-1}}. \]  

(18)

In this model the authorities use capital controls to pursue an independent monetary policy, as follows: for a desired level of the domestic interest rate, say \( i_n \), the level of the domestic money supply required to clear the money market, say \( \bar{M}_n \), is given by setting \( i = \bar{i} \) in the money-market equilibrium condition (15).

Given \( \bar{M}_n \) from equation (15) and the supply of credit \( DC_t \), equation (13) determines foreign exchange reserves \( R_t \). Subtracting the previous period’s reserves, \( R_{t-1} \), yields the balance of payments (\( \Delta R_t \)). Using the balance of payments identity

\[ e_t \Delta R_t = CA_t - e_t (\Delta F_{C,t} + \Delta F_{p,t}). \]  

(19)
where
\[ CA_t = P_t X_t - e_t P_t^* Z_t + i_t^* e_t (F_{P,t-1} + F_{G,t-1} + R_{t-1}) , \]
the authorities can derive the permissible level of private capital flows, \( \Delta F_{P,t} \), conditional on the current account, \( CA_t \), and public capital outflows, \( \Delta F_{G,t} \).

The authorities could choose to administer this system in a number of ways. If either \( i_t \) or \( \Delta F_{P,t} \) is treated as an exogenous variable, the other becomes endogenous and equation (16) drops out of the model. With \( i_t \) exogenous, the authorities announce a domestic interest rate, solve for the value of \( \Delta F_{P,t} \) required to support it, and permit this degree of capital mobility. Equation (16) becomes unnecessary, useful only for calculating a period-by-period index \( \phi_t \) of the degree of capital mobility. Alternatively, the authorities could choose \( \Delta F_{P,t} \) exogenously, with equation (19) determining \( R_t \), equation (13) determining \( M_t \), and equation (15) the domestic interest rate. The role of equation (16) would then be as in the previous case.

We will assume instead that the system is run somewhat less flexibly. The severity of capital controls, as measured by the parameter \( \phi \) in equation (16), is taken as a structural (institutional) feature of the economy. In this case, both \( i_t \) and \( \Delta F_{P,t} \) become endogenous. The domestic interest rate \( i_t \) will respond to factors affecting both the uncovered parity and the shadow interest rate. For the money market to clear, \( \Delta F_{P,t} \) must be adjusted in response to these factors as well. Notice that the structural interpretation of \( \phi \) permits its magnitude to be estimated empirically, in a manner to be discussed in the next section.

The real interest rate enters the model in both the consumption and investment functions. It is given by
\[ r_t = i_t - \frac{E_{t+1} P_{t+1} - P_t}{P_t}, \]
that is, the real interest rate is the nominal interest rate minus the expected rate of inflation.

**Government**

The model's dynamic specification is completed with a description of the behavior of the nonfinancial public sector. The public sector acquires assets in external markets \( (F_{G,t}) \) as well as from the domestic banking sector \( (D_{G,t}) \). For its revenues it relies on tax receipts, \( T_t \), and on

---

10 A negative value of \( F_{G,t} \) denotes accumulated debt.
interest on its foreign asset holdings. Expenditures \((G_i)\) consist of purchases of domestic goods for consumption purposes and interest payments on domestic debt. Combining these elements, the government budget constraint can be written as

\[
e_i \Delta F_{G,i} - \Delta DC_{G,i} = P_i (T_i - G_i) + i_i e_i F_{G,i-1} - i_i DC_{G,i-1}.
\]  

(22)

**Overall Structure of the Model**

The model that emerges from this specification is essentially a flexible-price dynamic variant of the traditional Mundell-Fleming model with specific developing country features. A single good is produced domestically, which can be sold at home or abroad. The home country has some monopoly power over the price of its output in world markets. It is a price-taker, however, in the market for its imports. However, as is common in developing countries, private agents may not be able to satisfy their notional demand for imports, because the authorities impose quantitative import restrictions that depend on the adequacy of their foreign exchange reserves. On the financial side, the degree of integration of the home economy with the rest of the world depends on the degree of severity with which capital controls are enforced. In principle, this can range from financial autarky to perfect capital mobility. The dynamics of the model arise from forward-looking expectations, partial adjustment in the behavioral relationships, and stock accumulation. Since the levels of investment and the current account are endogenous, the model can explain medium-term growth and external debt accumulation. Since expectations are forward-looking, these phenomena will depend not just on present, but also on future, values of the policy and exogenous variables.

**II. Estimation Issues**

The equations to be estimated are (2), (5), (6), (7), (12), (15), and (16). These are repeated for convenience in Table 1. The approach to estimation used here assumes that the slope parameters do not change across countries. The estimates should therefore be interpreted as “typical” of developing countries in general, rather than as specific to any particular country. This approach allows us to exploit the variation in data both across countries and within countries over time to estimate key macroeconomic parameters. We used annual data over 1963–87 for
Table I. Behavioral Equations of the Model

\[
\begin{align*}
(2) \quad & \log C_t = \alpha_0 + \alpha_1 r_t + \alpha_2 \log C_{t-1} + \alpha_3 \log Y^d_t + \alpha_4 \log Y^s_{t-1} \\
(5) \quad & i_t = k_1 (r_t - r_{t-1}) + k_2 (Y_t - Y_{t-1}) + k_3 i_{t-1} \\
(6) \quad & \log X_t = \tau_0 + \tau_1 \log \frac{P_t}{P_{t-1}} + \tau_2 \log Y^d_t + \tau_3 \log X_{t-1} \\
(7) \quad & \log Z_t = \delta_0 + \delta_1 \log \frac{P_t}{P_{t-1}} + \delta_2 \log Y_t + \delta_3 \log \frac{R_{t-1}}{P_{t-1} \cdot Z_{t-1}} + \delta_4 \log Z_{t-1} \\
(12) \quad & \log (Y/L)_t = \theta_1 + \theta_2 (K_t - \log L_t) + \theta_3 \log (Y/L)_{t-1} \\
(15) \quad & \log \frac{M_t}{P_t} = \beta_0 + \beta_1 i_t + \beta_2 \log Y_t + \beta_3 \log Y_{t-1} + \beta_4 \log \frac{M_{t-1}}{P_{t-1}} \\
(16) \quad & i_t = \phi \left( \frac{r_t^* + E_t e_{t+1} - e_t}{e_t} \right) + (1 - \phi) i_t.
\end{align*}
\]

31 developing countries\(^{11}\) collected from the International Monetary Fund’s World Economic Outlook data base and International Financial Statistics. In this section we discuss three estimation issues: the problem of unobserved variables; the approach to estimation with rational expectations; and the treatment of country heterogeneity. The estimated equations themselves are presented in Section III.

Unobserved Variables

The first estimation issue to be confronted is the absence of data on the market-determined interest rate \(i_t\) and, of course, the shadow interest rate \(i_t^*\). In developing countries the relevant market-determined interest rate is typically that for loans in informal, or “curb” markets. Time-series data on such interest rates are very rare. Published developing country interest rate data typically refer to central bank discount rates or to official interest rates on deposits or bank credit. Such interest rates have almost invariably been set by administrative fiat and do not adequately capture the marginal cost of funds.

This problem can be addressed by solving equation (18) for the shadow interest rate \(i_t^*\) and then substituting the resulting expression for \(i_t^*\) into equation (16) to solve for \(i_t\). The result is an equation for the domestic market-determined interest rate that expresses this variable as

\(^{11}\)The countries in the sample are Brazil, Chile, Colombia, Costa Rica, Ecuador, Egypt, Ethiopia, Greece, Guatemala, India, Indonesia, Jamaica, Jordan, Kenya, the Republic of Korea, Malawi, Malaysia, Malta, Mexico, Morocco, Nigeria, Paraguay, the Philippines, South Africa, Sri Lanka, Tanzania, Thailand, Tunisia, Turkey, Venezuela, and Zambia.
a function of domestic money-market conditions as well as of the external interest rate. The solution for the nominal interest rate can be used to eliminate \( i \) from the money-demand function (15), permitting that equation to be expressed in terms of observable variables. The expression for \( i \) can also be substituted into equation (21) to solve for the real interest rate \( r \). This solution for the real interest rate can be used to eliminate \( r \) from both the consumption function (2) and the investment function (5), rendering these equations in terms of observable variables. The revised equations (2), (5), and (15) are nonlinear in the structural parameters and subject to cross-equation restrictions among these parameters. This procedure has the virtue not only of making it possible to estimate the parameter \( \phi \), but also of permitting us to extract estimates of interest rate elasticities in consumption, investment, and money demand, which do not, as is common in much of the developing country literature, depend on proxies for market interest rates such as administered interest rates or inflation rates. The resulting system to be estimated consists of the revised versions of equations (2), (5), and (15)—with associated nonlinear parameter and cross-equation restrictions—as well as equations (6), (7), and (12).

**Expectations**

The next issue concerns the treatment of expectations in the estimation procedure. The assumption of rationality in our model implies that forward expectations are based on all available information, including the structure of the model. This implies the property that prediction errors should be nonsystematic:

\[
P_{t,t+1} = E_t P_{t,t+1} + \epsilon_{t,t+1},
\]

where \( \epsilon_{t,t+1} \) is a serially uncorrelated random disturbance term. For estimation a reasonable proxy is needed for \( E_t P_{t,t+1} \), which now appears in the revised versions of equations (2) and (5). One such observable proxy for the unobservable price-expectation variable \( E_t P_{t,t+1} \), according to equation (23), is the actual \( P_{t,t+1} \). The associated estimation procedure must take account of the errors-in-variables problem implied by (23). This errors-in-variables method (EVM), in which the expected forward price is replaced by the realized (observed) value, and the latter is treated as an additional endogenous variable of the model, is a well-known approach to estimation under rational expectations.\(^{12}\) An alter-

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native approach that has been used for estimation of simultaneous equation models with rational expectations is the so-called substitution method (SM) where the rationally expected variables are replaced by forecasts based on a restricted reduced form. Wickens (1982, 1986) emphasizes many advantages of the EVM approach over the SM method. He shows that in a nonlinear model such as ours, the additional nonlinearity in the parameters introduced owing to SM will make the estimation technique hopelessly complicated. Wickens (1982, 1986) also demonstrates that EVM is in general more robust than SM in cases where the variables in the information set (Ωi) are incomplete. Moreover, EVM is relatively easy to implement, making it more amenable to repeated experimentation with different specifications of the model. In addition, Wickens (1986) shows that until the type of rational expectations solution exhibited by the model is known, it will not be possible to select the appropriate fully efficient SM estimator.

The reduced-form equation for \( P_i \) in country \( i \) can be obtained by linearizing the model, solving it for \( P_i \), advancing it one period, taking expectations conditional on \( Ω_i \), and solving for \( E_i P_{i+1} \). If we write

\[
E_i P_{i+1} = Π \cdot X_{it} \tag{24}
\]

where \( X_p \) is the set of instruments belonging to \( Ω_i \), and \( Π \) is a vector of reduced-form coefficients, then equation (23) becomes

\[
P_{i+1} = Π \cdot X_{i} + ε_{i,t+1}. \tag{25}
\]

This equation can be used to generate the instruments for \( P_{i+1} \). In estimating the behavioral equations of the revised model, therefore, \( E_i P_{i+1} \) was replaced by \( P_{i+1} \), and \( C_{it}, I_{it}, X_{it}, Z_{it}, M_{it}, Y_{it}, P_{its} \), and \( P_{it} \) were treated as endogenous variables (that is, not part of the set of instruments). This yields consistent estimates of the structural parameters. Note that in order to identify and estimate all the structural parameters, we have to estimate the system of equations together, incorporating the nonlinear restrictions both within and across equations.

**Treatment of Country Heterogeneity**

The use of pooled cross-section, time-series data means that the issue of country heterogeneity has to be confronted. Most studies that use such data for empirical estimation rely on a fixed-effects model, using dummy variables to deal with country heterogeneity, primarily for ease of estimation (see, for example, Khan and Knight (1981)). In this study

\begin{flushleft}
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we adopted the alternative approach of variance components. Under this assumption, the error term of the $j$th equation, $\eta_j$, is composed of two terms: $\eta_{ij}$, the country-specific effect, which varies only across countries and not across time; and $e_{ij}$, an individual random effect which may differ for all observations. The approach has the advantage that it recognizes the possibility that country-specific effects may be correlated across equations.

**Method of Estimation**

As is well known, variance-components characterization of country heterogeneity implies that generalized least-squares (GLS) estimation techniques can be used to consistently estimate the model parameters as well as the variance components of the random error term. In order to deal with the error-component structure of the variance of the random error term in the model, generalized estimation techniques were implemented using a two-step procedure. At the first stage, the vector of residuals was calculated from two-stage least-squares (2SLS) estimates of the model. These residual estimates were used to calculate the variance and covariance components. See Wallace and Hussain (1969) and Maddala (1988).

With the variance components estimated, the variance-covariance matrix of the disturbance term can be constructed to allow generalized two-stage or three-stage least squares to be used for consistent estimation of the model parameters. Anderson and Hsiao (1982) and Sevestre and Trognon (1985) have shown that this estimator is consistent and, for dynamic models, independent of initial conditions. In our case, a generalized, nonlinear, three-stage least-squares estimator was used owing to the presence of nonlinearities and cross-equation restrictions. Following Breusch, Mizon, and Schmidt (1989), the instruments used were the within-country variables ($X_{ij} - \bar{X}_{ij}$) and the between-country variables ($X_{ij}$); they have shown that the use of this procedure allows efficient estimation in models with panel data.15

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15 Before estimating the model, we tested our assumed error-components structure, and also conducted tests for serial correlation. These tests are described in Haque, Lahiri, and Montiel (1990), which also provides a detailed treatment of estimation issues. The results were consistent with the variance-components model, and no signs of serial correlation were detected in the residuals.
III. Model Estimates

The error-components, two-stage least-squares (EC2SLS) estimates form the basis for the implementation of the error-components, three-stage least-squares (EC3SLS) estimation (see Baltagi (1981)). The results of the EC3SLS estimation are presented in Table 2. As will be discussed below, these results indicate that the model fits the data very well. Almost all the estimates are of the right sign, and a large number of them are estimated precisely. In what follows we shall discuss the estimates of, and the hypotheses embedded in, each of the behavioral equations separately.\(^{16}\)

Consumption

The estimated coefficients of the consumption function are all of the anticipated signs. In magnitude, these coefficients also conform well to theory as well as to consumption function estimates that are available in the literature. Interestingly enough, \(\alpha_i\) is negative and significant at the 10 percent level, verifying a negative relationship between consumption and the interest rate. Most studies of the consumption function have found this relationship to be statistically insignificant. Our results suggest that the use of inappropriate proxies for domestic real interest rates (for example, the rate of inflation) may have contributed to this result.\(^{17}\) The estimated coefficient is, however, quite small, suggesting that changes in interest rates would not induce substantial changes in consumption. This result confirms Rossi's (1988) finding of a significant but small real interest rate elasticity in the consumption function.

The estimation, as it turns out, supports a number of important hypotheses relating to the consumption function that were discussed above. The specification is very similar to the Haque and Montiel (1989) version of the permanent income model. The coefficient of lagged consumption

\(^{16}\)Note that our model formulation allows all the endogenous variables to be correlated with \(\eta_{ji}\) and \(\epsilon_{ji}\) in all equations. However, the exogenous variables are assumed to be uncorrelated with \(\eta_{ji}\) and \(\epsilon_{ji}\). Some of the exogenous variables, however, can be correlated with \(\eta_{ji}\), but uncorrelated \(\epsilon_{ji}\). Cornwell, Schmidt, and Wyhowski (1988) refer to this latter group as "singly" exogenous variables. For consistent estimation, the country means of the singly exogenous variables (that is, \(X_i\)) should not belong to the list of instrumental variables. In the context of EC2SLS estimation of each structural equation, we found that this had negligible effects on the reported estimates. Thus, our list of exogenous variables can safely be treated as "doubly" exogenous.

\(^{17}\)See Giovannini (1985) for a discussion of this issue.
Table 2. Nonlinear Error-Components, Three-Stage Least-Squares Estimates of Structural Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter Values</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consumption</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a_0$</td>
<td>0.047</td>
<td>5.62*</td>
</tr>
<tr>
<td>$a_1$</td>
<td>-0.076</td>
<td>-4.08*</td>
</tr>
<tr>
<td>$a_2$</td>
<td>1.010</td>
<td>96.28*</td>
</tr>
<tr>
<td>$a_3$</td>
<td>0.143</td>
<td>3.64*</td>
</tr>
<tr>
<td>$a_4$</td>
<td>-0.149</td>
<td>-4.23*</td>
</tr>
<tr>
<td>$R^2 = 0.997$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Investment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$k_0$</td>
<td>-0.226</td>
<td>-6.81*</td>
</tr>
<tr>
<td>$k_1$</td>
<td>-0.113</td>
<td>-4.03*</td>
</tr>
<tr>
<td>$k_2$</td>
<td>0.196</td>
<td>9.74*</td>
</tr>
<tr>
<td>$k_3$</td>
<td>0.809</td>
<td>44.94*</td>
</tr>
<tr>
<td>$R^2 = 0.980$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Production function</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\theta_0$</td>
<td>0.122</td>
<td>6.55*</td>
</tr>
<tr>
<td>$\theta_1$</td>
<td>0.881</td>
<td>63.38*</td>
</tr>
<tr>
<td>$\theta_2$</td>
<td>0.141</td>
<td>6.49*</td>
</tr>
<tr>
<td>$R^2 = 0.979$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Exports</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_0$</td>
<td>0.050</td>
<td>2.05*</td>
</tr>
<tr>
<td>$\tau_1$</td>
<td>0.084</td>
<td>1.78*</td>
</tr>
<tr>
<td>$\tau_2$</td>
<td>0.925</td>
<td>82.24*</td>
</tr>
<tr>
<td>$R^2 = 0.983$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Imports</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\delta_0$</td>
<td>-0.157</td>
<td>-5.09*</td>
</tr>
<tr>
<td>$\delta_1$</td>
<td>0.161</td>
<td>6.02*</td>
</tr>
<tr>
<td>$\delta_2$</td>
<td>0.038</td>
<td>5.96*</td>
</tr>
<tr>
<td>$\delta_3$</td>
<td>0.834</td>
<td>43.21*</td>
</tr>
<tr>
<td>$R^2 = 0.977$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Money demand</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_0$</td>
<td>-0.146</td>
<td>-4.36*</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>-0.038</td>
<td>-1.27</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>0.571</td>
<td>3.99*</td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>-0.397</td>
<td>-2.79*</td>
</tr>
<tr>
<td>$\beta_4$</td>
<td>0.881</td>
<td>59.56*</td>
</tr>
<tr>
<td>$R^2 = 0.997$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Capital mobility</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi$</td>
<td>1.004</td>
<td>90.59**</td>
</tr>
</tbody>
</table>

Note: one asterisk (*) indicates parameter significance at the 5 percent level; two asterisks (**) indicate not significantly different from unity; and $R^2$ denotes the coefficient of determination corrected for degrees of freedom.
is close to unity and significant, as expected in the Hall (1978) specification of the permanent income hypothesis. However, contrary to the Hall hypothesis, disposable income is significant in explaining consumption behavior. The coefficient of disposable income, $\alpha_3$, which is statistically significant, suggests that about 15 percent of consumers in developing countries are liquidity constrained, which is on the low end of the range of estimates reported in Haque and Montiel (1989).

**Investment**

The specification of the investment function was a relatively simple one. Nevertheless, it seems to provide a reasonably good explanation of investment behavior in developing countries. Most studies of investment behavior in such countries do not include interest rates as an explanatory variable because of lack of adequate information (see Blejer and Khan (1984a, 1984b)). Our approach to modeling capital mobility allows the identification of the effect of the real interest rate on investment. Although small, the coefficient of the real interest rate, $k_1$, is negative, as expected, and significant at the 5 percent level. Growth in income also affects investment positively and significantly, in keeping with the flexible-accelerator family of investment theories. The coefficient of lagged investment, $k_3$, is close to but less than unity, indicating both a stable investment function as well as a fairly protracted period of adjustment. Using this estimate, the long-run interest rate and output elasticities can be calculated—they turn out to be 0.59 and 1.02, respectively. Thus, as can be expected, in the long run, when all adjustments have been completed, the interest elasticity is substantially larger than it is on impact. Moreover, the steady-state property that per capita output and investment grow at the same rate is satisfied.

**Aggregate Supply**

All the variables in the estimated aggregate supply (production) function are significant and of the right sign. Since $\theta_0$ contains $\log K_0$, which is an initial-value parameter representing the initial stock of capital for each country, equation (12) was estimated from the “within” dimension of the data. The parameter $p$ was estimated to be 0.05, although estimates of $\theta_1$, $g$, and $\theta_3$ were not particularly sensitive to values of $p$ in the

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18 Since aggregate employment data are seldom available for developing countries, we used the population as a proxy for $L$. 

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vicinity of 0.05. The per capita stock of capital affects current output significantly and positively with a short-run elasticity of 0.12 and of close to unity in the long run. At the sample means, our results, which are derived from a log-linear specification, compare quite favorably to the estimates of Dadkhah and Zahedi (1986). Nevertheless, the supply equation provided the least satisfactory empirical results. The coefficient on the lagged dependent variable is implausibly high, suggesting that some of our maintained hypotheses (for example, regarding the form of the production function or the degree of wage-price flexibility) require further investigation.

**Foreign Trade**

The estimated export function fits the data well, with all coefficients bearing the expected signs and reasonable magnitudes. The fitted equation exhibits a significant export response to relative price changes, although one that is somewhat smaller in magnitude than other available estimates. The long-run elasticity of 0.66, though considerably higher than the short-run elasticity, still suggests a fairly inelastic response. In the estimated (foreign) function for the demand for exports, the coefficient of foreign income is positive and significant, with a long-run elasticity of 1.12. A fair amount of persistence in the level of exports appears to be indicated by the coefficient of lagged exports, which is both significant and close to unity, so that the response to changes in relative prices and foreign income tends to be quite prolonged over time.

In the import equation the estimated coefficients also bear the right signs and are all significant at conventional levels. Imports are responsive to real exchange rate changes with a short run elasticity of −0.157 and a long-run elasticity of about −0.94. Growth in the domestic economy increases imports, with an elasticity of 0.16 in the short run and about 0.96 (not significantly different from unity) in the long run. Reflecting foreign exchange constraints, the coefficient of the lagged reserve-import ratio is significant and positive. These estimates are similar to those in Khan and Knight (1988).

Our results suggest that the trade equations are not as responsive to real exchange rate changes and income growth as other studies have previously estimated. However, when these results are being com-

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19 It is interesting to note that this 5 percent value is consistent with those in Sundararajan and Thakur (1980) and Blejer and Khan (1984b).

pared, it must be borne in mind that most available estimates of such equations were constructed in a partial equilibrium setting. The estimates presented here, by contrast, are in the context of a complete macroeconomic model.

**Money and Capital Mobility**

The coefficients of the estimated money-demand function are all significant and of the expected sign. Money demand, in keeping with expectations, is quite interest inelastic, with the short-run interest elasticity estimated at about $-0.04$ and the long-run elasticity estimated at about $-0.26$. The estimated income elasticities are much higher: the short- and long-run elasticities turn out to be 0.22 and 1.82, respectively.

As described above, our modeling approach and method of estimation allow us to estimate the effective degree of capital mobility (indexed by the parameter $\phi$) for this group of developing countries. Somewhat surprisingly, the estimate of $\phi$ turns out to be insignificantly different from unity, suggesting that capital was in effect highly mobile for these countries over our sample period. This result supports the validity of the small-open-economy approach to modeling the financial sector in developing economies and implies that economic agents readily find ways to get around official barriers to capital mobility. Thus, the uncovered interest parity condition can be used to proxy for interest rates in modeling developing economies.\(^{21}\)

**IV. Conclusions**

This paper attempts to fill a void in empirical developing country macroeconomies. There is at present no consensus on "representative"

\(^{21}\) Estimates of income elasticities of money demand substantially above unity are quite common in developing countries. See Khan (1980).

\(^{22}\) In view of this result, we re-estimated the model, imposing perfect capital mobility to see if the coefficients were altered in any significant manner. The results were essentially unchanged, with the exception of the consumption function. This function exhibited a substantially greater interest rate elasticity. The estimated fraction of liquidity-constrained households was about one third, a result which is much closer to the estimates in Haque and Montiel (1989).

\(^{23}\) Evidence in favor of a high degree of capital mobility was also found in Haque and Montiel (1990a, 1990b).
developing country values of the parameters of key macroeconomic behavioral relationships. Although empirical estimates are available for these parameters, the lack of convergence of views reflects differences in the specifications estimated by various analysts, in data definitions and time periods and countries covered, and in empirical methodology. In this paper, using conventional, widely accepted specifications and appropriate econometric techniques, we pooled consistent time-series data for 31 developing countries to derive estimates for the key behavioral parameters of a small but complete model of a small and open developing economy. The model itself is innovative only in that expectations are formed rationally and that the severity of capital controls is treated as a structural feature of the economy that is subject to empirical estimation.

The estimates and test statistics presented above suggest that the model is not far off the mark as a framework for macroeconomic analysis of developing countries. Its estimated parameters, presented in Table 1, generally conform to standard economic theory, and in many cases approximate those that are available in the literature. Unsatisfactory results emerged only with regard to the economy’s supply function, and this suggests an important avenue for future research.

The most surprising result that emerged from the estimation was the verification of perfect effective capital mobility for this group of countries. Barriers to capital mobility would seem to be totally ineffectual. This result has important policy implications—that is, it suggests that little leverage can be exercised on domestic aggregate demand through monetary policy in these countries, even though the effects of changes in credit policy on the balance of payments may be substantial. This degree of capital mobility is consistent with the episodes of massive capital flight that have been observed in a number of developing countries in recent years. Finally, although we were able to estimate substitution elasticities fairly precisely, our estimated values were in many cases somewhat lower than available estimates. This interaction of low substitution elasticities, perfect capital mobility, and forward-looking behavior represents a possible framework within which to study the dynamic response of developing economies to both exogenous and policy shocks.

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Haque • Lahiri • Montiel


Dynamic Responses to Policy and Exogenous Shocks in an Empirical Developing Country Model with Rational Expectations

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SHOCKS EMANATING from domestic policies or from changes in the external economic environment in developing countries invariably set off a dynamic process of adjustment that frequently takes some time to work itself out. Although analysis of the macroeconomic effects of such shocks typically focuses on impact effects or on the eventual steady state at which the economy settles, it is the intermediate run— that is, the “real-time” effect of such shocks—that is often of equal if not even greater concern to policymakers in developing countries. While explicit dynamic solutions to small analytical models can yield valuable insights into particular aspects of the economy’s response to such shocks, general-equilibrium interactions can only be studied in the context of larger models that, unfortunately, do not often prove to be analytically tractable. Thus, numerical simulation experiments with dynamic macroeconomic models become the tool of choice for understanding the real-time effects of policy measures and external shocks in developing countries.

In such macroeconomic models, dynamic behavior may arise from a number of sources. The most familiar are partial adjustment of the endogenous variables and the formation of expectations. Whereas the assumption that agents’ expectations are formed rationally now pervades policy-oriented discussions involving macroeconomic problems in developing countries (see Corden (1989)), medium-sized dynamic macroeconomic models estimated under the rational expectations assumption are not available for such countries. Moreover, research on adjustment

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paths produced in response to policy and exogenous shocks in developing countries under rational expectations is not much advanced.¹

This paper builds on recent research by Haque, Lahiri, and Montiel (1990), in which a fairly small macroeconomic model for developing countries was specified and estimated under the assumption of rational expectations. Our purpose is to explore the model's implications for the economy's path of adjustment to the domestic policy shocks and changes in the external environment---on the assumption that expectations are formed rationally. We shall examine the dynamic effects of policy shocks—devaluation, expansionary fiscal policy, and an expansion of domestic credit—as well as of changes in external demand and in foreign interest rates.

The first section of the paper briefly describes the model and some of its more relevant properties. Section II examines the effects of the policy shocks, while the external shocks are analyzed in Section III. The final section summarizes the findings, focusing specifically on the role of expectations in determining the nature of the adjustment paths generated by the shocks.

I. The Model

The model that we intend to utilize in our simulation exercises represents a small open economy with a Mundell-Fleming production structure, a fixed exchange rate, perfect capital mobility, and continuous full employment. The model is presented in Appendix I, which also contains a definition of the variables. The parameters reported in Appendix I were estimated empirically, using an error-components three-stage least-squares technique, for a pooled cross-sectional time-series sample of 31 developing countries.² Its behavioral equations consist of conventional, widely used specifications, since the model was intended to provide "representative" developing country estimates of parameters that figure prominently in policy discussions. The parameters were estimated using

¹ The best-known macroeconomic simulation model for developing countries is by Khan and Knight (1981). That model is estimated and simulated with adaptive expectations. Haque, Montiel, and Symansky (1989) construct a developing country simulation model and use it to examine the dynamic effects of several policy and external shocks with forward-looking expectations. Agénor (1990) estimates and simulates a small rational expectations model for developing countries.

² Details of the estimation, including diagnostic statistics, are provided in Haque, Lahiri, and Montiel (1990). Since that paper also contains a detailed equation-by-equation description of the model, the exposition in this section will be brief.
a large pooled cross-sectional time-series sample of countries, a consistent data set, and appropriate empirical techniques. The Mundell-Fleming structure is typically adopted for empirical models of developing countries because of the difficulty of conforming the data to the traded-nontraded distinction required by the analytically preferable “dependent economy” framework. Fixed exchange rate arrangements are common among developing countries, and were even more so during the period of our sample. The empirical model was designed to test for the degree of effective capital mobility, and proved unable to reject the hypothesis of perfect capital mobility (that is, uncovered interest parity) for the group of countries in the sample. Finally, the full-employment assumption is controversial, but the question of the existence of Keynesian unemployment in developing countries arising from sluggish price adjustment is unsettled, and we have chosen to work with the polar case of complete price flexibility.

The behavioral equations of the model consist of standard empirical specifications, but one feature worth highlighting is the presence of the reserve-import ratio in the import demand function (equation (6) in Appendix I). This is a common specification in the developing country context and is meant to capture, albeit in a crude way, the importance of quantitative import restrictions based on foreign exchange reserves in developing countries (see Khan and Knight (1988)). As will be shown, this feature turns out to affect significantly both the dynamics of adjustment and the steady-state effects of shocks. Rational expectations enter the model in two ways. First, expectations of devaluation of the official nominal exchange rate enter the interest-parity condition (equation (11) in Appendix I), which determines the domestic nominal exchange rate. Second, the real interest rate, which affects both consumption and investment behavior and is given by equation (14)), is assumed to incorporate a rational forecast of the next period’s price level.

To better understand the policy simulations, it is useful to examine the steady-state version of the model, which is given in Appendix II. The model is here presented in recursive blocks, according to its solution algorithm, which works as follows: Since in this paper we work with steady states for which the nominal exchange rate \( e \) is fixed, we have \( E_t (e_t + 1 | \Omega_t) = e_{t + 1} = e_t \), where \( \Omega_t \) denotes the set of information available at time \( t \) and \( E \) is the expectations operator. Since the real exchange rate must be constant in the steady state, the domestic price level must

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3 As of June 30, 1989, 84 developing country members of the International Monetary Fund defended an exchange parity for their currencies; see International Monetary Fund (1989).
be constant also, so that \( E_t(P_{t+1} | \Omega_t) = P_{t+1} = P_t \). With these conditions, equations (13) and (16) of Appendix I yield the steady-state values of the domestic nominal \((i_t)\) and real \((r_t)\) interest rates, both of which equal the foreign nominal interest rate \(i^*\). These equations thus appear in block 1 of Appendix II. This solution for \( r \) derived from block 1, together with the use of the steady-state condition \( K_t = K_{t-1} \) for the capital stock in equation (9) of Appendix I, permits block 2 (consisting of equations (5), (8), and (9) of Appendix I) to be solved for real GDP, \( Y \), the capital stock, \( K \), and investment, \( I \). The solutions will take the form \( Y = Y(i^*), K = K(i^*), \) and \( I = I(i^*) \), with \( Y', K', I' < 0 \).

The third block contains the monetary equations (10), (11), and (12). The steady-state version of equation (12) (equation (27) in Appendix II) reflects the conditions that \( Y_t = Y_{t-1} = Y(i^*) \), with its implication that the money supply \((M)\) is constant—that is, \( M_t = M_{t-1} \). Substituting equations (10) and (11) in this version of equation (27) yields

\[
\log \left( \frac{eR + DC_P + DC_G}{P} \right) = \beta_0 + \beta_1 i^* + \beta_2 Y(i^*), \tag{36}
\]

where \( R \) is the foreign currency value of international reserves and \( DC_P \) and \( DC_G \) denote central bank credit to the private and public sectors, respectively. Since \( e, Y, i \) are determined in blocks 1 and 2, respectively, and since \( e, DC_P, \) and \( DC_G \) are exogenous, this equation contains only two endogenous variables—\( R \) and \( P \). To display the solution of the steady-state model diagrammatically, we can depict the combinations of \( R \) and \( P \) that satisfy equation (36) as the locus \( MM \) in Chart 1. The slope of this locus is

\[
\left. \frac{dR}{dP} \right|_{MM} = M/eP > 0.
\]

The remainder of the model is grouped into the fourth block, which we have termed the demand block. Using equations (14), (15), and (17) of Appendix I in equation (30) of Appendix II, we can rewrite private disposable income \((Y^d)\) as

\[
Y^d = Y + \frac{eP^*Z}{P} - (G + X),
\]

where \( P^* \) is the level of foreign prices, \( Z \) is the volume of imports measured in units of the foreign good, \( G \) is real government spending, and \( X \) denotes real exports. Substituting this in equation (2) and then using equations (2), (6), (7), and (9) in equation (1), we have
Chart 1. Solution of the Steady-State Model

\[ Y(i^*) = c \left\{ i^*, Y(i^*) + \frac{eP^*}{P} Z(eP^*/P, Y(i^*), R/P^*) \right\} \]
\[ + I(i^*) + G + X(eP^*/P, Y^*) \]
\[ - \frac{eP^*}{P} Z \left( \frac{eP^*}{P}, Y(i^*), \frac{R}{P^*} \right). \]  

(37)

Since \( e, G, i^*, \) and \( Y^* \) are exogenous, this equation only contains the endogenous variables \( R \) and \( P \). Block 4 therefore also generates a locus in \((R, P)\) space, which is given by equation (37). This locus is denoted by \( DD \) in Chart 1. Its slope is negative, that is,

\[ \left. \frac{dR}{dP} \right|_{DD} = - \frac{Z(\eta X/Z + \eta_r - 1)}{dZ/dR} < 0, \]
where \( \eta_x \) and \( \eta_z \) are the relative price elasticities of exports and imports, respectively.

The key endogenous variables in the steady-state version of the model are thus the stock of international reserves \( R \) and the domestic price level \( P \). The solution of the model is depicted by the intersection of the MM and DD loci at point A in Chart 1. The model’s exogenous variables consist of policy variables, namely, the nominal exchange rate, \( e \), the stocks of credit to the private and government sectors, respectively, \( DC_p \) and \( DC_C \), and government spending on home goods, \( G \), as well as external variables, consisting of the external interest rate, \( i^* \), foreign demand, \( Y^* \), and the foreign price, \( P^* \). Once the solution values for \( R \) and \( P \) are determined as in Chart 1, the values of the remaining endogenous values in block 4 (that is, \( C, X, Z, Y^d, F_P, CA, \) and \( GZ \)) can be found.

The stability of the steady-state equilibrium at \( A \) can be verified by computing the model’s characteristic roots. We computed these roots by using the parameter estimates in Appendix I and linearizing around an artificial steady state generated by values of the exogenous variables intended to capture a “representative” developing country configuration. We found a single root with modulus above unity. Since our model contains a single “jump” variable (the domestic price level), it thus exhibits saddlepoint stability (see Blanchard and Kahn (1980)).

Having described the nature of the steady state and established the model’s stability, we now examine the adjustment paths. In the next section we examine responses to shocks in the domestic policy variables—the exchange rate, the stock of credit, and government spending on domestic goods. Then Section III looks at the dynamic effects of shocks in the external environment—specifically, changes in world interest rates and foreign demand.

II. Dynamic Responses to Policy Shocks

Before considering the simulated economy’s response to domestic policy shocks individually, it may be useful to verify the model’s neutrality by examining the effects of a particular combination of nominal shocks—that is, an equiproportional exchange rate devaluation and an increase in both (private and public) domestic credit stocks. Notice that an \( x \) percent increase in \( e, DC_p, \) and \( DC_C \) would continue to satisfy equation (36) if \( P \) also increased by \( x \) percent. The same is true of equation

4 The roots were computed through the subroutine LIMO in TROLL.
(37), where $DC_p$ and $DC_G$ do not appear. Thus, the model is homogeneous of degree one in $e$, $DC_p$, and $DC_G$—since all nominal values change in the same proportion, real variables are unaffected, and the model's neutrality is verified. In terms of Chart 1, both the $MM$ and $DD$ loci shift to the right by $x$ percent, increasing the equilibrium price level by this amount, but leaving the equilibrium stock of reserves and all other real variables unchanged.

**Devaluation**

A neutral shock in this model is one in which the nominal exchange rate and the credit stock are changed in the same proportion. An exchange rate change by itself (a devaluation coupled with unchanged domestic credit targets) is therefore not a neutral shock. For our first exercise we consider a nominal exchange rate devaluation of 10 percent. The steady-state effects of this shock are depicted in Chart 2. Since the stock of domestic credit does not affect equation (37), the $DD$ curve shifts horizontally to the right, say to $D'D'$, in proportion to the devaluation (by 10 percent), as in the case of the neutral shock. Because $DC_p$ and $DC_G$ are unchanged, however, the proportional shift in $MM$, which can be derived from equation (36), amounts to

$$
\frac{dP}{de} \bigg|_{MM} \hat{e} = \frac{R/P}{M/P^2} \hat{P} \hat{e} = (eR/M) \hat{e} < \hat{e},
$$

since $eR/M < 1$.5 Thus the shift of $MM$ to $M'M'$ in Chart 2 falls short of the neutral shift. As a result, the steady-state stock of reserves increases (which presumably motivated the devaluation in the first place) and the steady-state real exchange rate depreciates.

The long-run real depreciation comes about through the effect of reserve accumulation on the intensity of import restrictions. This can be verified from equation (37). An increase in the stock of reserves increases imports by reducing the severity of such restrictions, and since this diverts demand from domestic to foreign producers, it has a contractionary impact which must be offset by a lower domestic price level.6 This is the intuition behind the negative slope of $DD$ in Chart 1. In the absence of this mechanism, the increase in the stock of reserves would not affect demand, and the $DD$ curve would be vertical. In this case, as can be

5The symbol "\( \cdot \)" denotes a proportionate rate of change.
6For an analysis of the aggregate demand effects of import restrictions in developing countries, see Ocampo (1987).
verified from Chart 2, the domestic price level would increase fully in proportion to the devaluation, that is, the steady-state real exchange rate would be unchanged. Because of the larger increase in the domestic price level in these circumstances, the steady-state stock of reserves would also be larger.

It may be worth pointing out that the only endogenous variables whose steady-state values are affected by devaluation are those determined in blocks 3 and 4 of Appendix II. Specifically, real output, which emerges from block 2, is not affected. Thus devaluation is neither expansionary nor contractionary in the long run. The reason is that the domestic real interest rate, which determines the capital stock, continues to be determined by the unchanged foreign interest rate. Thus, the output effects of devaluation are temporary, appearing only during the process of adjustment.

We now examine the dynamics of adjustment, considering first the case when the devaluation is unanticipated, and then when it is anticipated.
Unanticipated Devaluation

On impact, devaluation creates an incipient excess demand for domestic goods through substitution effects. Since output is supply constrained, this implies an increase in the domestic price level in the first period. However, the price level cannot immediately settle at its new steady-state level. If it did, the commodity market would not clear in the first period, because the real depreciation implied by the steady-state price increase leads to increased exports (equation (6)) and reduced imports (equation (9)). Thus, the trade balance improves. Since the domestic real interest rate would be unchanged (given that the price level would be expected to remain at its steady-state level), output, consumption, and investment would also be unchanged. From equation (1), an improvement in the trade balance with unchanged output and absorption would result in an excess demand for domestic goods.

On impact, therefore, the domestic price level must overshoot its steady-state value (see Chart 3, panel A). This promotes equilibrium in the commodity market in two ways—since the movement in the real exchange rate is dampened, the trade balance improvement is muted. Also, since the price level will now be expected to fall, the domestic real interest rate will rise, as shown in Chart 3, panel D. This chokes off both consumption and investment demand.

The expected reduction in the domestic price level mentioned above materializes in the next period (as it must, under rational expectations) because the economy is then subjected to a deflationary shock in that period. The first-period price increase raises the demand for money, giving rise to a capital inflow and a reserve gain that exceeds the steady-state increase in the stock of reserves (shown in Chart 3, panel C). This first-period reserve gain induces the authorities to permit an easing of import restrictions in the second period, and the resulting increase in imports diverts demand away from domestic goods, causing the price level to fall below its steady-state level (Chart 3, panel A). Since the nominal interest rate continues to be held in place by the interest parity condition, and since no further price decreases are forthcoming, the real interest rate falls sharply—to below its steady-state value—in the second period (Chart 3, panel D).

After the second period, the economy remains close to its steady-state
Chart 3. Unanticipated Devaluation (first period)

Panel A: Percent deviations
Panel B: Percent deviations (right scale)
Panel C: Level deviations
Panel D: Level deviations

Note: All panels reflect deviations from the steady state.
configuration, with the small deviations from that configuration being eliminated very gradually. The price level gradually rises (keeping the real interest rate below its steady-state value), then overshoots its steady-state level, gradually approaching that level from above. In consequence, the real interest rate also moves to its steady-state level from above (Chart 3, panel D).

The behavior of real output during the adjustment period merits particular attention. The first-period increase in real interest rates reduces investment, causing the capital stock to decline. Output therefore falls (Chart 3, panel B)—that is, devaluation has a contractionary effect on output in the short run. This contractionary effect is fundamentally brought about by the price level overshooting and its incorporation into the domestic real interest rate via rational expectations. This result underlines the importance of dynamic analysis and expectational phenomena in assessing the macroeconomic impacts of devaluation (see Lizondo and Montiel (1989)). As the real interest rate falls below its original (and final) level in the second period, investment recovers. However, the capital stock remains below its steady-state level, and so does real output. As the capital stock begins to increase, output recovers (Chart 3, panel B), but before it reaches its steady-state level, the real interest rate overshoots, thus depressing investment and again causing the capital stock to decline. Real output follows the capital stock, which implies that output recovers its steady-state value from below (Chart 3, panel B). In sum, devaluation causes real output to decline in the short and medium terms in this model, primarily because of its short-run impact on domestic real interest rates.8

**Anticipated Devaluation**

The anticipation of a future devaluation will itself have macroeconomic effects in this model. To investigate these, we simulated the effects of a devaluation that is expected to—and actually does—take place in the second period of the simulation. The steady-state outcomes are, of course, the same as in an unanticipated devaluation, since they are independent of the initial conditions when the devaluation is implemented. Because of the forward-looking expectations, however, the macro effects of the devaluation begin to be felt when the expectations are formed, rather than when the devaluation actually takes place. These effects are summarized in Chart 4.

8This result is sensitive to the assumptions of perfect wage-price flexibility and perfect capital mobility. For an analysis directed specifically to these issues, see Haque and Montiel (1990).
Chart 4. Anticipated Devaluation

(Second period)

Panel A

Percent deviations

Panel B

Percent deviations

Panel C

Level deviations

Panel D

Level deviations

Note: All panels reflect deviations from the steady state.
Since domestic interest rates are determined by the uncovered interest parity condition, the expectation of a 10 percent devaluation in the next period immediately raises the domestic nominal interest rate in the first period by an equivalent amount. Since the devaluation is also expected to raise the domestic price level when it is implemented, however, domestic real interest rates do not rise by this amount. As shown in the previous section, a nominal devaluation results in a real devaluation both on impact and in the steady state in this model. Thus domestic prices are expected to rise by less than the rate of devaluation, and this expected real depreciation means that the domestic real interest rate will rise (though by substantially less than the nominal rate) in the first period (Chart 4, panel D). As a result, both domestic consumption and investment are discouraged, and the domestic price level falls in the first period (Chart 4, panel A). The reduction in domestic investment causes the capital stock to fall, which reduces output (Chart 4, panel B)—that is, the mere expectation of devaluation is itself contractionary in its effects on real output.

The combination of higher domestic nominal interest rates, lower real output, and lower domestic prices lowers the nominal demand for money, giving rise to a capital outflow and associated reserve loss (Chart 4, panel C). Thus, the expectation of devaluation in the model permits us to simulate an episode of capital flight. When the devaluation takes place, this capital flight is reversed. The nominal interest rate falls, returning to its original level, and domestic prices rise (Chart 4, panel B) for the reasons described in the preceding subsection. Though real output continues to fall, this effect is slight in comparison. Thus the demand for money increases, motivating the reflow of capital, and causing reserves to rise sharply (Chart 3, panel C). From this point on, the dynamics reproduce those of an unanticipated devaluation.

Though it is not obvious from a comparison of the A panels in Charts 3 and 4, the initial price increase in the period when the devaluation is actually implemented is greater when the devaluation was previously anticipated than when it comes as a surprise. The reason is that the loss of reserves brought about by capital flight in anticipation of devaluation implies the presence of tighter import restrictions when the devaluation was anticipated than when it comes as a surprise. Imports are thus lower when devaluation was anticipated, and domestic demand pressures are consequently higher.

**Government Spending Shock**

In this subsection we consider the effects of an increase in government spending on domestic goods, financed by an equivalent reduction in
government imports. We analyze three cases: an unanticipated permanent increase in spending, an increase in spending that is expected to occur in the future and be permanent, and an unanticipated increase in spending that is transitory in nature.

**Unanticipated Permanent Spending Increase**

The steady-state effects of an increase in government spending on home goods are depicted in Chart 5. Since the level of government spending on such goods affects only the demand block (equation (37)) and not the monetary block (equation (36)), only the DD curve is affected. Because the change in the spending mix is expansionary, the domestic price level must increase at a given value of $R$—that is, the DD curve must shift to the right, while the $MM$ curve is stationary. The new equilibrium will thus be found at a point like $B$, with higher reserves and a higher domestic price level. In other words, the shock will result in a real exchange rate appreciation. Reserves increase because the higher domestic price level increases the demand for money. Since the spending increase on home goods is financed by curtailing government imports and not by domestic credit expansion, the increased demand for money can be satisfied only by a reserve inflow.

This reserve inflow tends to mute the inflationary consequences of the spending shift, because the relaxation of import restrictions that it entails shifts private demand away from domestic products, thus in part offsetting the shift of government demand toward such products. In the absence of this effect the $DD$ curve would be vertical in Chart 5, and $D'D'$ would pass through the point $D$ on $MM$. Thus the new steady state would exhibit both higher prices and larger reserves than that at $B$.

It may be worth noting that the spending shift has no effect on domestic interest rates or output in the long run. Again, this is a consequence of the interest parity condition and the determination of output in block 2 (Appendix II), which is unaffected by the composition of government spending.

The dynamics of adjustment are similar in many ways to those of an unanticipated devaluation. The shock increases domestic demand on impact, and therefore results in a price increase (panel A of Chart 6). Although, as shown above, domestic prices also rise in the steady state, the price increase on impact must exceed its steady-state value. The reason is that in the first period import restrictions are unchanged, whereas in the steady state such restrictions are eased owing to the higher steady-state stock of reserves. Since this easing relieves domestic demand pressure, the price increase needed to clear the home commodity market...
is greater in its absence. The higher domestic price level induces a first-period capital inflow, increasing the stock of foreign exchange reserves (Chart 6, panel C). Prices must fall in the second period, as the higher first-period reserve stock leads to an easing of import restrictions. Because rational agents expect this to happen, the first-period domestic real interest rate rises dramatically (Chart 6, panel D). This crowds out investment and depresses output, so the increase in government spending on home goods is actually contractionary on impact (Chart 6, panel B).

As already mentioned, prices fall in the second period. However, this decrease still leaves the price level above its steady-state level (Chart 6,
Chart 6. Unanticipated Permanent Fiscal Shock

Panel A: Percent deviations
Panel B: Percent deviations
Panel C: Level deviations
Panel D: Level deviations

Note: All panels reflect deviations from the steady state.
panel A). This occurs because, owing to slow adjustment of exports and imports, a larger real appreciation is necessary in the short run to clear the home goods market with the increase in government demand than is necessary in the steady state. Because prices remain relatively high in the second period, the real interest rate remains slightly above its steady-state level (Chart 6, panel D), thus continuing to exert a depressing influence on domestic investment. By the third period, the domestic price level has fallen below its steady-state value, which it thereafter approaches from below. Since the price level is gradually rising, therefore, the domestic real interest rate also approaches its steady-state value from below.

The dynamic path of real output is governed by the effects of the real interest rate path described above on investment and thus on the domest­ic capital stock. After the initial drop in output, recovery sets in as the depleted capital stock stimulates a temporary increase in investment. Though investment remains slightly above its steady-state value for some time after the initial two periods, it takes time to restore the capital stock, so output remains below its equilibrium value, though on a rising trend, in the medium term (Chart 6, panel B). In this model, therefore, the spending shift induces a dynamic response on the part of real output that can be described as contractionary in both the short run and the medium term, but with no change in the long run.

Anticipated Permanent Spending Increase

The anticipation of a future increase in government spending on domes­tic goods has macroeconomic consequences before the spending shifts come into play. These are brought about through the implications of such expectations for the domestic real interest rate. As shown above, the shift in spending will increase domestic prices on impact. The expectation of these higher future prices lowers the real interest rate in the first period, since arbitrage holds the nominal interest rate at its initial level (Chart 7, panel D). Lower real interest rates stimulate both consumption and investment demand, thereby causing an immediate increase in the domestic price level (Chart 7, panel A), which is accompanied by a capital inflow and an accumulation of foreign exchange reserves (Chart 7, panel C). The higher level of investment increases the capital stock, raising real output in the first period (Chart 7, panel B). The anticipated spending shift thus has expansionary output effects before the shock itself actually takes place.

When the spending shift occurs (in the second period), prices rise further and the real interest rate increases sharply (Chart 7, panels A and D). These results are the same as observed when the spending shift is
Chart 7. Anticipated Fiscal Shock
(Second period)

Panel A
Percent deviations

Panel B
Percent deviations

Panel C
Level deviations

Panel D
Level deviations

Note: All panels reflect deviations from the steady state.
unanticipated. However, comparison of panels A in Charts 6 and 7 indicates that the price level effect of the shift at the instant it occurs is greater when it is not anticipated than when it is. The mechanism that produces this result is similar to that described in connection with devaluation—that is, the reserve increase in anticipation of the spending shift causes the latter to take place with less stringent import restrictions. The higher level of imports absorbs some of the demand pressure, muting the effect on prices. After the change in government spending is in place, the dynamics are again qualitatively similar to those that follow an unanticipated spending shift.

Temporary Government Spending Increase

The dynamics of a temporary shift in government spending toward home goods are given in Chart 8. We have assumed that the shock takes place one period ahead and remains in place for five periods, after which it is completely removed. Notice that in this case the economy must return to its initial steady-state configuration, because the shock is not permanent.

For the period that the shock is announced (or becomes anticipated), and through the first two periods of the shock's duration, the economy's dynamic responses are qualitatively very similar to the case of an anticipated permanent fiscal shock, described above. Quantitatively, however, comparison of panels A and D in Chart 8 to panels A and D in Chart 7 reveals that with the transitory shock the initial burden of demand adjustment falls relatively less heavily on the price level and more heavily on the real interest rate—that is, the peak increase in the price level is smaller in the present case than in the case of the permanent shock, and the opposite is true of the real interest rate.

The forward-looking nature of expectations is the reason. When the spending shift is reversed at the end of the sixth period, domestic prices must fall (this corresponds to the lowest point for $P$ in Chart 8, panel A). In anticipation of this, the real interest rate must be high in the previous (the fifth) period. But because demand is being restrained by the high real interest rate in that period, the price level can be correspondingly lower. This lower price level, in turn, sustains a high (but not quite as high) real interest rate in the previous (the fourth) period, and so on. Thus, the real interest rate remains above its steady-state level while the shock is in place, and indeed rises toward the end of the shock (Chart 8, panel D), while the price level falls increasingly below its own steady-state level—despite the exogenous increase in demand for domestic goods represented by the spending shift—for the duration of the shock. For the last
Chart 8. Temporary Fiscal Shock

(Five-period)

Panel A: Percent deviations

Panel B: Percent deviations

Panel C: Level deviations

Panel D: Level deviations

Note: All panels reflect deviations from the steady state.
three periods of the shock, the burden of demand restraint falls increas­
ingly on the real interest rate and decreasingly on the price level. When
the shock is removed, the price level and the real interest rate both fall,
the latter in anticipation of a price level recovery in the subsequent
period, when further demand shocks are anticipated. Reserve dynamics
follow the path of prices (Chart 8, panel C), while the behavior of output
is governed by the spell of high real interest rates that accompanies the
fiscal shock while it is in place (Chart 8, panels D and C).

**Domestic Credit Shock**

The final policy shock examined is a permanent increase in the stock
of domestic credit to the private sector, announced and implemented
simultaneously in the first period. Since this economy is characterized by
perfect capital mobility—in the sense that uncovered interest parity holds
continuously—the standard “monetary approach to the balance of pay­
ments” (MABP) analysis would suggest that the credit expansion would
displace an equivalent amount of reserves in the central bank’s balance
sheet, leaving all else unaffected. This does not happen in the model
under examination, however, because of the role of the reserve stock in
determining the severity of import restrictions—that is, because the au­
thorities look at their own gross stock of reserves when setting the degree
of import restrictions.\(^9\) Thus the reserve outflow caused by a credit expan­
sion gives rise to an increase in the severity of import restrictions, which
produces long-lasting macroeconomic effects.

This increase is illustrated for the steady-state configuration in Chart 9.
Since \(DC_p\) only appears in equation (36), only the locus \(MM\) is affected
by the credit expansion. Since (36) would continue to hold if \(edR = -dDC_p\),
the \(MM\) locus shifts downward by the amount of the credit
expansion, to a point like \(C\) at the original domestic price level \(P_0\). The
consequent loss of reserves at \(C\), amounting to \((R_0 - R_2)\) in Chart 9, is
what would be observed under the MABP, since without the feedback
from reserves to imports the locus \(DD\) would be vertical, passing through

\(^9\) Under perfect capital mobility, one might question why they should do so,
since a reserve target could readily be attained by altering the stock of domestic
credit, thereby inducing private capital flows that would permit achievement of
a reserve target. Implicitly, it is assumed that the authorities face constraints—
perhaps in the form of imperfect control over the supply of domestic credit—that
do not permit credit policy to be flexibly adjusted to this end. An alternative
specification—in which import restrictions depend on the sum of the foreign
exchange held by the central bank and the private sector (which might be more
reasonable when capital mobility is high)—is explored in a separate paper (see
Haque and Montiel (1990)).
both $A$ and $C$ and resulting in a new steady-state equilibrium at $C$. In this model, however, the loss of reserves triggers a tightening of import restrictions. This shifts demand toward the domestic good, raising the domestic price level and thereby containing the loss of reserves. This mechanism results in a new steady-state equilibrium at $B$, rather than $C$, with both reserves and output higher than would be observed under the MABP, but nevertheless with lower reserves and higher prices than without credit expansion.

The dynamics of adjustment to the new steady state at $B$ are rather simple, and are depicted in Chart 10. The initial credit expansion generates a capital outflow that results in a loss of reserves (panel C). Since this loss will induce a tightening of import restrictions in the next period, domestic prices will rise at that time, in anticipation of which the first-period real interest rate falls (panel D). But this decline in the real interest rate stimulates domestic consumption and investment, which means that
Chart 10. Credit Shock

Panel A: Percent deviations

Panel B: Percent deviations (right scale)

Panel C: Level deviations

Panel D: Level deviations

Note: All panels reflect deviations from the steady state.
domestic prices must also rise on impact (panel A). Because investment has risen, the capital stock increases, and output rises (panel B). Thus the credit increase works through a reduction in the real interest rate to exert expansionary effects on both domestic prices and output on impact.

As the import restrictions take hold in the second period, domestic prices rise as expected (panel A). Reserves consequently recover somewhat (panel C). The price level must overshoot its steady-state value in the second period, because short-run trade elasticities are smaller than long-run elasticities, requiring a larger real appreciation to clear the domestic goods market. Since the price level will be expected to fall from this point, the real interest rate exceeds its steady-state value in the second period (panel D). This recovery in the real interest rate depresses investment and halts the output expansion (panel B). From this point, the price level and the real interest rate begin to fall toward their steady-state values, with international reserves following domestic prices owing to the impact of the latter on money demand.

III. Dynamic Responses to External Shocks

The economy modeled in Appendix I is affected by changes in both foreign interest rates and incomes. Because the country is small and uncovered interest parity holds continuously, the fixed nominal exchange rate implies that the domestic nominal interest rate must adjust to the nominal interest rate that prevails externally. Also, since domestic output is an imperfect substitute for the output of the rest of the world, foreign incomes affect the foreign demand for domestic output. In this section we examine the effects of unanticipated permanent shocks in both of these variables, forgoing the analysis of anticipated or transitory shocks to avoid taxonomy.

Permanent Increase in External Interest Rate

Unlike the previous shocks, an increase in the external interest rate affects both of the steady-state loci described above, because the foreign interest rate enters both equations (36) and (37). An increase in \( i^* \) reduces the real demand for money, requiring an increase in the price level to clear the money market, thus causing \( MM \) to shift to the right, to a position such as \( M'M' \) in Chart 11. At the same time, the increase in \( i^* \) has contractionary effects on the demand for domestic output, so \( DD \)

\[ \text{(36)} \]

\[ \text{(37)} \]

\[ \text{(38)} \]

\[ \text{(39)} \]

\[ \text{(40)} \]

\[ \text{(41)} \]

10 A third link to the rest of the world, through foreign prices, is also present in the model. However, we will not describe the effect of shocks to this variable.
shifts to the left, to a position such as $D'D'$ in Chart 11. The steady-state effect on international reserves is theoretically unambiguous—they must fall, as depicted in Chart 11. On the other hand, while the effect on domestic prices is ambiguous in theory, our estimated parameters and reference data imply that the domestic price level must fall—that is, the equilibrium real exchange rate depreciates, because the downward shift in the $DD$ curve exceeds that in the $MM$ curve. Incidentally, notice that this is the result that would in any case emerge if $DD$ were vertical—in other words, if the effect of reserves on import restrictions were absent from the model.

It is worth noting as well that in this case, unlike all the others analyzed in this paper, the long-run level of output is affected. The increase in the steady-state interest rate depresses investment, which in turn implies a
reduction in the size of the capital stock that can be maintained in the long run, and consequently in the level of output produced.

The dynamics of adjustment to the new steady-state equilibrium are again rather simple. Since no devaluation is anticipated, the domestic nominal interest rate adjusts immediately to the new level of the external rate. Because of lags in the response of domestic absorption to a change in the real interest rate, however, the price level cannot adjust immediately to its new lower steady-state value. If it did so, a state of excess demand would exist in the domestic commodity market, since domestic absorption would remain in excess of its steady-state level. Thus, the price level must fall in the first period, but not all the way to its steady-state value. Since reserves fall in the first period, following domestic prices (Chart 12, panel C), import restrictions are tightened in the second period, causing a slight increase in the price level. Because this increase is anticipated in the first period, the increase in the first-period domestic real interest rate falls short of its steady-state value. On impact, therefore, both prices and the real interest rate move partially toward their steady-state value.

Since domestic prices resume their downward adjustment after the second period, the real interest rate must overshoot its steady-state value from the second period onward (Chart 12, panel D). Adjustment in both prices and the real interest rate is monotonic and quite prolonged. As in previous cases, the behavior of real output follows that of the real interest rate. Output falls sharply on impact and in the second period. It continues to fall gradually to its lower steady-state value, as the prolonged duration of high real interest rates depresses investment and gradually depletes the capital stock. This shock is contractionary on impact, during the transition, and in the long run.

**An Increase in External Demand**

An increase in external demand ($Y^*$ in Appendices I and II) affects the demand block (block 4) in the steady-state model, but not the monetary block (block 3). An increase in export demand is expansionary, requiring an increase in domestic prices at a given value of $R$ to restore equilibrium in the domestic commodity market. Thus the $DD$ curve shifts to the right. Qualitatively, the situation is similar to that arising from a permanent shift in government spending toward home goods depicted in Chart 2—international reserves rise and the real exchange rate appreciates in steady state.

The dynamics of adjustment take on a now familiar form. Prices rise on impact, reflecting the expansionary demand stimulus from abroad.
Chart 12. Foreign Interest Rate Shock

Panel A: Percent deviations
Panel B: Level deviations (right scale)
Panel C: Trade balance
Panel D: Level deviations

Note: All panels reflect deviations from the steady state.
The real interest rate shows a small initial increase, reflecting an anticipated reduction in the price level in the second period owing to an easing of import restrictions induced by a first-period reserve gain (Chart 13, panel C). Owing to partial adjustment in the export function, the demand stimulus arising from the increase in foreign income builds gradually over time to its steady-state level. Since this source of demand pressure thus rises over time, domestic prices must follow a rising trend after the second period. This means that the real interest rate must lie below its steady-state value during this time (Chart 13, panel D). The requirement that the domestic price level rise to its steady-state value explains why the second-period level of prices must be below that value (panel A). Finally, even after the adjustment of exports to the (once and for all) foreign demand shock is effectively complete, adjustment lags in the export and import functions imply that the trade balance will not have fully adjusted to past price changes. Thus the domestic price (and consequently the real interest rate as well) must slightly overshoot its steady-state level, approaching that level from above.

The dynamics of reserves and real output follow those of prices and the real interest rate, respectively. Reserves rise on impact and decrease slightly (following the price level) in the second period, recovering gradually thereafter in close similarity to the path of the domestic price level (panel C). Output falls in the short run, owing to the effect of the higher domestic real interest rate on the capital stock. As the real interest rate falls below its steady-state level and remains there for a prolonged period, however, investment and the capital stock recover, pushing output toward its steady-state level (Chart 13, panel B). The overshooting of the real interest rate causes investment to once again fall below its steady-state value, bringing the expansion of output to a halt. Investment and output gradually recover their steady-state levels from below.

**IV. Summary and Conclusions**

In each of the simulations described above, the dynamic response of the economy to a shock emerges from the interaction of several important features of the model employed. These features include price flexibility, rational expectations, perfect capital mobility, and endogenous import restrictions. The qualitative properties of the adjustment paths generated by the shocks we have studied depend on these properties, and are not very sensitive to parameter values (such as response speeds in the behavioral equations) that leave these features unchanged. At the most general level, therefore, we offer the following conclusion. Properties of developing country economies about which no consensus currently exists
Chart 13. External Demand Shock

Panel A: Percent deviations
Panel B: Level deviations
Panel C: Trade balance
Panel D: Percent deviations (right scale)

Note: All panels reflect deviations from the steady state.
among knowledgeable observers (that is, the degree of wage-price flexibility, the extent of capital mobility, etc.) are crucially important for determining the "real-time" response of such economies to both policy and exogenous shocks. While a convergence of views may emerge about certain steady-state properties of developing country models—for example, that expectations should be correct, prices flexible, and capital mobility perfect—they tell little about the process of adjustment.

This conclusion has important implications for both policy and research on developing country macroeconomics. Regarding policy, the implication is that the state of our knowledge of most developing countries suggests that real-time macroeconomic "fine-tuning" is likely to be very difficult, because the dynamic responses of the system to the policies one might choose to administer will in most cases be highly uncertain. Regarding research, the obvious suggestion is that much needs to be learned about the empirical relevance in particular developing economies of structural features such as those listed above that proved to be critical in determining the nature of adjustment paths in our model. The empirical approach adopted in Haque, Lahiri, and Montiel (1990) yields evidence about the degree of capital mobility, while maintaining the hypotheses of price flexibility and rational expectations. More research is needed on both of the latter. However, given data limitations in developing countries, progress is likely to be slow.

In the meantime, the relevance of the particular substantive results derived in our simulations depends, of course, on one's readiness to accept these maintained hypotheses. Conditional on their validity, some of our salient findings are as follows:

- The speed of adjustment, even to permanent shocks that are perceived as such, can differ markedly across shocks. In the case of devaluation and a permanent shift in government spending, for example, after three years the economy is essentially in the vicinity of its steady state. By contrast, adjustment to an external interest rate shock is quite protracted.
- As is familiar in rational expectations models, the macroeconomic effects of shocks depend on whether they are anticipated or not. In this model, an important difference between anticipated and unanticipated shocks is that, in the context of endogenous import restrictions, the degree of severity of the restrictions in place when the shock actually occurs depends on whether the shock had previously been anticipated.
- As is also familiar from such models, shocks begin to exert macro-

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11 This is confirmed in Haque and Montiel (1990), where the dynamic effects of devaluation are shown to be highly sensitive to features of this type.

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economic effects when they first become anticipated, rather than when they actually occur. This is particularly evident with devaluation, where the anticipation of an impending change in the exchange rate gives rise to capital flight, which in turn causes a tightening of import restrictions that later increase the price level effects of devaluation.

- Output dynamics suggest that it is meaningless to ask whether particular shocks are contractionary unless the time frame is specified. With devaluation, for example, we found a contractionary effect in the short run, but no effect in the long run.

- Finally, endogenous import restrictions were found to have important effects, not only on the dynamics, but also in the steady state. Because of such restrictions, a nominal devaluation results in a long-run real depreciation in our model, and changes in the stock of domestic credit have real effects, even with perfect capital mobility.

These conclusions, while conditional on the specified model and the form of the simulation experiments, may not appear particularly controversial. Nonetheless, without a model at hand of the type we have employed, they would be difficult to verify. Certainly understanding the time paths taken by the key macroeconomic variables after a shock would be out of the question. The next stage in the exercise could be the derivation of the paths of the policy variables, taken either individually or in a combination, to achieve the desired impact, transition, and steady-state values of the target variables—output, balance of payments, prices, real exchange rate, etc. The model we have developed and analyzed can be readily used toward such an end.

References


APPENDIX I

Structure of the Dynamic Model

\[ Y_t = C_t + i_t X_t = \frac{e_i P_t^* Z_t}{P_t} + G_t \]  
(1)

\[ \log C_t = b_0 - 0.12 r_t + 0.99 \log C_{t-1} + 0.34 \log Y_{t}^d - 0.33 \log Y_{t-1}^d \]  
(2)

\[ Y_t^d = Y_t + i_t e_i \left( \frac{F_{P_t^*}}{P_t} - i_t \frac{DC_{P_t}}{P_t} - T_t \right) \]  
(3)

\[ Y_t^d = C_t + i_t \]

\[ = \left\{ (M_t - M_{t-1}) + e_i (F_{P_t^*} - F_{P_{t-1}^*}) - (DC_{P_t} - DC_{P_{t-1}}) \right\} / P_t \]  
(4)

\[ \log l_t = k_0 - 0.207 r_t + 0.199 \log Y_t + 0.815 \log K_{t-1} \]  
(5)

\[ \log X_t + \tau_t + 0.054 \frac{e_i P_t^*}{P_t} + 0.106 \log Y_t^d + 0.927 \log X_{t-1} \]  
(6)

\[ \log (e_i Z_{t/P}) = \delta_0 - 0.129 \log \frac{e_i P_t^*}{P_t} + 0.135 \log Y_t \]

\[ + 0.061 \log \frac{R_{t-1}^*}{P_{t-1}} + 0.847 \log \frac{e_{t-1} Z_{t-1}}{P_{t-1}} \]  
(7)

\[ \log Y_t + q_0 + 0.162 \log K_t + 0.838 \log L_t \]  
(8)

\[ K_t = I_t + 0.95 K_{t-1} \]  
(9)

\[ M_t = e_i R_t + DC_i \]  
(10)

\[ DC_i = DC_{P,i} + DC_{G,i} \]  
(11)
\[
\log \left( \frac{M_t}{P_t} \right) = \beta_0 - 0.055 i_t + 0.203 \log Y_t + 0.796 \log \left( \frac{M_{t-1}}{P_{t-1}} \right)
\]

(12)

\[
i_t = i^*_t + \frac{E_t e_{t+1} - e_t}{e_t}
\]

(13)

\[
CA_t + p_t X_t - e_t p_t^* Z_t + i^*_t e_t \left( F_{p,t-1} + F_{G,t-1} \right)
\]

(14)

\[
e_t \Delta R_t = CA_t - e_t \left( \Delta F_{G,t} + \Delta F_{p,t} \right)
\]

(15)

\[
r_t = i_t - \frac{E_t P_{t+1} - P_t}{P_t}
\]

(16)

\[
\Delta F_{G,t} - \Delta DC_{G,t} = P_t (T_t - G_t - (e_t P_t^*/P_t) G Z_t) + i^*_t e_t (F_{G,t-1} - i_t DC_{G,t})
\]

(17)

\[
e_{t+1} = E_t (e_{t+1} | \Omega_t)
\]

(18)

\[
P_{t+1} = E_t (P_{t+1} | \Omega_t)
\]

(19)

**Definition of Variables**

- **Y**: Real GDP
- **C**: Real private consumption expenditures
- **I**: Total real investment expenditures
- **G**: Government expenditure on domestic goods
- **X**: Real exports
- **e**: Nominal exchange rate (price of foreign currency in domestic currency terms)
- **P^***: Foreign currency price of imports
- **P**: Domestic currency price of domestic goods
- **Z**: Real imports in terms of foreign goods
- **r**: Real rate of interest
- **Y^d**: Real disposable income
- **F_p**: Stock of foreign assets held by the private sector (measured in foreign currency terms)
- **DC_p**: Stock of domestic bank credit held by the private sector
- **i**: Nominal interest rate
- **T**: Real taxes
- **M**: Money supply (nominal)
- **K**: Aggregate capital stock
- **Y^***: Real foreign income
- **R**: Reserves
- **DC**: Total domestic credit
- **DC_G**: Domestic credit to the public sector
- **CA**: Current account of the balance of payments
- **F_G**: Foreign assets held by nonfinancial public sector
- **L**: Population
APPENDIX II
Structure of the Steady-State Model

1. Interest Rates
   \[ i_t = i_t^* \]  
   \[ r_t = i_t \]  

2. Output-Capital Block
   \[ \log I = k_0 - 0.207 r + 0.199 \log Y + 0.815 \log K \]  
   \[ \log Y = q_0 + 0.162 \log K + 0.838 \log L \]  
   \[ I = 0.05K \]  

3. Monetary Block
   \[ M = eR + DC \]  
   \[ DC = DC_p + DC_o \]  
   \[ \log (M/P) = \beta_0 - 0.27 i + \log Y \]  

4. Demand Block
   \[ Y = C + I + G + X - eP^*Z/P \]  
   \[ \log C = \alpha_0 + 12 r + \log Y^d \]  
   \[ Y^d = Y + i^*F_p - i\frac{DCP}{P} - T \]  
   \[ \log X = \delta_0 + 0.74 \log(eP^*/P) + 1.45 \log Y^* \]  
   \[ \log Z = \delta_0 + 0.84 \log (eP^*/P) + 0.882 \log Y + 0.399 \log (R/P^*Z) \]  
   \[ CA = PX - eP^* (Z + GZ) + i^* (F_p + F_o + R) \]  
   \[ CA = 0 \]  
   \[ eP^*GZ = P(T - G) + i^* (F_o + R) + iDC_p \]
A Forward-Looking Macroeconomic Simulation Model for a Developing Country

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Macroeconomic policy in developing countries has received considerable attention in recent years as continuing external and internal imbalances have contributed to a slowdown in growth, balance of payments difficulties, and high inflation. Many countries have undertaken adjustment programs whose announced objectives have been to reduce external imbalances and to lower inflation while avoiding recession and enhancing medium-term growth. The consequences of such programs for income distribution have also received increased attention. Diverse macroeconomic targets such as these respond to policy and other shocks via fairly complex general equilibrium interactions. Thus, the analysis of the effects of policies on such variables, as well as of the trade-offs among conflicting macroeconomic targets confronted by policymakers, must necessarily be conducted by using reasonably detailed quantitative macroeconomic models. Existing quantitative models for developing countries are not well suited for exploring these issues, however, because they typically incorporate ad hoc behavioral relationships and generally provide inadequate treatment of expectations. The formation of expectations is generally modeled in a static or adaptive fashion, even though forward-looking expectations have by now become an important feature of macroeconomic analysis for developing countries.

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1 Existing policy-oriented models are also lacking in the latter respect (see Khan, Montiel, and Haque [1990]).

2 A number of examples can be cited in support of this assertion. Rational expectations have been used to explain short-run output determination in developing countries by Barro (1979), Edwards (1983a and b), and many others; to model consumption by Leiderman and Razin (1988), Haque (1988), and Haque and Montiel (1989); to explain hyperinflation by Dornbusch and Fischer (1986)
The purpose of this paper is to construct and analyze a small, but well-articulated and internally consistent, dynamic macroeconomic model for a representative developing country that relies on familiar macroeconomic theory and in which expectations are formed rationally. This model is intended to be suitable for the analysis of general equilibrium interactions among the key macroeconomic variables that typically concern policymakers in such countries. Our primary concern is to explore in which direction and through which channels policy variables that are typically addressed to correct external imbalances (fiscal, monetary, and exchange rate policies) affect other important macroeconomic variables such as real output, inflation, medium-term growth, and the real wage in a forward-looking model of a developing economy. Our model is a developing country model in the following senses: (1) it incorporates structural features commonly perceived relevant in such countries, such as the role of imported intermediate and capital goods in the production process, the absence of domestic equity or securities markets, and the presence of dual markets for foreign exchange; (2) the numerical values of its parameters are taken from available developing country estimates; and (3) it is simulated using data chosen to be representative of a "typical" developing country. This "core" model can be extended to analyze other phenomena that may be of interest to policymakers—for example, by incorporating a different commodity structure to permit analysis of the effects of terms-of-trade shocks, and by allowing a role for nominal wage contracts, thereby creating the scope for Keynesian unemployment.

The model is described in the first section. In Section II we study several illustrative simulation experiments, involving changes in policy variables and shocks related to the external economic environment. The key features of the model that govern the results of these simulations are analyzed. A concluding section summarizes the results and presents some possible directions for future research. The appendices contain a description of the parameter estimates used, an explanation of how the data were constructed for the simulations, and a simulation with an alternative expectations structure.

I. Model Specification

In this section we specify a relatively simple and familiar macroeconomic model of a small, open developing economy. Despite its simplicity, and others; to explain the behavior of dual exchange rates by many authors, including Kiguel and Lizondo (1986); and to model balance of payments crises by Connolly and Taylor (1984) as well as Blanco and Garber (1986).
the model captures several important macroeconomic characteristics found in many developing countries and incorporates a number of features that reflect the modern macroeconomic literature. In that sense, it is both a departure from, and an improvement on, the developing country models that are currently available.

It may first be useful to summarize some of the model's general features. It is built around a consistent accounting framework (that is, a set of budget constraints) that links the behavior of private agents, government, and a central bank. The behavior of private agents is described along familiar lines—the model includes features such as a permanent-income specification for consumption and a standard neoclassical investment function. It contains three key structural features of developing countries. First, in keeping with the observation that most developing countries maintain some form of capital controls, dual exchange rates have been introduced. A fixed exchange rate for current account transactions and public capital flows is assumed to be determined by policy, while a market-determined rate is applied to the private capital account on the assumption that the authorities do not supply foreign exchange at the official rate for capital transactions. There are no leakages between markets. Second, since for many developing countries a large component of imports tends to consist of capital goods and other inputs in the production process, the demand for imports of final goods is related to the composition of domestic absorption, and imported intermediate goods have been accorded a prominent role. Third, we have assumed that (central) bank credit is the only domestic interest-bearing financial asset and that there are no organized markets for equities or bonds. On the other hand, the model contains two features not typically found in developing country macro-models. For example, as indicated above, agents form their expectations rationally, and fiscal policy choices are made to obey an intertemporal budget constraint, in recognition of the solvency condition imposed by external creditors.

Prices

The model has a Mundell-Fleming structure, with one domestically produced good and one foreign good.\(^3\) The price of the foreign good in the home country, \(p^*\), is given by the law of one price:

\[
p^*_t = e_t p_t^f, \tag{1}
\]

where \(e\) is the official exchange rate and \(p^f\) is the price of the foreign good.

\(^3\)The model can easily be extended to a three-good (exportables, importables, nontraded goods) structure. However, to preserve clarity in this presentation, the more familiar two-good structure has been preserved.
in foreign currency terms. Denoting the price of the domestic good by \( p \), the real exchange rate (denoted by \( er \)) may be written as

\[
er_t = \frac{p^*_t}{p_t}.
\]  

Since both goods are used for consumption and investment, there are two price indices in the economy. The price of the consumption bundle, \( p_{c,t} \), is a weighted average of the domestic prices of foreign and home goods, with the weights depending on the share of imports in domestic consumption, \( p_1 \):

\[
p_{c,t} = p^*_t p_1^{(1 - p_1)}, \quad 0 < p_1 < 1.
\]  

Using the weight of imports in the capital stock, \( q_1 \), the price of capital (\( p_k \)) can be similarly written

\[
p_{k,t} = p^*_t q_1 p_1^{(1 - q_1)}, \quad 0 < q_1 < 1.
\]  

These price indices and the consumption, investment, and import behavior that follow reflect the assumption that both the instantaneous utility function for consumption and the implicit subproduction function that produces capital out of domestic and foreign goods are of the Cobb-Douglas type.

**Aggregate Supply**

Technology in our economy is represented by a Cobb-Douglas production function with three inputs: labor (\( L \)), capital (\( k \)), and imported materials (\( z_M \)). Assuming a constant growth rate (\( n \)) for the labor force from an initial normalized value of unity, the aggregate production function for the economy, in logarithmic form, can be written as follows

\[
\log y_t = \alpha_0 + \alpha_1 nt + \alpha_2 \log k_t + \alpha_3 \log z_{M,t},
\]  

where \( y \) is gross domestic output. The \( \alpha_i (i = 1, 2, 3) \) are positive and sum to unity. They represent the shares of each of the three inputs in domestic output.

The demand for imported materials is derived from the first-order condition for profit maximization in production, that is,

\[
z_{M,t} = \frac{\alpha_3 y_t p_t}{p_t^*}.
\]  

In the present version of the model, nominal wages are taken to be

\[\text{The subscript } t \text{ denotes the time period throughout the model. The use of the official exchange rate in equation (1) relies on the important assumption that no current transactions leak into the free exchange market.}\]
instantaneously flexible, so that full employment holds continuously. Assuming that the supply of labor is inelastic with respect to changes in the real wage, the firm's labor demand function can be solved for the equilibrium product wage, which can be expressed in consumption units as

$$w_t = \frac{\alpha y_t}{(1 + n_t) p_t}.$$  \hspace{1cm} (7)

**Aggregate Demand**

The assumptions about the household's instantaneous utility function and the subproduction function for capital imply that the equilibrium condition in the market for domestic goods can be written as

$$y_t = (1 - q_t) C_t e_t + (1 - q_t) I_t e_t + GD_t + X_t,$$  \hspace{1cm} (8)

where $C_t$ and $I_t$ denote total real consumption and investment, measured in units of the consumption and investment bundles, respectively, while $GD_t$ and $X_t$ denote government spending on domestic goods and exports, both measured in units of the domestic good.

Total consumption demand in the country is modeled according to the permanent income hypothesis and may be written as

$$\log C_t = c_0 + c_1 (r_t - \rho) + c_2 \log y_{p,t},$$  \hspace{1cm} (9)

where $r_t$ is the real consumption rate of interest (the nominal interest rate corrected for the expected change in $p_t$), $\rho$ is the rate of time preference, $y_p$ is permanent income, and $c_0$, $c_1$, and $c_2$ are parameters. Since $c_2$ is set at unity, consumption will be proportional to permanent income unless the rate of time preference deviates from the real rate of interest. The coefficient $c_1$ is taken to be negative, implying that consumption will be reduced (increased) when the rate of interest exceeds (is less than) the rate of time preference.

Permanent income is simply the smoothed income generated by individual wealth. Real wealth, $r_w$, is the sum of all the financial assets held by the private sector at the beginning of the period and the present value of all expected per capita disposable factor incomes in the future. It can be written

$$r_w = (1 + r_t) M_t + d_t F_{p,t} - DC_{p,t}$$

$$+ \sum_{j=1}^{i} \prod_{j=1}^{i} \frac{1}{(1 + E_{r_{t+j}})} E_{r_{t+j}}.$$  \hspace{1cm} (10)

See Friedman (1957) and Hall (1978).
Here $M$ is the nominal money supply, $d$ is the free exchange rate, $F_p$ is the stock of foreign bonds held by the private sector, $DC_p$ is the stock of domestic bank credit allocated to the private sector, $E_i$ is the expectation operator based on information available at time $t$, and $y^d$ is real disposable factor income, measured in units of the consumption good. This equation incorporates the implicit assumption that there is no market for existing capital. Thus, future earning streams from capital are not capitalized by the market and must be treated symmetrically with labor income (that is, discounted back to the present by the household).

Disposable income $y^d$ is the domestic component of real output, $rgdp$, net of the forgone interest on holdings of real cash balances, of lump-sum taxes, $tx$, and of investment, all measured in terms of domestic consumption units:

$$y^d_t = \frac{prgdp_t - (i_t p_{ct} / p_{ct-1}) M_t - (tx_t + I_t er_t^t) p_t}{p_{ct}}$$

where

$$rgdp_t = (1 - \alpha_3) y_t$$

is the domestic component of real output (gross output net of the share of imported intermediate goods).

Finally, permanent income is derived from private wealth according to:

$$y_{p,t} = \left[ 1 + \sum_{i=1}^{19} \prod_{j=1}^{i} (1 + E_t r_{t+i})^{-1} \right]^{-1} rw_t .$$

Investment has been modeled along conventional neoclassical lines. The desired capital stock, denoted $k^*$, is that which equates the marginal revenue product of capital ($\alpha_2 p y / k$) to the rental rate for capital services ($\{r_t + \delta\} p_k$). Thus the desired capital stock can be written as

$$k^*_t = \frac{\alpha_2 p_t y_t}{(r_t + \delta) p_k}$$

where $r_t$ is the real investment rate of interest (the nominal interest rate corrected for the expected change in $p_k$). A fraction $i_1$ of the gap between the actual and desired capital stocks is closed each period. Additional investment is required to permit the capital stock to grow at the rate that

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*For all stock variables (such as $M$, $F_p$, and $DC$), the subscript $t$ denotes beginning-of-period values.

*Notice that in equation (10) we have adopted a 20-period horizon for household consumption behavior. This is consistent with evidence of Leiderman and Razin (1988), Haque (1988), and Haque and Montiel (1989) that households in developing countries not subject to liquidity constraints tend to behave as if their consumption plans are formulated over horizons of many periods.
will allow a constant capital-labor ratio in the steady state. Consequently, the complete investment function is

$$I_t = (n + \delta) k_t + \left( \frac{\alpha_2 p_t y_t}{k_t p_t (r_t + \delta)} - 1 \right) k_t .$$

(15)

Since government expenditures on domestic goods, $GD_t$, are determined by policy subject to the intertemporal government budget constraint to be discussed below, the specification of aggregate demand is completed with the description of export demand. This equation is again fairly standard. Real exports, $X_t$, are taken to be negatively related to the real exchange rate, $er_t$, and positively related to real income abroad, $y^*$, that is:

$$\log X_t = x_0 + x_1 \log er_t + x_2 \log y^* + x_3 t .$$

(16)

**External Accounts**

We distinguish between imports by the private sector, denoted $Z_p$, and imports by the public sector, denoted $Z_g$, as well as between external assets held by the private sector, $F_p$, and by the government, $F_G$. With these distinctions, we can write the current account as

$$ca_t = \frac{X_t p_t}{e_t} - (Z_p + Z_g + Z_m) p_t' + i_t^* (F_p + F_G + F_B) .$$

(17)

Equation (17) measures the current account, $ca$, in terms of the foreign currency. The current account is simply the value of exports minus the total value of all final goods imports by both the private and the public sectors as well as of imported intermediate goods, plus the interest on net foreign assets of the private and nonfinancial public sectors, plus the interest on reserve holdings, denoted $F_B$.

Given private consumption and investment demands as outlined above, and the Cobb-Douglas preference and production structures, import demand can be determined from the shares of imports in consumption and investment. Thus, the private sector demand for imports is merely the sum of the shares of imports in both consumption and investment, that is:

Note that, unlike the conventional specification in the trade-function literature, this import-demand equation allows for a direct role of intertemporal substitution in current account determination, as in Svensson and Razin (1983).
The capital account surplus is equal to minus the change in foreign asset holdings of the public and private nonbank sectors:

\[ ka_t = -(F_{G,t+1} - F_{G,t} + F_{p,t+1} - F_{p,t}). \]  

Finally, the current and capital accounts make up the balance of payments:

\[ F_{B,t+1} - F_{B,t} = ca_t + ka_t. \]  

**Monetary and Financial Sectors**

Since we assume that domestic (that is, bank credit) and foreign interest-bearing instruments are perfect substitutes, the domestic interest rate \( (i) \) is equal to the external interest rate \( (i^*) \) plus the expected rate of change in the free exchange rate,

\[ i_t = \frac{E_t d_{t+1} - d_t}{d_t} + i^* e_t. \]  

This equation in addition relies on the assumption that all interest receipts have to be repatriated through the official market, which accounts for the factor \( e/d \) applied to the external interest rate. The real consumption and investment rates of interest are then the nominal rate corrected for the expected changes in the domestic currency prices of the consumption and investment bundles. Thus,

\[ r_t = (1 + i_t) \frac{p_{c,t}}{p_{c,t+1}} - 1 \]  

and

\[ r_{it} = (1 + i_t) \frac{p_{k,t}}{p_{k,t+1}} - 1. \]  

The demand for money is derived from a simple transaction motive and is given by

\[ \log \left( M_t/p_{c,t} \right) = \lambda_0 + \lambda_1 i_t + \lambda_2 \log y_t; \lambda_1 < 0, \lambda_2 > 0. \]  

The financial structure of our model thus allows households to hold two marketable assets (money and foreign exchange) and a marketable liability (bank credit), as well as two nonmarketable assets (physical and human capital), a setup that seems appropriate for a large number of developing countries.
The supply of money is equal to the sum of reserves valued in domestic currency terms and the stock of domestic credit minus the central bank's net worth, denoted $N$:

$$M_t = e_t F_{B,t} + DC_t - N_t,$$

where total domestic credit, $DC_t$, consists of credit to the private sector, $DC_p$, and to the public sector, $DC_G$:

$$DC_t = DC_{p,t} + DC_{G,t}.$$  \hspace{1cm} (24)

The central bank's net worth increases when total interest receipts plus profits on central bank sales of foreign assets in the free exchange market (given by $(d - e)\Delta F_p$), plus devaluation-induced capital gains on reserves ($\Delta e F_{R,t}$) exceed bank transfers to the government. The latter are denoted $tr_t$, measured in units of the domestic good. Thus the central bank's budget constraint is

$$N_{t+1} = N_t + \iota^*_t e_t F_{B,t} + \iota_t DC_t + (d_t - e_t)\Delta F_{p,t} + \Delta e F_{R,t} - tr_t p_t.$$ \hspace{1cm} (25)

The amounts of credit extended to the private and public sectors ($DC_p$ and $DC_G$), the amount of central bank intervention in the free exchange market ($\Delta F_p$), and the level of real central bank transfers to the government ($tr_t$) are all policy variables. In the simulations reported here, we will assume that the central bank fixes paths for both total credit and its sectoral allocation as well as for sales in the free exchange market, allowing the money supply to adjust endogenously. With regard to transfers to the government, these are taken to be set by the rule:

$$tr_t p_t = \iota^*_t e_t F_{B,t} + \iota_t DC_t + (d_t - e_t)\Delta F_{p,t} - \left(\frac{p_{t+1}}{p_t} (1 + n) - 1\right) N_t.$$ \hspace{1cm} (26)

Thus, operating profits other than devaluation-induced capital gains are transferred to the government, except for the portion required to maintain the steady-state value of the central bank's net worth constant.

**Government**

The government's revenue sources consist of taxes on the private sector and transfers from the central bank. The government consumes both domestic and foreign goods, and pays interest on its domestic and external debt. Consequently, the government surplus, denoted $s$, can be written
The deficit is financed by borrowing either at home or abroad, that is,

\[ e_i(F_{G,i+1} - F_{G,i}) = s_t + DC_{G,i+1} - DC_{G,i}. \]  

(28)

The government is subject to an intertemporal budget constraint that prevents its external debt from growing excessively, thus precluding Ponzi schemes. We incorporate this constraint in our model through a particularly simple mechanism—specifically, the government is assumed not to tolerate an ever-increasing debt/GDP ratio. When the ratio of debt to GDP differs from its baseline value, government spending is adjusted to reduce debt. It is convenient to suppose that government imports are the policy variable that is adjusted in this fashion:10

\[ (e_{FG_i + p_{FG_i}}) - (e F_{G,i + P_{FG_i}}) \geq 0. \]

(29)

where \( z_{G,i} \) is an exogenous level of government imports, \( \theta \) is the (negative) baseline value of the government debt/GDP ratio, and \( \sigma \) is an adjustment parameter.

**Expectations**

As mentioned in the previous section, an important feature of our model is that agents' expectations are forward-looking and specifically are formed rationally for all relevant future variables.11 They include the consumption real interest rate, real disposable factor incomes, the dual exchange rate, and the domestic currency prices of both the consumption and capital goods. The model is thus closed with the following relationships, which must hold for all \( i \):

\[ E_i(r_{t+i}) = r_{t+i} \]  

(30a)

\[ E_i(y_{t+i}^d) = y_{t+i}^d \]  

(30b)

\[ E_i(d_{t+i}) = d_{t+i} \]  

(30c)

10 This rule, which places the burden of adjustment on expenditures, has been used because developing countries tend to encounter severe difficulties in increasing domestic revenues rapidly. Using expenditure on imports, rather than on domestic goods, is a convenient initial simplification, because under this rule the domestic economy is insulated from the effects of fiscal adjustment.

11 While we refer to expectations as being formed rationally, the simulations reported in fact reflect the stronger assumption of perfect foresight, since they are carried out in a nonstochastic environment.
II. Simulations

In view of the complexity of the model and the lack of reliable and detailed time series of adequate length for a broad group of countries, the strategy adopted was to base our choice of parameters on existing estimates rather than to attempt to obtain our own estimates. Fortunately, many of the specifications have been individually estimated. Consequently, estimates of elasticities that are considered reasonable do exist for many of the parameters. The data used in the simulations were constructed by solving the steady-state version of the model and setting key ratios (such as consumption/GDP) equal to their average values in a large sample of developing countries, in an effort to ensure that our baseline represents a developing country prototype. Details of these estimates, as well as of the procedure for constructing the data, are presented in Appendix III.

With the baseline established, the properties of the model can be investigated by subjecting it to a variety of policy and exogenous shocks. We study the effects of five shocks—four domestic policy shocks and an external shock. The domestic policy shocks consist of an increase in domestic credit, an increase in real government expenditure, central bank intervention in the free exchange market, and a devaluation of the official exchange rate. For the external shock we considered an increase in the external interest rate. With the exception of the official devaluation, all the shocks examined here are transitory.\(^\text{12}\) Model solutions were obtained using the Fair-Taylor algorithm in TROLL (see Fair and Taylor (1983)).

**Domestic Credit Shock**

The first simulation consists of an unanticipated transitory increase in domestic credit. Specifically, domestic credit was changed to bring about a 5 percent increase in the monetary base for five periods, after which credit was reduced to its earlier levels. Since credit to the public sector

\(^{12}\)The results of this section would, of course, be substantially different if the shocks were permanent. Transitory shocks are better suited to the analysis of stabilization issues and have the convenient computational feature that the steady-state values of the expectational values are unchanged. The analysis of permanent shocks is quite feasible, however, as demonstrated later by the devaluation exercise.
is given, this increase in domestic credit takes the form of an increase in the credit made available by the banking system to the private sector. Chart 1 shows deviations from baseline values for several of the key endogenous variables in the model. The increase in domestic credit has a short-run expansionary effect on the economy; on impact, real output, the real wage, and the price level all increase. In addition, the free exchange rate depreciates, the nominal interest rate and both real interest rates decline, and investment demand increases (the change in consumption is positive, but negligible). As a result of these changes the real exchange rate appreciates, exports fall, and imports increase. Both the current account and overall balance of payments worsen.

An increase in domestic credit to the private sector results in an instantaneous incipient excess supply of money (see equation (23)). To restore equilibrium in the money market, the domestic nominal interest rate has to decline and/or prices have to rise (the latter both reduces the real money supply and increases money demand by stimulating an increase in output). The increase in the supply of credit has no direct effect on the commodity market. In this simulation, the money market is cleared through an increase in prices, because the nominal interest rate increases, rather than falls. Interest parity (equation (21a)) requires an increase in the domestic nominal interest rate, because of a continued depreciation of the free exchange rate after the first period, which under perfect foresight is anticipated by agents. The price increase and free exchange depreciation both contribute to a reserve outflow through a deterioration of the current account (Chart 1, panel C). In the case of the free exchange rate, this effect operates through wealth effects on consumption, and thus on domestic absorption. The price increase switches both foreign and domestic spending away from the domestic and toward the foreign good. Over time, this reserve outflow reduces the supply of money. Finally, after its initial (two-period) depreciation, the free exchange rate appreciates for six periods (Chart 1, panel B). This lowers the domestic nominal interest rate and also contributes to eliminating the incipient excess supply of money.

The increase in output on impact is brought about through two channels. First, the increase in domestic prices necessary to clear the money market results in a real exchange rate appreciation, which, by reducing the real cost of imported materials, results in an expansion of domestic production. Both directly (recall that capital has an imported component) and through this induced expansion of output, the real appreciation increases the value of the marginal product of capital. Investment rises, the capital stock is increased, and this contributes a second channel of supply expansion.
Chart 1. Domestic Credit Shock

Panel A: Level deviations

Panel B: Percent deviations

Panel C: Percent deviations

Panel D: Percent deviations

Note: All panels reflect deviations from the baseline.
While the stock of domestic credit is maintained above its baseline value, the capital stock continues to rise and the stock of international reserves continues to be depleted (Chart 1, panel C). The increase in the capital stock increases the demand for money, and, as indicated above, the reserve outflow reduces the supply. This results in continuous disinflation and appreciation of the free exchange rate after the initial two periods of the shock (Chart 1, panel B). Both the free exchange rate and domestic prices must overshoot their steady-state values, because when the credit shock is removed, the economy finds itself with a larger capital stock and a smaller stock of reserves than initially. To clear the money and goods markets requires below-baseline values of both the free exchange rate and the price of domestic goods. Notice that, since falling prices and an increasing capital stock have offsetting effects on aggregate supply, output remains roughly stable while the shock is in place (Chart 1, panel D).

When the increase in credit is removed, the appreciation of the free exchange rate and the decrease in the domestic price level are quite sharp. Output declines abruptly, but because of the larger inherited capital stock, does not initially fall very far below its baseline value, in spite of the negative effects associated with the overshooting of the domestic price level to substantially below its baseline value. As the previous mechanism is reversed, reserves begin to recover and the capital stock to fall (relative to baseline). All variables gradually return to their baseline levels, with the free exchange rate depreciating, domestic prices rising, and output gradually increasing.

The behavior of the real wage over the course of this shock is depicted in panel D of Chart 1. As indicated by equation (7), the path of the real wage follows that of output and the price level. The real wage rises on impact, both because output increases and because domestic prices rise. The former leads to an increase in the product wage, and the latter to an increase in the purchasing power of the product wage over the consumption bundle. The path of the real wage lies above that of output when the domestic price level exceeds its baseline value, and below it otherwise. Thus, in panel D of Chart 1 the wage rises proportionately more than real output on impact, owing to the price increase. The increase in the real wage reflects an increase in the marginal product of labor owing to a larger capital stock and increased use of intermediate goods, as well as increased purchasing power of domestic goods over the consumption bundle. The reduction in the real wage exceeds that of output when the shock is removed, owing to the collapse of domestic prices. Finally, in the post-shock period, the real wage rises relative to baseline.
Government Expenditure Shock

The unanticipated and transitory government expenditure shock consisted of an increase in expenditures equal to 1 percent of GDP lasting for five periods and financed entirely by external borrowing. The increase in expenditures is devoted entirely to domestic goods. Chart 2 illustrates the effects of this shock on several of the key endogenous variables. Notice first that, over most of its duration, this transitory increase in spending is expansionary. Specifically, though output falls on impact (panel D of Chart 2), both output and the price level increase after the first period. The real exchange rate appreciates over the course of the shock, while the free market exchange rate depreciates.

The assumed mode of financing is important in determining the effects of this shock. The combination of external borrowing and domestic spending, with no sterilization of the capital inflow by the central bank, implies that the central bank's stock of international reserves increases continuously while the shock is in place, as shown in panel C of Chart 2. Since the stock of domestic credit is unchanged, the fiscal stimulus is therefore accompanied by a monetary expansion that builds up over time. In the first period, before the monetary effects begin to be felt, fiscal demand pressures lead to an increase in domestic prices (panel B). This puts upward pressure on both nominal and real interest rates. Since domestic goods carry less weight in capital accumulation than in consumption, the anticipated domestic inflation provides a weaker offset to the increase in the nominal interest rate for such goods, and the real investment interest rate rises more than the real consumption interest rate. Through this mechanism investment is crowded out on impact, and capital accumulation falls below baseline levels (panel C), as real output and the real wage fall (panel D), in spite of the increase in domestic prices.

As the fiscal deficit begins to contribute to a cumulative monetary infusion, the nominal interest rate begins to fall, and by the fifth period it is below its baseline level. Since the domestic rate of inflation is above its baseline value while the shock is in place, real interest rates must therefore fall below their baseline levels. For reasons described in the previous section, the monetary injection results in a depreciation of the free market exchange rate, which has an expansionary influence on demand through positive wealth effects on consumption. The combination of output expansion induced by increased government spending and wealth-induced increases in consumption, coupled with lower real investment interest rates, eventually results in increased investment, causing
Chart 2. Government Spending Shock

Panel A: Level deviations
- \( \hat{d} \)
- \( \hat{\rho} \)

Panel B: Percent deviations
- \( d \)
- \( \rho \)

Panel C: Percent deviations
- \( F_B \)
- \( F_G \)
- \( k \)

Panel D: Percent deviations
- \( y \)
- \( w \)

Note: All panels reflect deviations from the baseline.
the capital stock to exceed its baseline value by the fifth period of the shock (Chart 2, panel C). This adds a positive supply effect to support the demand pressures that cause output and the real wage to exceed their baseline levels after the first period of the shock (panel D).

The removal of the fiscal shock leaves the economy with larger stocks of both foreign exchange reserves and capital. The removal of the government spending stimulus immediately causes prices to fall (panels A and B) in order to clear the commodity market. Since the nominal money supply remains high (though it is no longer rising), the nominal interest rate falls sharply, resulting in a decline in real interest rates. Thus investment, the capital stock, output, and the real wage all receive a temporary boost. Once the fiscal adjustment is complete, however, contractionary monetary effects associated with reserve depletion become dominant and real interest rates begin to rise to their baseline levels. The reserve depletion comes about because, without the capital inflows associated with the financing of the fiscal deficit, the current account deficit owing to the previous cumulative increase in the money stock dominates the balance of payments. As reserve outflows deplete the stock of money, domestic prices, the free exchange rate, output, and the real wage all move toward their baseline levels.

It is worth noting that, since the stock of foreign exchange reserves (and thus the money supply) returns to its baseline level earlier than the capital stock (panel C of Chart 2), the domestic price level must overshoot its own baseline value. This is because once the baseline value of the money supply is restored, the accumulated increase in the capital stock creates excess supply pressures in the domestic commodity market. To clear this market, the price level must fall below its baseline value. Low prices imply a high real money supply, and excess supply pressure in the money market keeps the nominal interest rate below its baseline value. Moreover, since the domestic price level must rise from its depressed level to recover its baseline value, the low nominal interest rate and rising prices keep real interest rates below their baseline values. This tends to stimulate investment, which prolongs the required downward adjustment of the capital stock (panel C of Chart 2). The implication is that output and the real wage return to their baseline levels very slowly (panel D).

**Central Bank Intervention in Free Market**

The instruments of monetary policy in this model consist of both changes in the stock of credit and central bank purchases or sales of foreign exchange in the free market. Since the former was analyzed in the first subsection, we now examine the macroeconomic effects of a central
bank sale of foreign exchange in the free market. Specifically, we consider an increase in $F_p$ amounting to 5 percent of the money stock and lasting for six periods. The central bank in essence sells a substantial amount of foreign exchange to the private sector in the first period, continues to intervene in smaller amounts for five periods to keep $F_p$ at its desired relationship to the baseline money stock, and then in the seventh period buys back all the foreign exchange it initially sold.

The macroeconomic effects of this temporary free market sale of foreign exchange arise from its monetary consequences. By selling foreign exchange, the central bank reduces the money supply ($F_S$ falls in equation (23)). The consequences of this are essentially identical to those of a credit contraction. This can be verified by comparing Chart 3 with Chart 1. The former, which describes the effects of the free market intervention, is essentially the reverse of the latter, which concerns the effects of a credit expansion. Thus, the central bank can undertake a monetary expansion (contraction) either by increasing (reducing) the supply of credit or by buying (selling) foreign exchange in the free market.

The primary difference between the outcomes concerns the behavior of foreign exchange reserves (Chart 3, panel C). Notice first that, unlike the other variables depicted, reserves move in the same direction (that is, reserves fall relative to baseline) on impact when domestic credit is expanded as when foreign exchange is sold. The reasons are quite different in the two cases, however. When the supply of credit is increased, the reduction in reserves is gradual and is brought about by the expansionary effects on the economy of the increase in the money supply. Reserves fall while the shock is in place. When foreign exchange is sold, by contrast, reserves fall all at once because, of course, the foreign exchange sold by the central bank is drawn from its reserve stocks. In this case, however, reserves rise until the foreign exchange is repurchased, owing to the contractionary macroeconomic effects of the reduction in the money supply. Moreover, whereas reserves remain below their baseline levels throughout the credit expansion exercise, reserves overshoot in the case of foreign exchange sales. This overshooting occurs when the foreign exchange is repurchased by the central bank and is caused by the reserve accumulation induced while the shock was in place. The repurchase implies an above-baseline monetary expansion, so that reserves decline to baseline levels as the economy returns to equilibrium.

**Foreign Interest Rate Shock**

We now turn to an external shock, in the form of a temporary increase in the foreign interest rate. This interest rate is assumed to increase by
Chart 3. Free Market Intervention

Panel A
Level deviations

Panel B
Percent deviations

Panel C
Percent deviations

Panel D
Percent deviations

Note: All panels reflect deviations from the baseline.
2 percentage points (200 basis points) for six periods, and then to return to its original level.

Contrary to what might be expected, for most of the duration of the foreign interest rate increase, domestic real output exceeds its baseline level (the exception is the first period—that is, the impact effect). Thus, the shock proves to be expansionary. The explanation for this is the following: when the interest rate on foreign assets rises, individuals attempt to shift their portfolios from domestic to foreign assets. Since the central bank does not accommodate this desired portfolio shift ($F_p$ is exogenous), the free exchange rate depreciates sharply (Chart 4, panel B). As the private sector is a net external creditor, the positive wealth effect of this depreciation increases private consumption, which is the source of the expansionary effect on aggregate demand.

Since the model assumes uncovered interest parity, it might be expected that this expansionary effect would be offset by a contractionary effect arising from higher domestic interest rates. The domestic nominal interest rate indeed rises, but not by as much as the foreign interest rate because, since the shock is temporary, the free exchange rate is expected to reverse its initial depreciation. This expected appreciation holds the nominal interest rate increase to about 50 basis points on impact, compared with the 200 basis-point increase in the foreign interest rate. Moreover, the balance of payments improves (panel C of Chart 4) because the higher interest receipts by the private sector more than offset the deterioration in the trade balance.\(^{13}\) Thus the money supply rises over time, exerting downward pressure on the nominal interest rate. The anticipated price rise associated with the expansion of demand means that, even on impact, domestic real interest rates are largely unaffected and, with prices rising at above-baseline rates while the free exchange rate appreciates, domestic real interest rates fall below the baseline by the second period of the shock. Capital accumulation is discouraged on impact by a very slight increase in the real interest rate on investment, but as this rate falls below baseline and both domestic prices and output begin to rise, investment increases. Thus, when the foreign interest rate reverts to its initial level, domestic prices, output, the capital stock, and the level of reserves all exceed their baseline levels (Chart 4, panels B–D). Because the capital stock and the stock of foreign exchange reserves exceed their baseline levels, when the shock is terminated both the domestic price level and the free exchange rate must be above their baseline values (panel B). From here on, events unfold as in previous

\(^{13}\) Higher public sector interest payments abroad are financed by capital inflows, with no net effect on the balance of payments.
Chart 4. Foreign Interest Rate Shock

Note: All panels reflect deviations from the baseline.
exercises. When the infusion of reserves through interest receipts from the private sector is removed, the stock of reserves (and thus the money supply) begins to fall. This gradual monetary contraction returns the economy to its baseline configuration in a now familiar manner.

This shock has a very severe impact on public sector debt. As shown in panel C of Chart 4, debt rises abruptly from the shock's inception, because the nonfinancial public sector is a large external debtor and, for a time, it finances its increased interest payments by further borrowing abroad. The rate of debt accumulation slows abruptly when the interest rate on external debt returns to its original level. This is the cause for the first kink in the \( F_C \) curve in panel C of Chart 4. After a time, the adjustment mechanism described in equation (29) becomes operative and the government reduces spending on imports, in this way accumulating the savings necessary to retire some of its increased debt. In panel C of Chart 4, this appears as the second kink in the \( F_C \) curve.

Note that the dynamics are greatly affected by the size of the stock of foreign assets held by the private sector. Both the size of the initial jump in \( d \), which generates the wealth effects necessary to clear the money and commodity markets on impact, and the rate of reserve accumulation, which is a crucial determinant of medium-term dynamics, are dependent on the initial value of \( F_P \). While a larger initial value of \( F_P \) would require less of an initial jump in \( d \) to generate the equilibrating wealth effects, it also would imply more rapid reserve accumulation through private interest receipts while the foreign interest rate is high.

**Devaluation of Official Exchange Rate**

Up to now, both the domestic and the external shocks considered have been transitory in nature. We now turn to the analysis of a permanent shock—a 5 percent devaluation of the official exchange rate. We assume that the devaluation is accommodated by a change in credit policy, so the stock of credit is also increased by 5 percent. However, intervention in the free exchange market is unchanged, and devaluation profits are retained by the central bank, rather than transferred to the government.

Since the shock is permanent, we begin by describing steady-state outcomes. In the long run, domestic prices rise by 5 percent and the free exchange rate depreciates by 5 percent. The nominal money supply must similarly increase by 5 percent. The capital stock, real output, and the real wage all return to their baseline levels. Because devaluation profits are not monetized and the real stock of credit is restored to its baseline level, a return to baseline real money balances implies an increase in the long-run stock of reserves, amounting to slightly less than 5 per-
cent of its initial level. This increase in the steady-state reserve stock is presumably the motive for the devaluation.

The dynamics of adjustment are depicted in Chart 5. The economy cannot immediately return to its real steady state, because the required reserve inflow can only be procured by a succession of current account surpluses. These are brought about through relative price effects as well as through the contractionary effects of the official devaluation. Since the increase in the price of foreign goods causes the price of the consumption bundle to rise and this is not fully offset by the size of the expansion in domestic credit, the real money supply falls and nominal interest rates rise. This increase is sufficient to increase both real interest rates (and particularly the real investment interest rate) in spite of anticipated inflation. Coupled with the negative wealth effect of the increase in the price of the consumption bundle, the increases in real interest rates reduce aggregate demand.

Since the real exchange rate depreciates on impact, the effect of the contraction in demand on domestic economic activity is partially offset by the expenditure-switching effect mentioned above—exports rise and imports fall on impact, improving the trade balance. However, the real depreciation simultaneously has contractionary effects on the supply side of the economy. Since imported inputs are now more costly in real terms, domestic producers are subjected to an adverse supply shock via this route. Thus, although domestic prices rise, real output falls on impact.\(^{14}\) With higher real interest rates, higher real costs of imported capital and intermediate goods, and lower output, investment decreases, moving the capital stock below its baseline level. The contraction of output on impact, together with the real exchange rate depreciation, results in a reduction of the real wage more than in proportion to that of output.

Over time, these effects are dissipated through traditional monetary channels. The improvement in the current account brought about by the devaluation increases the stock of reserves, which causes the money supply to increase, lowering domestic interest rates and raising prices. By the fourth period, the real depreciation has been reversed. Since reserves reach their steady-state level while the capital stock still remains below its baseline value, reserves and prices—as well as the real exchange rate—must overshoot their steady-state levels, and the eventual return to the steady state involves a gradual decrease in reserves as well as falling domestic prices.

\(^{14}\)This outcome of increased inflation and contraction in output following a nominal devaluation has long been claimed by structuralist critics of orthodox stabilization policies (see Taylor (1981)).
Chart 5. Exchange Rate Shock

Panel A: Level deviations

Panel B: Percent deviations

Panel C: Percent deviations

Panel D: Percent deviations

Note: All panels reflect deviations from the baseline.
In summary, a nominal devaluation leads to a temporary contraction in output, a more pronounced reduction in the real wage, and a short-run decrease in investment. Moreover, a temporary increase in the rate of inflation accompanies these effects. At the same time, however, devaluation is effective in improving both the trade balance and the current account. In the end, output and the real wage return to their baseline levels, as does the capital stock. The legacy of the devaluation becomes a permanently higher price level and a permanently larger stock of foreign exchange reserves.

III. Conclusions

Since we know of no other attempts to construct small macroeconomic simulation models with developing country features and forward-looking agents, our primary purpose here has been to describe the structure of our model and analyze how it works—that is, our attention has been devoted to the model itself, rather than to using it to address substantive research or policy questions. Nonetheless, a number of interesting results have emerged from our simulations.

The simulation exercises demonstrate the usefulness of models of this type. Complex general equilibrium interactions can be disentangled and the proximate determinants of movements in key variables traced. By specifying a model that incorporates these relationships in an internally consistent fashion, the behavior of certain variables that are of independent interest but do not typically occupy center stage in the analysis of the effects of stabilization policies in developing countries—such as the stock of external debt and the real wage—can be observed and explained. As would be expected, the assumption of forward-looking expectations fundamentally affects the economy’s dynamic response to shocks. This is evident in the role played by future variables in the analysis of the various simulation exercises, particularly in determining the behavior of nominal and real interest rates, as well, therefore, as of interest-sensitive components of demand.

The simulations themselves are reassuring in that they produce some familiar results while offering some new insights. Temporary increases in government spending on domestic goods financed by external borrowing, or in the availability of bank credit to the private sector, boost economic activity, raise prices, and cause the current account to deteriorate for some time. All these results accord with what one expects. Among the new insights, however, are the following:

- The impact effects of a number of shocks are contrary to their medium-term effects. For example, nominal interest rates rise on impact...
when credit to the private sector is expanded, output falls on impact when government spending increases, and output falls in the first period when foreign interest rates rise. All these effects are reversed in subsequent periods, while the shock is still in effect. This result underlines the importance of dynamic analysis in this context.

- Central bank intervention in the free exchange market has macroeconomic effects similar to changes in availability of credit. Thus even in developing countries with very limited markets for securities the monetary authorities may have more policy tools at their disposal than is commonly supposed.
- Even for a net debtor country, an increase in the foreign interest rate may prove to be expansionary. While debt would increase, the economy need not contract—at least not without a policy response to prevent debt accumulation. This result depends critically on the private sector being a net external creditor, as well as on the repatriation of its interest receipts through the official market.
- While devaluation may indeed achieve its desired goal of improving the current account and promoting long-run reserve accumulation, it may prove to have contractionary macroeconomic effects in the short run, even in a context where all prices are flexible and no rationing or bottlenecks of the type typically associated with “structuralist” analysis are present.

Our model can be extended in a number of ways. Among those we consider most important are certain modifications to the consumption and investment functions, the introduction of an exportables-importables-nontraded commodity structure, and allowing scope for nominal wage sluggishness. Regarding the consumption function, the primary modifications that can be implemented are the explicit introduction of an optimizing framework for non-liquidity-constrained households as well as allowing for the presence of liquidity-constrained households. A longer time horizon for investment decisions would also be desirable. A three-good commodity structure would permit the analysis of the effects of exogenous terms-of-trade shocks, and slow nominal wage adjustment would allow the economy to exhibit Keynesian unemployment. While changes such as these can undoubtedly enrich the model, we believe that the present version represents a useful starting point for improved analysis of a broad range of macroeconomic issues in developing countries.

**References**

Barro, Robert J., “Money and Output in Mexico, Colombia and Brazil,” in *Short-Term Macroeconomic Policy in Latin America*, ed. by Jere Behrman and James Hanson (Cambridge, Massachusetts: Ballinger. 1979).


APPENDIX I

The Complete Model

1. Prices
\[ p^* = e_p \]  
\[ e_r = \frac{p^*}{p_t} \]  
\[ p_t = p^{*p_1} p_t(1 - p_1); \quad 0 < p_1 < 1 \]  
\[ p_t = p^{*q_1} p_t(1 - q_1); \quad 0 < q_1 < 1 \]  

2. Aggregate Supply
\[ \log y_i = \alpha_0 + \alpha_1 n_t + \alpha_2 \log k_t + \alpha_3 \log z_{M,t} \]  
\[ z_{M,t} = \frac{\alpha_3 y_i p_t}{p^*} \]  
\[ w_t = \frac{\alpha_3 y_i p_t}{(1 + n_t) p_t} \]  

3. Aggregate Demand
\[ y_i = (1 - p_t) C,er_t^p + (1 - q_t) I,er_t^q + GD_t + X_t \]  
\[ \log C_t = c_0 + c_1 (r_t - p) + c_2 \log y_{p,t} \]  
\[ r_{w_t} = (1 + r_t) \frac{M_t + d_2 p_{p,t} - D_{p,t}}{p_c} \]  
\[ y^*_t = p_r gdp_t - (i_t p_c, p_{c,t}) M_t - (x_t + l, er_t^q) p_t \]  
\[ r_{gdp_t} = (1 - \alpha_3) y_t \]  
\[ y_{p,t} = \left[ 1 + \sum_{i=1}^{19} \prod_{j=0}^{i-1} (1 + E_t r_{2,i}) \right]^{-1} r_{w_t} \]  
\[ k_t^* = \frac{\alpha_2 p_t y_t}{(r_t + \delta) p_k} \]  
\[ l_t = (n + \delta) k_t + l_i \left[ \frac{\alpha_2 p_t y_t}{k_t p_k (r_t + \delta)} - 1 \right] k_{t-1} \]  
\[ \log X_t = x_0 + x_1 \log e_r + x_2 \log y^*_t + x_M \]  

4. External Account
\[ c_{a_t} = \frac{X_t p_t}{e_t} - (z_p + z_g + z_m) p_t^i + i_t^* (F_p + F_G + F_B) \]  
\[ z_{p,t} = p_1 C,er_t^{(p_1 - 1)} + q_1 I,er_t^{q_1 - 1} \]  
\[ k_{a_t} = - \left[ F_{G, t+1} - F_G + F_{p,t+1} - F_{p,t} \right] \]
\[ F_{B,t+1} - F_{B,t} = c_a + k a_t \]  
\[ i_t = \frac{E_t d_{t+1} - d_t}{d_t} + i_t^* \]  
\[ r_t = (1 + i_t) \frac{p_t}{p_{t-1}} - 1 \]  
\[ r_t = (1 + i_t) \frac{p_t}{p_{t-1}} - 1 \]  
\[ \log (M_t / P_{c,t}) = \lambda_0 + \lambda_1 i_t + \lambda_2 \log y_t \]  
\[ M_t = e_t F_{B,t} + D_{C,t} - N_t \]  
\[ D_{C,t} = D_{C,P,t} + D_{C,G,t} \]  
\[ N_{t+1} = N_t + i_t e_t F_{B,t} + i_t D_{C,t} + (d_t - e_t) \Delta F_{p,t} + \Delta e F_{B,t} - tr_p \]  
\[ tr_p = i_t^* e_t F_{B,t} + i_t D_{C,t} + (d_t - e_t) \Delta F_{p,t} - \left( \frac{p_{t+1}}{p_t} (1 + n) - 1 \right) N_t \]  
\[ s_t = p_t \left( \alpha_t + tr_t - gd - p_t^* \frac{z_{G,t}}{p_t} \right) + i_t^* e_t F_{G,t} - i_t D_{C,G,t} \]  
\[ e_t (F_{G,t+1} - F_{G,t}) = s_t + D_{C,G,t+1} - D_{C,G,t} \]  
\[ z_{G,t} = \bar{z}_{G,t} + \theta \left( 1 - \frac{e_t F_{G,t}}{p_t y_t} \right) \bar{x}_{G,t}; \theta > 0, \theta < 0 \]

**APPENDIX II**

**Definition of Variables**

- **ca**: Current account in foreign currency units
- **Cr**: Real consumption measured in units of the consumption good
- **d**: Free exchange rate (price of foreign currency in terms of domestic currency)
- **DC**: Total domestic credit
- **DCp**: Stock of domestic credit to the private sector
- **DCg**: Stock of domestic credit to the public sector
- **e**: Official (fixed) exchange rate (domestic currency price of foreign currency)
- **er**: Real exchange rate
- **E_t**: Expectation operator based on information available at time t
- **F_{B}**: Stock of foreign exchange reserves
- **F_{p}**: Stock of foreign bonds held by the private sector, measured in foreign currency
- **F_{G}**: Stock of foreign bonds held by the government
- **GD**: Real government spending on domestic goods
- **i**: Domestic nominal interest rate
- **i^***: External nominal interest rate
Appendix III

Data Construction

The parameters imposed on the model to generate the data and run the simulations are reported in Table 1. The numbers were drawn from developing country estimates in the literature, with two major exceptions. In the case of the consumption and money-demand functions, the elasticities with respect to the scale variables (permanent income and gross output, respectively) were set at unity, which is quite close to most empirical estimates and permits us to derive a steady-state solution to the model. Second, although empirical estimates of
### Table 1. Parameters Employed in the Simulations

<table>
<thead>
<tr>
<th>Category</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition of Spending</strong></td>
<td>(a) Share of consumption devoted to imports</td>
<td>$p_1 = 0.06$</td>
</tr>
<tr>
<td></td>
<td>(b) Share of investment devoted to imports</td>
<td>$q_1 = 0.167$</td>
</tr>
<tr>
<td><strong>Production Function</strong></td>
<td>(a) Share of labor</td>
<td>$a_1 = 0.74$</td>
</tr>
<tr>
<td></td>
<td>(b) Share of capital</td>
<td>$a_2 = 0.21$</td>
</tr>
<tr>
<td></td>
<td>(c) Share of imported inputs</td>
<td>$a_3 = 0.05$</td>
</tr>
<tr>
<td><strong>Consumption</strong></td>
<td>(a) Interest semi-elasticity</td>
<td>$c_1 = -0.13$</td>
</tr>
<tr>
<td></td>
<td>(b) Permanent income elasticity</td>
<td>$c_2 = 1.0$</td>
</tr>
<tr>
<td><strong>Investment</strong></td>
<td>(a) Speed of adjustment</td>
<td>$i_i = 0.1$</td>
</tr>
<tr>
<td></td>
<td>(b) Rate of depreciation</td>
<td>$\delta = 0.1$</td>
</tr>
<tr>
<td><strong>Exports</strong></td>
<td>(a) Price elasticity</td>
<td>$x_1 = 0.57$</td>
</tr>
<tr>
<td></td>
<td>(b) Foreign income elasticity</td>
<td>$x_2 = 2.0$</td>
</tr>
<tr>
<td></td>
<td>(c) Trend</td>
<td>$x_3 = -0.025$</td>
</tr>
<tr>
<td><strong>Money Demand</strong></td>
<td>(a) Interest rate semi-elasticity</td>
<td>$\lambda_1 = -0.2$</td>
</tr>
<tr>
<td></td>
<td>(b) Income elasticity</td>
<td>$\lambda_2 = 1.0$</td>
</tr>
</tbody>
</table>

the money-demand semi-elasticity seem to cluster around $-2$, we arbitrarily set the value of this parameter an order of magnitude lower to magnify interest rate responses and thus permit us to detect the role of interest rate movements more readily. The results of our simulations are not qualitatively different when $\lambda_1 = -2$.

Given these parameters, the baseline data were generated as follows. First, the model was solved to derive its steady-state equilibrium. Next, in order to impose a "representative" developing country configuration, the variables $\text{rgdp}$, $C$, $F_G$, $F_B$, $M$, $DC_P$, $d$, and $p$ were made exogenous, while $\alpha_0$, $c_0$, $x_0$, $\alpha_0$, $GD$, $DC$, $DC_G$, and $\tau$ became endogenous. The initial values of $\text{rgdp}$, $p$, and $d$ were arbitrarily set at 100, 1, and 1, respectively. The remaining variables were given initial values of $C = 65\%$, $M = 20\%$, $DC_P = 6\%$, $F_B = 6\%$, and $F_G = \text{-}40\%$. The first four of these reproduced the ratios of the corresponding variables to GDP found in data drawn from *International Financial Statistics (IFS)* for a large sample of developing countries (the value 20 for $M$ was a compromise between 12 for base money and 38 for money and quasi-money in our sample). In the case of debt, the value of 40 percent of GDP for public sector debt is larger than the average in our sample, but we chose the larger figure because of the inherent interest of debt-related issues. The initial values for the remaining exogenous variables were $y^* = 100\%$, $F_p = 8\%$, $F_G = 5\%$, $i^* = 0.065$, $p^* = e = 1.0$. The values taken by $F_G$, $F_B$, and $F_p$ imply that, while the country as a whole is a net external debtor (its net external

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15With our current fiscal adjustment specification (equation (29)), this value has no effect on the variables depicted in the charts, except for the debt variable itself.
debt, given by $F_0 + F_B + F_p$, is 26 percent of GDP), the private sector is a net external creditor. Finally, we assumed that the labor force and foreign output both grew at 2.5 percent a period, and that the domestic and foreign inflation rates were both 4 percent a period. This implies steady-state growth rates of 2.5 percent for the exogenous real variables and 6.6 percent for the exogenous nominal variables. Given the paths of the exogenous variables and the values chosen for the parameters, the remaining baseline data were generated by the model itself.

APPENDIX IV

Domestic Credit Shock with Adaptive Expectations

A graphic illustration of the role of the expectations assumption appears in Chart 6, which presents the domestic credit shock analyzed in Section II under an alternative version of the model that embodies the assumption that expectations are formed adaptively. The paths of the free exchange rate, real output, the real wage, the capital stock, and many other macroeconomic variables are markedly affected by this change. Overall, while the short-run behavior of the economy is qualitatively similar, the movement in macroeconomic variables is much more pronounced in this case (compare the peak movements of $d$, $k$, $F_B$, and $y$ in panels B–D of Chart 6 with the corresponding peak movements in panels B–D of Chart 1). Convergence to the steady state exhibits pronounced cycles under adaptive expectations, compared with the smooth convergence achieved with perfect foresight.
Chart 6. Adaptive Expectations Domestic Credit Shock

Note: All panels reflect deviations from the baseline.