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A Forward-Looking Macroeconomic Simulation Model for a Developing Country

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Abstract

The paper develops a small dynamic macroeconomic simulation model for a representative developing country which relies on familiar macroeconomic theory and in which expectations are formed rationally. The model is useful for the analysis and simulation of important policy questions in a general-equilibrium setting. Several policy experiments are conducted which illustrate the workings of the model and yield fresh insights into the effects of standard macroeconomic policies in developing countries.

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Contents

I. Introduction

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 the reducing of external imbalances and lowering inflation while avoiding recession and enhancing medium-term growth. The income-distribution consequences of such programs 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 tradeoffs among conflicting macroeconomic targets confronted by policymakers, must necessarily be conducted by using reasonably detailed quantitative macroeconomic models. *Existing quantitative developing-country models are not* well suited for exploring these issues, however, because they typically incorporate ad hoc behavioral relationships and generally provide an inadequate treatment of expectations. 1/ 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 developing-country macroeconomic analysis. 2/

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 which 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 what direction and through what channels policy variables that are typically addressed to the correction of 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: (a) it incorporates structural features commonly perceived as relevant in such countries, such as the role of imported intermediate and capital goods in the production

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1/ Existing policy-oriented models are also lacking in this latter respect (see Khan et. al. (1989)).

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), (1983b), 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) 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 (1982).

process, the absence of domestic equity or securities markets, and the presence of dual markets for foreign exchange; (b) the numerical values of its parameters are taken from available developing-country estimates; and (c) 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 remainder of the paper is organized into three sections. The model is described in the section that follows. In Section III 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.

II. Model Specification

In this section we specify a relatively simple and familiar macroeconomic model of a small open developing economy. Despite its simplicity, the model captures several important macroeconomic characteristics found in many developing countries and incorporates a number of features that reflect the modern macroeconomics literature. In that sense, it is both a departure from, and an improvement on, the developing country models that are currently available.

Before getting into the details of the model, it might be useful to summarize some of its general features. In brief, the model is built around a consistent accounting framework (i.e., 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--i.e., the model includes features such as a permanent-income specification for consumption and a standard neoclassical investment function. It contains three key developing-country structural features. 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 into the production process, the demand for final-goods imports 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.

1. Prices

The model has a Mundell-Fleming structure, with one domestically-produced good and one foreign good. 1/ 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 in foreign currency terms. 2/ Denoting the price of the domestic good by p, the real exchange rate (denoted by er) may be written as:

$$er_t = \frac{p_t^*}{p_t} \tag{2}$$

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, i.e.:

$$p_{c_t} = p_t^{*p_1} p_t^{(1-p_1)} \; ; \; 0 < p_1 < 1 \tag{3}$$

1/ The model can easily be extended to a three-good (exportable, importables, nontraded goods) structure. However, to preserve clarity in this presentation, the more familiar two-good structure has been preserved.

2/ The subscript t 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.

Using the weight of imports in the capital stock, q_1, the price of capital (p_k) can be similarly written,

$$p_{k_t} = p_t^{*q_1} p_t^{(1-q_1)} \quad ; \; 0 < q_1 < 1 \tag{4}$$

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 sub-production function that produces capital out of domestic and foreign goods are of the Cobb-Douglas type.

2. 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:

$$\log y_t = \alpha_0 + \alpha_1 nt + \alpha_2 \log k_t + \alpha_3 \log z_{M,t} \tag{5}$$

where y is gross domestic output. The α_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, ie.,

$$z_{M,t} = \frac{\alpha_3 y_t p_t}{p_t^*} \tag{6}$$

In the present version of the model, nominal wages are taken to be 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:

$$w_t = \frac{\alpha_1 y_t}{(1+n)^t} \frac{p_t}{p_{c_t}} \tag{7}$$

3. Aggregate demand

The assumptions about the household's instantaneous utility function and the sub-production function for capital imply that the equilibrium condition in the market for domestic goods can be written as:

$$y_t = (1-p_1)\, C_t er_t^{p_1} + (1-q_1)\, I_t er_t^{q_1} + GD_t + X_t \tag{8}$$

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: 1/

$$\log C_t = c_0 + c_1 (r_t - \rho) + c_2 \log y_{p,t} \tag{9}$$

where r is the real consumption rate of interest (the nominal interest rate corrected for the expected change in p_c), ρ the rate of time preference, y_p is permanent income, and c_o, 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, rw, 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 as follows:

1/ See Friedman (1975) and Hall (1978).

$$rw_t = (1+r_t)\frac{M_t + d_t F_{p,t} - DC_{p,t}}{p_{c_t}} \qquad (10)$$

$$+ y_t^d + \sum_{i=1}^{19} \prod_{j=1}^{i} \left(\frac{1}{(1 + E_t r_{t+j})}\right) E_t y_{t+i}^d \quad .$$

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_t 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. 1/ 2/ 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 (i.e., discounted back to the present by the household).

Disposable income y^d is the domestic component of real output, rgdp, net of the foregone interest on holdings of real cash balances, of lump-sum taxes, tx, and of investment, all measured in terms of domestic consumption units:

$$y_t^d = \frac{p_t rgdp_t - (i_t p_{c,t}/p_{c,t+1})M_t - (tx_t + I_t er_t^{ql})p_t}{p_{c_t}} \quad , \qquad (11)$$

where:

$$rgdp_t = (1 - \alpha_3)y_t \qquad (12)$$

is the domestic component of real output (gross output net of the share of imported intermediate goods).

1/ For all stock variables (such as M, F_p, and DC), the subscript t denotes beginning-of-period values.

2/ 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 many-period horizons.

Finally, permanent income is derived from private wealth according to:

$$y_{p,t} = \left[1 + \sum_{i=1}^{19} \prod_{j=1}^{i} (1+E_t r_{t+j})^{-1} \right]^{-1} rw_t \qquad (13)$$

Investment has been modeled along conventional neoclassical lines. The desired capital stock, denoted k*, is that which equates the marginal revenue product of capital (α_2 py/k) to the rental rate for capital services ($(r_I+\delta)p_k$). Thus the desired capital stock can be written as:

$$k_t^* = \frac{\alpha_2 \, p_t \, y_t}{(r_{I,t}+\delta) \, p_{k_t}} \qquad (14)$$

where r_I 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 will allow a constant capital-labor ratio in the steady state. Consequently, the complete investment function is:

$$I_t = (n+\delta)k_t + i_1 \left[\frac{\alpha_2 \, p_t \, y_t}{k_t p_{k_t} (r_{I_t}+\delta)} - 1 \right] k_t \qquad (15)$$

Since government expenditures on domestic goods, GD, 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, are taken to be negatively related to the real exchange rate, er, and positively related to real income abroad, y*, i.e.: 1/

$$\log X_t = x_0 + x_1 \log er_t + x_2 \log y_t^* + x_3 t \qquad (16)$$

1/ Demand-side determination of exports, as in (16), is a standard characteristic of Mundell-Fleming models. A trend is introduced in (16), however, to allow for different steady-state growth rates of real output at home and abroad.

4. The 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:

$$ca_t = \frac{X_t p_t}{e_t} - (z_p+z_g+z_m)p_t^f + i_t^*(F_p+F_G+F_B)_t \qquad (17)$$

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, i.e., 1/

$$z_{p,t} = p_1 C_t er_t^{(p_1-1)} + q_1 I_t er_t^{(q_1-1)} \qquad (18)$$

The capital account surplus is equal to minus the change in foreign asset holdings of the public and private nonbank sectors:

$$ka_t = -\left(F_{G,t+1} - F_{G,t} + F_{p,t+1} - F_{p,t}\right) \qquad (19)$$

Finally, the current and capital accounts make up the balance of payments:

1/ Notice 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).

$$F_{B,t+1} - F_{B,t} = ca_t + ka_t \tag{20}$$

5. The monetary and financial sectors

We assume that domestic (i.e., bank credit) and foreign interest-bearing instruments are perfect substitutes, so 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.e.,

$$i_t = \frac{E_t d_{t+1} - d_t}{d_t} + i_t^* \frac{e_t}{d_t} \tag{21a}$$

This equation in addition relies on the assumption that all interest receipts are required 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,

$$r_t = (1 + i_t) \frac{p_{c_t}}{p_{c,t+1}} - 1 \tag{21b}$$

and

$$r_{I_t} = (1 + i_t) \frac{p_{k_t}}{p_{k,t+1}} - 1 \tag{21c}$$

The demand for money is derived from a simple transaction motive and is given by:

$$\log (M_t/p_{c,t}) = \lambda_o + \lambda_1 i_t + \lambda_2 \log y_t \; ; \; \lambda_1 < 0 \; , \; \lambda_2 > 0 \; . \tag{22}$$

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:

$$M_t = e_t F_{B,t} + DC_t - N_t \ , \tag{23}$$

where total domestic credit, DC, consists of credit to the private sector, DC_p, and to the public sector, DC_G:

$$DC_t = DC_{p,t} + DC_{G,t} \tag{24}$$

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 ($\Delta e F_{B,t}$) exceed bank transfers to the government. The latter are denoted tr, measured in units of the domestic good. Thus the central bank's budget constraint is:

$$N_{t+1} = N_t + i^*_t e_t F_{B,t} + i_t DC_t + (d_t - e_t)\Delta F_{p,t} + \Delta e F_{B,t} - tr_t p_t \tag{25}$$

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 (ΔF_p), and the level of real central bank transfers to the government (tr) 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:

$$tr_t p_t = i^*_t e_t F_{B,t} + i_t DC_t + (d_t - e_t)\Delta F_{p,t} - \left(\frac{p_{t+1}}{p_t}(1+n)-1\right)N_t \tag{26}$$

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.

6. Government

The government's revenue sources consist of taxes on the private sector and transfers from the central bank. It consumes both domestic and foreign goods, and pays interest on its domestic and external debt. Consequently, the government surplus, denoted s, can be written as follows:

$$s_t = p_t(tx_t + tr_t - gd_t - \frac{p^*_t z_{Gt}}{p_t}) + i^*_t e_t F_{G,t} - i_t DC_{G,t} \qquad (27)$$

The deficit is financed by borrowing either at home or abroad, i.e.,

$$e_t (F_{G,t+1} - F_{G,t}) = s_t + DC_{G,t+1} - DC_{G,t} \qquad (28)$$

The government is subject to an intertemporal budget constraint which prevents its external debt from growing excessively, thus precluding Ponzi schemes. We incorporate this in our model via a particularly simple mechanism--specifically, the government is assumed not to tolerate an ever-increasing debt to 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 1/:

$$z_{G,t} = \bar{z}_{G,t} + \sigma(1 - \frac{e_t F_{G,t}/p_t y_t}{\theta})\bar{z}_{G,t} \quad ; \ \sigma > 0 \ , \ \theta < 0 \qquad (29)$$

where $\bar{z}_G$ is an exogenous level of government imports, θ is the (negative) baseline value of the government debt/GDP ratio, and σ is an adjustment parameter.

7. Expectations

As mentioned in the previous section, an important feature of our model is that agents' expectations are forward-looking and specifically

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1/ 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.

are formed rationally for all relevant future variables. 1/ These 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:

$$E_t(r_{t+i}) = r_{t+i} \tag{30a}$$

$$E_t(y^d_{t+i}) = y^d_{t+i} \tag{30b}$$

$$E_t(d_{t+i}) = d_{t+i} \tag{30c}$$

$$E_t(p_{c,t+i}) = p_{c,t+i} \tag{30d}$$

$$E_t(p_{k,t+i}) = p_{k,t+i} \tag{30e}$$

III. 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 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 (e.g., consumption to 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 the Appendix.

With the baseline established, the properties of the model can be investigated by subjecting it to a variety of policy and exogenous shocks. In this paper we study the effects of five shocks, consisting of 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

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1/ 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.

transitory. 1/ Model solutions were obtained using the Fair-Taylor algorithm in TROLL (see Fair and Taylor (1983)).

1. 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 5 periods, after which credit was reduced back to its earlier levels. Since credit to the public sector 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. Charts 1a to 1d show 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 1c). 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 1b). This lowers the domestic nominal interest rate and also contributes to eliminating the incipient excess supply of money.

1/ 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.

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.

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 1c). 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 1b). 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 smaller stock of reserves than initially. To clear the money and goods markets, this 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 1d).

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 Chart 1d. 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 Chart 1d the wage rises proportionately more than real output on impact, due to the price increase. The increase in the real wage reflects an increase in the marginal product of labor due 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, due to the

Domestic Credit Shock

Chart 1a

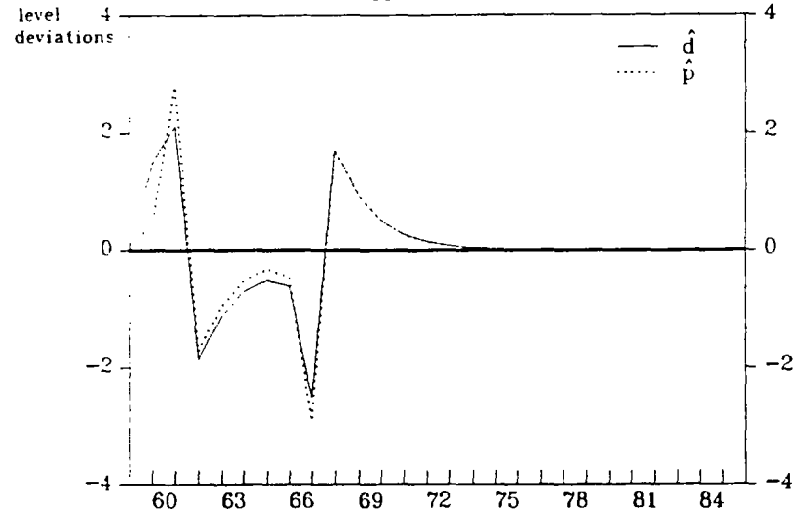


Chart 1b

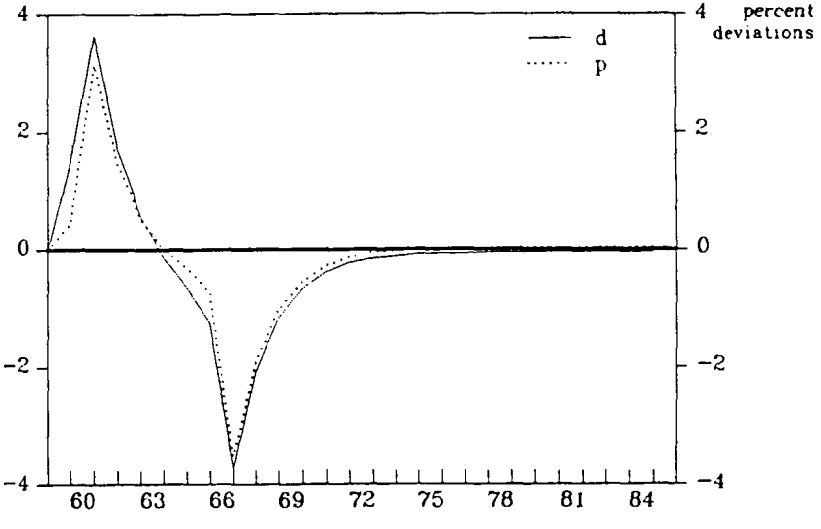


Chart 1c

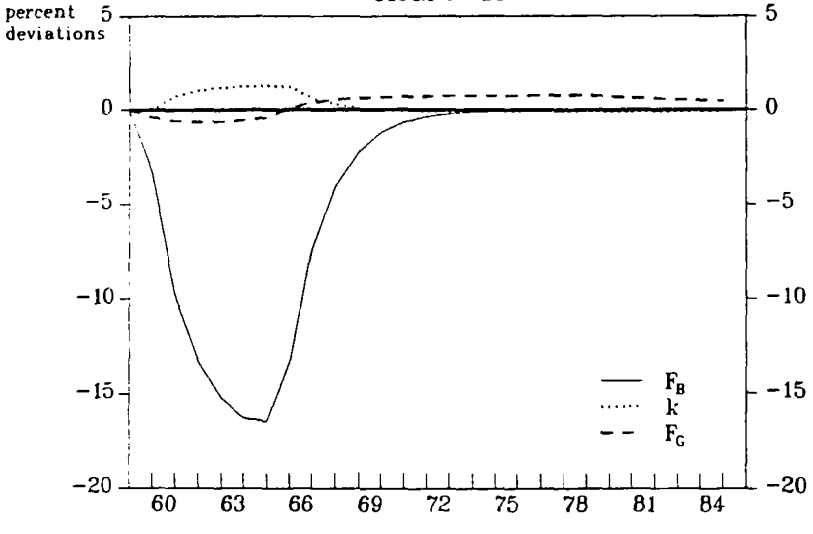
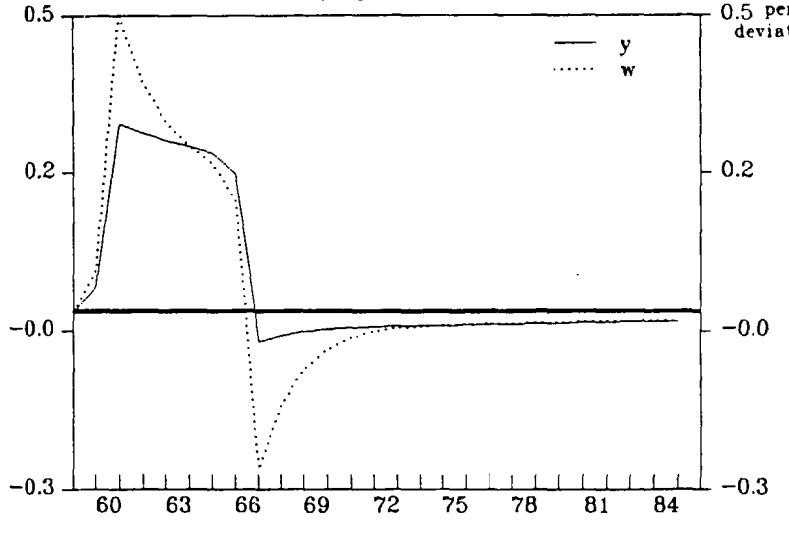


Chart 1d



** All charts reflect deviations from the baseline.

collapse of domestic prices. Finally, in the post-shock period, the real wage rises relative to baseline.

2. Government expenditure shock

The unanticipated and transitory government expenditure shock consisted of an increase in expenditures equal to one percent of GDP lasting for 5 periods and financed entirely by external borrowing. The increase in expenditures is devoted entirely to domestic goods. Charts 2a to 2d illustrate 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 (Chart 2d), 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 Chart 2c. Since the stock of domestic credit is unchanged, the fiscal stimulus is therefore accompanied by a monetary expansion which 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 (Chart 2b). This puts upward pressure on both nominal and real interest rates. Since domestic goods carry a smaller 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 (Chart 2c), as do real output and the real wage (Chart 2d), 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 the capital stock to exceed its baseline value by the fifth period of the shock (Chart 2c). This adds a positive supply effect to support the demand pressures which cause output and the real wage to exceed their baseline levels after the first period of the shock (Chart 2d).

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 (Charts 2a and 2b) 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 back to their baseline levels. The reserve depletion comes about because, in the absence of the capital inflows associated with the financing of the fiscal deficit, the current account deficit due 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 more 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 (Chart 2c), 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 (Chart 2c). The implication is that output and the real wage return to their baseline levels very slowly (Chart 2d).

3. Central Bank intervention in the 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_D amounting to five 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 so as to keep F_D 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_B falls in equation

Government Spending Shock

Chart 2a

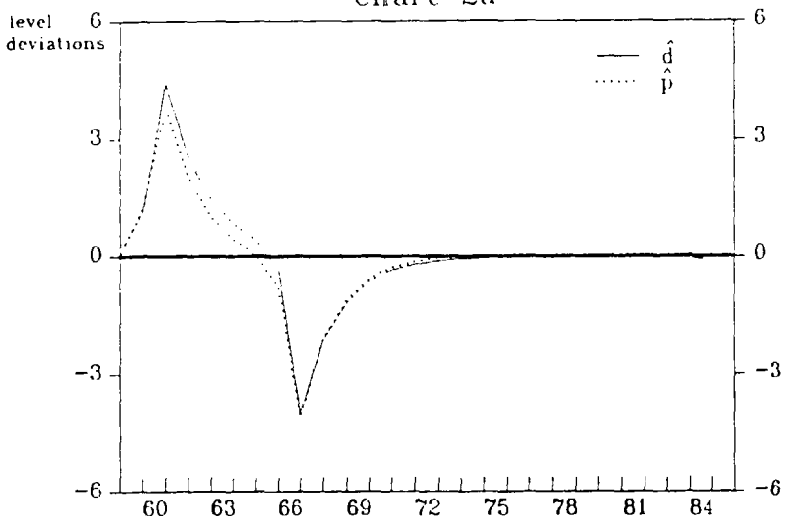


Chart 2b

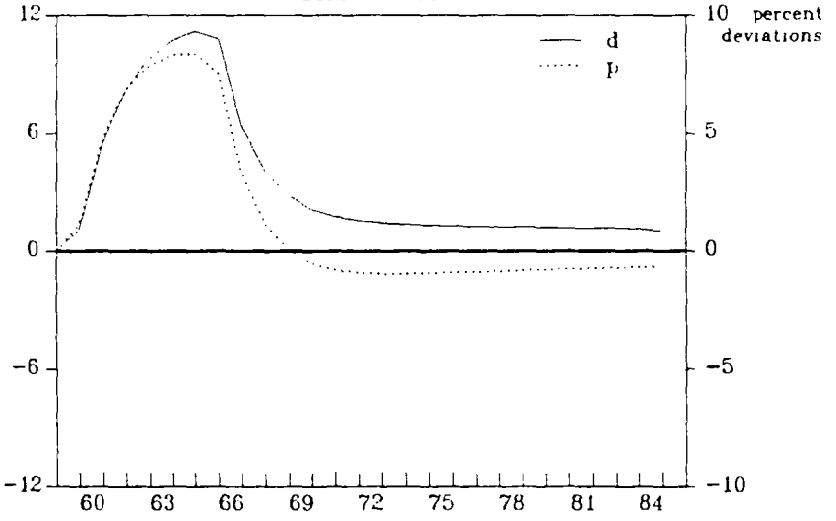


Chart 2c

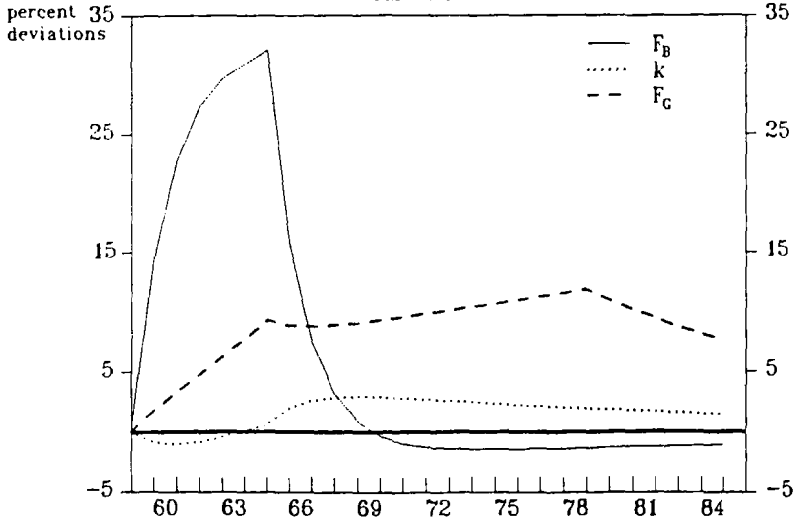
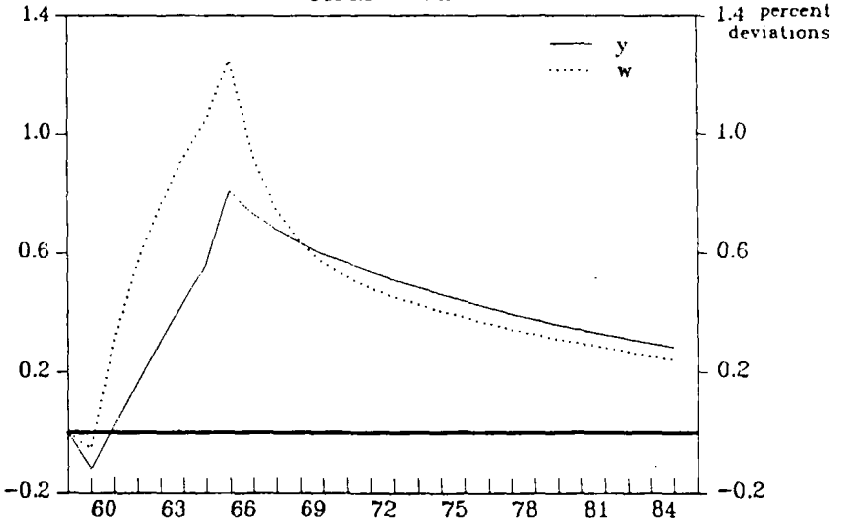


Chart 2d



** All charts reflect deviations from the baseline.

(23)). The consequences of this are essentially identical to those of a credit contraction. This can be verified by comparing Charts 3a-3d with Charts 1a-1d. The former, which describe the effects of the free-market intervention, are essentially the reverse of the latter, which concern 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 3c). Notice first that, unlike the other variables depicted, reserves move in the same direction (i.e,. 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. This is, of course, because 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, due 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 occurs when the foreign exchange is repurchased by the central bank and is due to 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.

4. 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 two percentage points (200 basis points) for six periods, followed by a 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--i.e., 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 (i.e., F_p is exogenous), the free exchange rate depreciates sharply (Chart 4b). 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 it does not do so 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 to the 200 basis point increase in the foreign interest rate. Moreover, the balance of payments improves (Chart 4c) because the higher interest receipts by the private sector more than offset the deterioration in the trade balance. 1/ 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 investment real interest rate, 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 (Charts 4b-4d). 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 (Chart 4b). From here on, events unfold as in previous exercises. When the infusion of reserves through private-sector interest receipts 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 Chart 4c, debt rises abruptly from the shock's inception. The reason is, of course, that 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_G curve in Chart 4c. 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 Chart 4c, this appears as the second kink in the F_G 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

1/ Higher public-sector interest payments abroad are financed by capital inflows, with no net effect on the balance of payments.

Free Market Intervention

Chart 3a

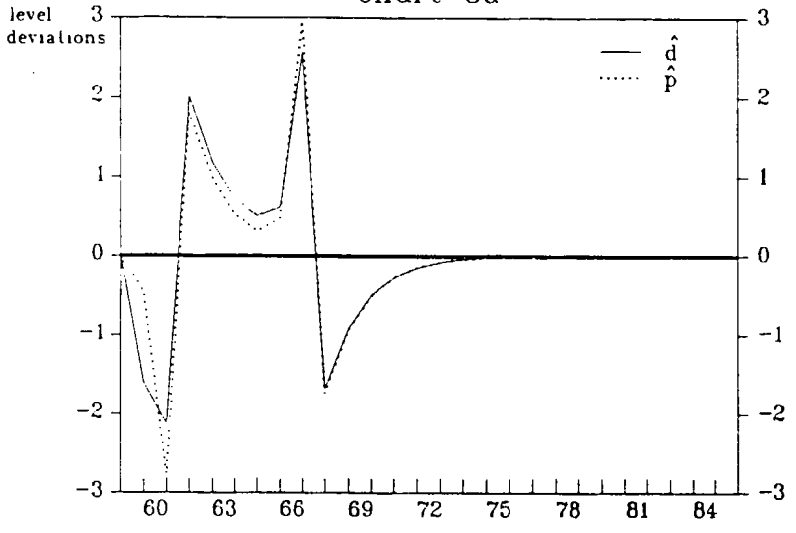


Chart 3b

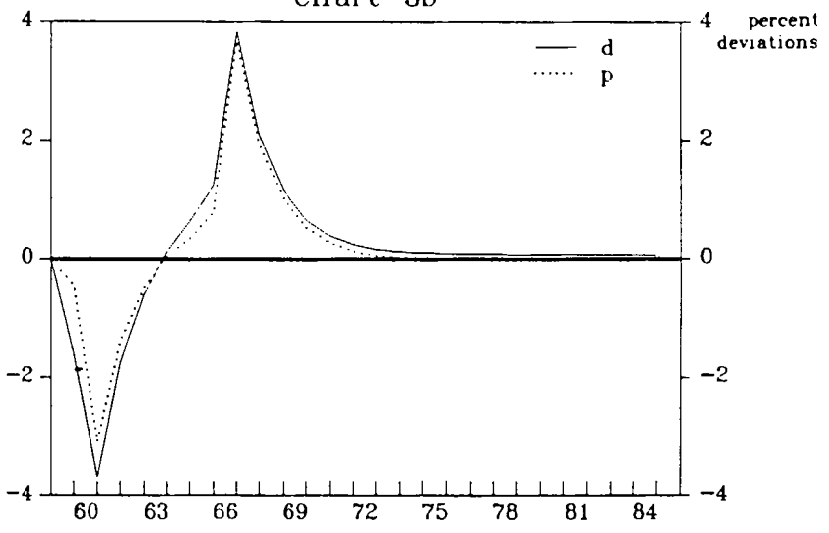


Chart 3c

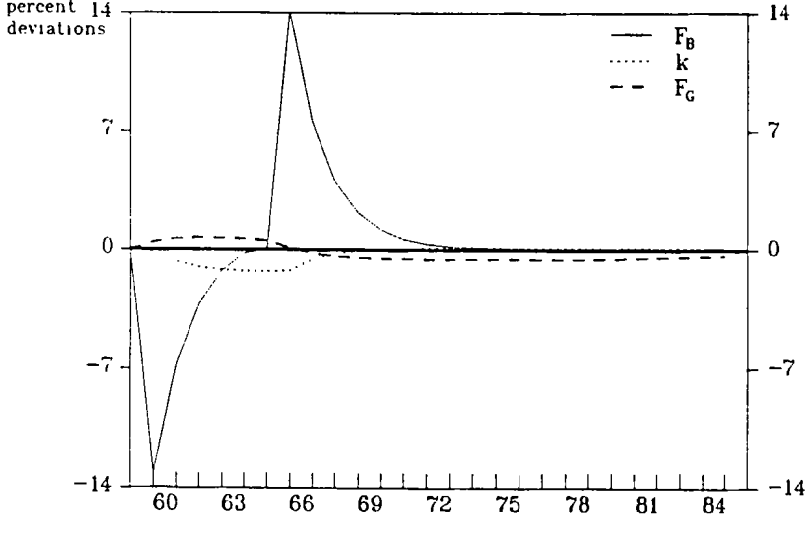
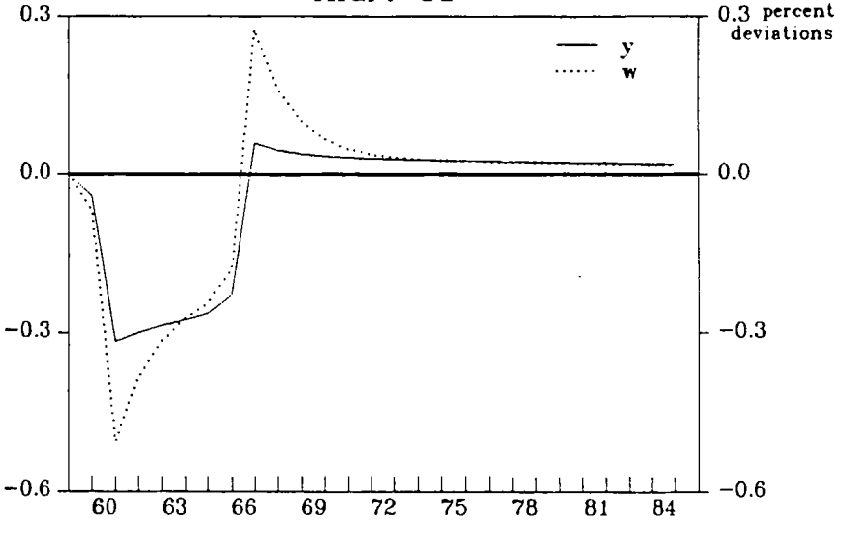


Chart 3d



** All charts reflect deviations from the baseline.

Foreign Interest Rate Shock

Chart 4a

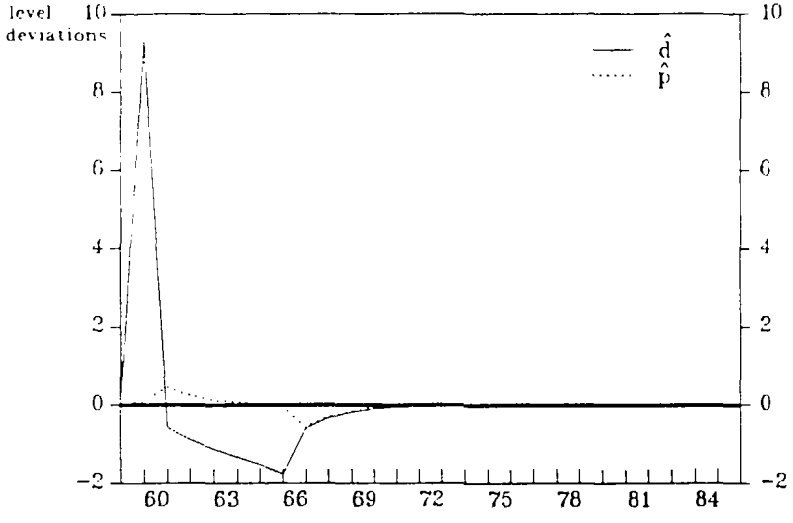


Chart 4b

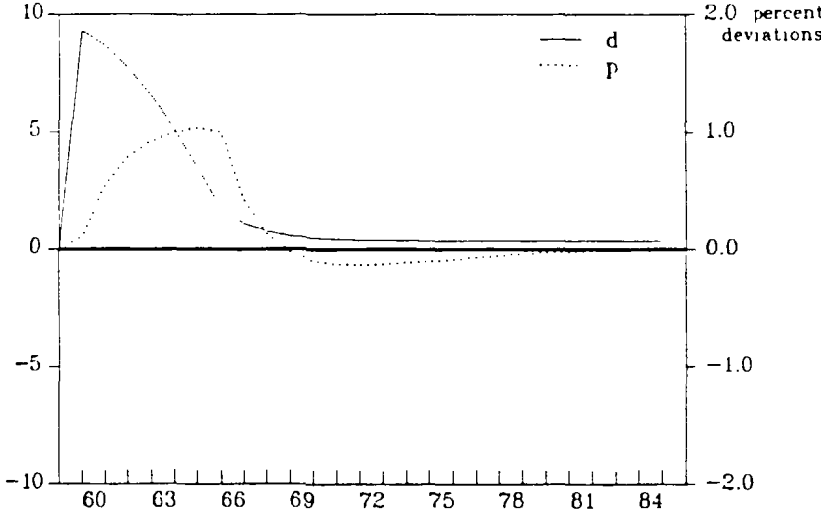


Chart 4c

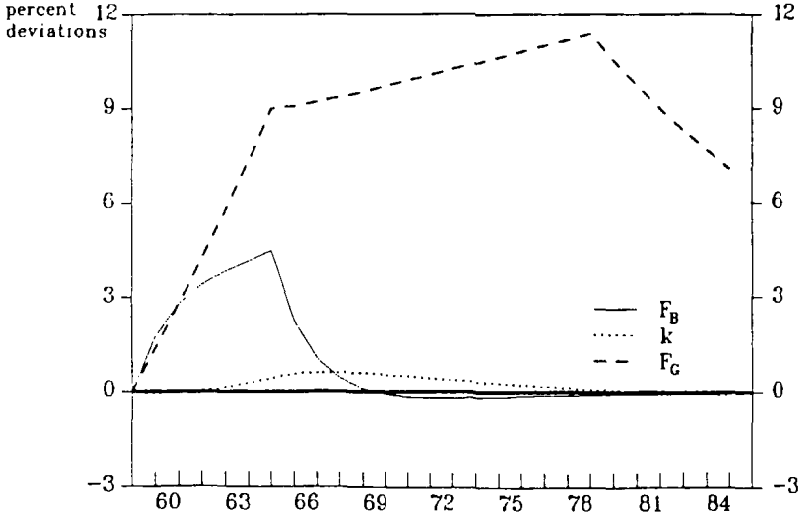
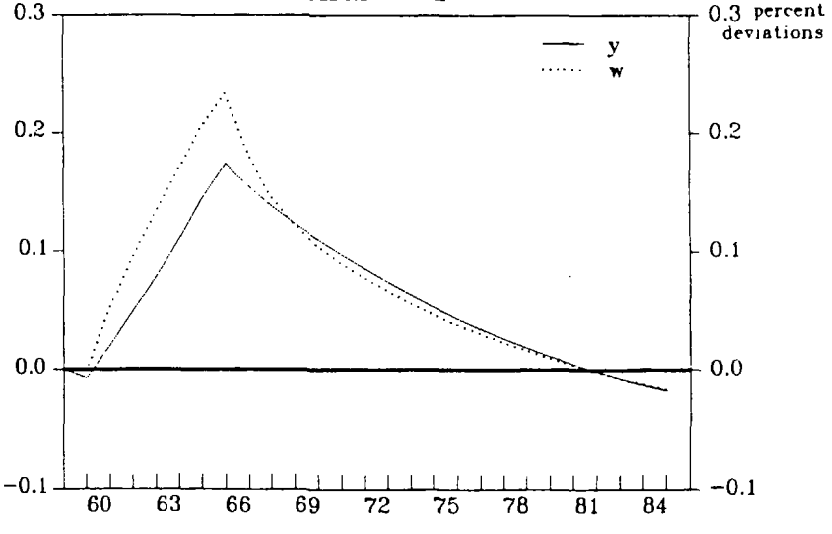


Chart 4d



** All charts reflect deviations from the baseline.

would require less of an initial jump in d to generate the equilibrating wealth effects, it also would imply more rapid reserve accumulation via private interest receipts while the foreign interest rate is high.

5. Devaluation of the official exchange rate

Up to now, both the domestic and external shocks considered have been transitory in nature. We now turn to the analysis of a permanent shock--a five 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 five 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 five percent. The nominal money supply must similarly increase by five 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 about a little less than 5 percent 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 Charts 5a-5d. The economy cannot immediately return to its real steady state, because the required reserve inflow can only be procured via 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 demand contraction on domestic economic activity is partially offset by the expenditure-switching effect mentioned above--i.e., 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. 1/ 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 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.

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 permanently larger stock of foreign-exchange reserves.

IV. 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--i.e., our attention has been devoted to the model itself, rather than to using the model to address substantive research or policy questions. Nonetheless, a number of interesting results have emerged from our simulations. We can now offer some general conclusions about the model, followed by specific findings from the simulations, and finally by a partial list of planned future modifications in the model.

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 inde-

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1/ This outcome of increased inflation and output contraction following a nominal devaluation has long been claimed by structuralist critics of orthodox stabilization policies (see Taylor (1981)).

Exchange Rate Shock

Chart 5a

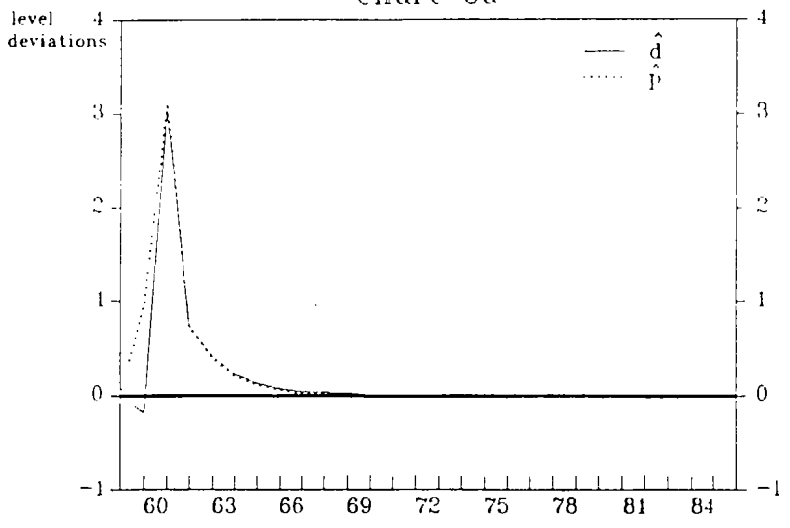


Chart 5b

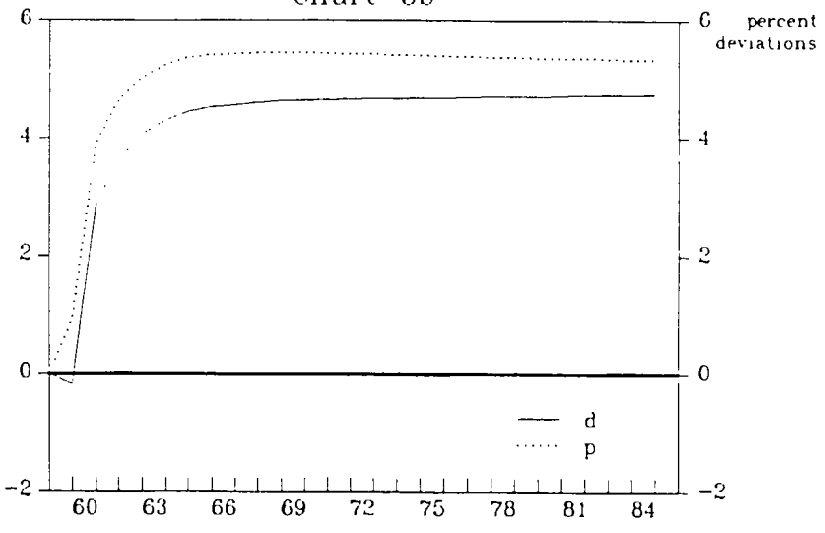


Chart 5c

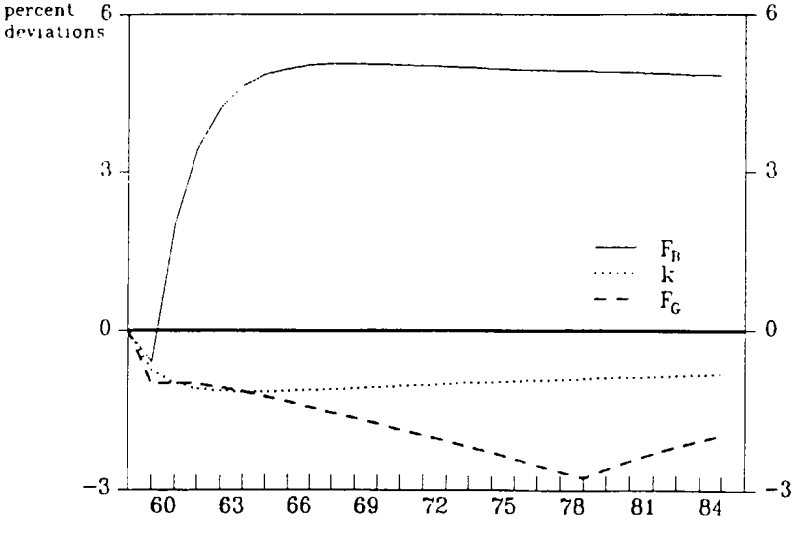
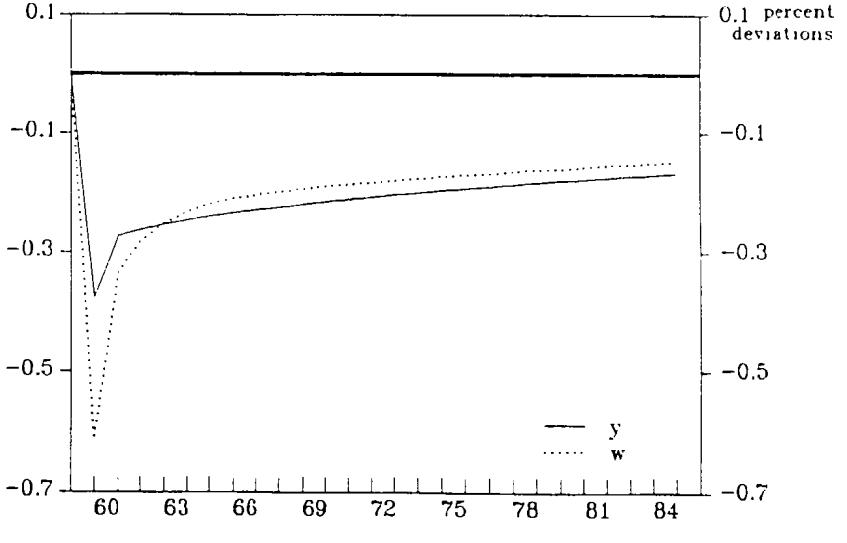


Chart 5d



** All charts reflect deviations from the baseline.

pendent interest, but that 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. Regarding the former, temporary increases in government spending on domestic goods financed by external borrowing, or in the availability of bank credit to the private sector, indeed boost economic activity, raise prices, and cause the current account to deteriorate for some time. All this accords with what one should expect. Among the new insights, however, are the following:

(a) The impact affects of a number of shocks are opposite 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 underlines the importance of dynamic analysis in this context.

(b) Central bank intervention in the free exchange market has macroeconomic effects similar to changes in credit availability. Thus the policy tools available to the monetary authorities even in developing countries with very limited markets for securities may be greater in number than is commonly supposed.

(c) 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 in the absence of 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.

(d) 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 function, 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 developing-country macroeconomic issues.

The Complete Model

1. Prices

$$p_t^* = e_t p_t^f \tag{1}$$

$$er_t = \frac{p_t^*}{p_t} \tag{2}$$

$$p_{c_t} = p_t^{*p_1} p_t^{(1-p_1)} \; ; \; 0 < p_1 < 1 \tag{3}$$

$$p_{k_t} = p_t^{*q_1} p_t^{(1-q_1)} \; ; \; 0 < q_1 < 1 \tag{4}$$

2. Aggregate Supply

$$\log y_t = \alpha_0 + \alpha_1 nt + \alpha_2 \log k_t + \alpha_3 \log z_{M,t} \tag{5}$$

$$z_{M,t} = \frac{\alpha_3 y_t p_t}{p_t^*} \tag{6}$$

$$w_t = \frac{\alpha_1 y_t}{(1+n)^t} \frac{p_t}{p_{c_t}} \tag{7}$$

3. Aggregate Demand

$$y_t = (1-p_1) C_t er_t^{p_1} + (1-q_1) I_t er_t^{q_1} + GD_t + X_t \tag{8}$$

$$\log C_t = c_0 + c_1(r_t - \rho) + c_2 \log y_{p,t} \tag{9}$$

$$rw_t = (1+r) \frac{M_t + d_t p_{p,t} - D_{p,t}}{p_{c_t}} \tag{10}$$

$$+ y_t^d + \sum_{i=1}^{19} \prod_{j=0}^{i} \left(\frac{1}{(1 + E_t r_{t+j})}\right) E_t y_{t+i}^d$$

$$y_t^d = \frac{p_t rgdp_t - (i_t p_{c,t}/p_{c,t+1})M_t - (tx_t + I_t er_t^{q1})p_t}{p_{c_t}}, \tag{11}$$

$$rgdp_t = (1 - \alpha_3) y_t \tag{12}$$

$$y_{p,t} = \left[1 + \sum_{i=1}^{19} \prod_{j=0}^{i-1} (1+E_t r_{t+j})^{-1} \right]^{-1} rw_t \tag{13}$$

$$k_t^* = \frac{\alpha_2 \, p_t \, y_t}{(r_{I,t} + \delta) \, p_{k_t}} \tag{14}$$

$$I_t = (n+\delta)k_t + i_1 \left[\frac{\alpha_2 \, p_t \, y_t}{k_t p_{k_t} (r_{I_t} + \delta)} - 1 \right] k_{t-1} \tag{15}$$

$$\log X_t = x_0 + x_1 \log er_t + x_2 \log y_t^* + x_3 t \tag{16}$$

4. The External Account

$$ca_t = \frac{X_t P_t}{e_t} - (z_p + z_g + z_m) P_t^f + i_t^* (F_p + F_G + F_B)_t \tag{17}$$

$$z_{p,t} = p_1 C_t er_t^{(p_1 - 1)} + q_1 I_t er_t^{(q_1 - 1)} \tag{18}$$

$$ka_t = -\left[F_{G,t+1} - F_{G,t} + F_{p,t+1} - F_{p,t}\right] \tag{19}$$

$$F_{B,t+1} - F_{B,t} = ca_t + ka_t \tag{20}$$

5. The Monetary and Financial Sectors

$$i_t = \frac{E_t d_{t+1} - d_t}{d_t} + i_t^* \frac{e_t}{d_t} \tag{21a}$$

$$r_t = (1 + i_t) \frac{p_{c_t}}{p_{c,t+1}} - 1 \tag{21b}$$

$$r_{I_t} = (1 + i_t) \frac{p_{k_t}}{p_{k,t+1}} - 1 \tag{21c}$$

$$\log (M_t / p_{c,t}) = \lambda_o + \lambda_1 i_t + \lambda_2 \log y_t \tag{22}$$

$$M_t = e_t F_{B,t} + DC_t - N_t \ , \tag{23}$$

$$DC_t = DC_{p,t} + DC_{G,t} \tag{24}$$

$$N_{t+1} = N_t + i_t^* e_t F_{B,t} + i_t DC_t + (d_t - e_t)\Delta F_{p,t} + \Delta e F_{B,t} - tr_t p_t \qquad (25)$$

$$tr_t\, p_t = i_t^*\, e_t\, F_{B,t} + i_t\, DC_t + (d_t - e_t)\Delta F_{p,t} - \left(\frac{p_{t+1}}{p_t}\,(1+n) - 1\right)N_t \qquad (26)$$

$$s_t = p_t\left(tx_t + tr_t - gd - \frac{p_t^*\, z_{Gt}}{p_t}\right) + i_t^*\, e_t\, F_{G,t} - i_t\, DC_{G,t} \qquad (27)$$

$$e_t\,(F_{G,t+1} - F_{G,t}) = s_t + DC_{G,t+1} - DC_{G,t} \qquad (28)$$

$$z_{G,t} = \bar{z}_{G,t} + \sigma\left(1 - \frac{e_t F_{G,t}/p_t y_t}{\theta}\right)\bar{z}_{G,t} \;;\; \sigma > 0 \;,\; \theta < 0 \qquad (29)$$

APPENDIX II

Variable Definitions

ca	=	Current account in foreign currency units
C_t	=	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
DC_p	=	Stock of domestic credit to the private sector
DC_g	=	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_t	=	Real government spending on domestic goods
i	=	Domestic nominal interest rate
i^*	=	External nominal interest rate
I_t	=	Real investment measured in units of the capital good
k	=	Capital stock, measured in units of the capital good
k*	=	Desired capital stock, measured in units of the capital good
ka	=	Capital account in foreign currency units
M	=	Nominal money supply
N	=	Central bank's net worth
n	=	Constant growth rate of the labor force

p	=	Price of the domestic good
p^*	=	Price of the foreign good in domestic currency terms
p_1	=	Share of imports in domestic consumption
p_c	=	Price of the consumption good
p_k	=	Price of capital
p^f	=	Price of the foreign good in foreign currency terms
q_1	=	Share of imports in capital
r	=	Real rate of interest for consumption
r_I	=	Real rate of interest for investment
rgdp	=	Real domestic value added, measured in units of the domestic good
rw	=	real wealth
s	=	Surplus in the government budget
t	=	Time in years
tr	=	real transfers
tx	=	Real taxes
w	=	Average real wage rate in the economy measured in units of consumption goods
X_t	=	Real exports
y	=	Gross domestic output
y^*	=	Real income abroad
y_t^d	=	Real private disposable income, measured in units of the consumption good
y_p	=	Permanent income, measured in units of the consumption good
z_g	=	Government imports
$\bar{z}_g$	=	Policy-determined z_g
z_m	=	Imported inputs

z_p = Imports of final goods by the private sector

ρ = Rate of time preference

δ = Rate of depreciation of capital stock

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 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 rgdp, c, F_G, F_B, M, DC_p, d, and p were made exogenous, while α_o, c_o, x_o, λ_o, GD, DC, DC_G, and tx became endogenous. The initial values of rgdp, p, and d were arbitrarily set at 100, 1, and 1 respectively. The remaining variables were given initial values of c = 66, M = 20, DC_p = 6, F_B = 6, and F_G = -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. 1/ The initial values for the remaining exogenous variables were: $y^* = 100$, $F_p = 8$, $\bar{z}_G = 5$, $i^* = 0.065$, $p^* = e = 1$. 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 debt, given by $F_G+F_B+F_p$, 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 per period, and that the domestic and foreign inflation rates were both 4 percent per 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 baseline data were generated by the model itself.

1/ With 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.

Table 1. Parameters Employed in the Simulations

1.	Composition of Spending	
a.	Share of consumption devoted to imports	$(p_1) = 0.06$
b.	Share of investment devoted to imports	$(q_1) = 0.167$
2.	Production Function	
a.	Share of labor	$(\alpha_1) = 0.74$
b.	Share of capital	$(\alpha_2) = 0.21$
c.	Share of imported inputs	$(\alpha_3) = 0.05$
3.	Consumption	
a.	Interest semi-elasticity	$(c_1) = -0.13$
b.	Permanent income elasticity	$(c_2) = 1$
4.	Investment	
a.	Speed of adjustment	$(i_1) = 0.1$
b.	Rate of depreciation	$(\delta) = 0.1$
5.	Exports	
a.	Price elasticity	$(x_1) = 0.57$
b.	Foreign income elasticity	$(x_2) = 2.0$
c.	Trend	$(x_3) = -0.025$
6.	Money Demand	
a.	Interest rate semi-elasticity	$(\lambda_1) = -0.2$
b.	Income elasticity	$(\lambda_2) = 1.0$

Domestic Credit Shock with Adaptive Expectations

A graphical illustration of the role of the expectations assumption appears in Charts 6a-6d, which present the domestic credit shock analyzed in Section III.1 under an alternative version of the model which 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 Charts 6b-6d with the corresponding peak movements in Charts 1b-1d). Convergence to the steady state exhibits pronounced cycles under adaptive expectations, compared to the smooth convergence achieved in the case of perfect foresight.

Adaptive Expectations Domestic Credit Shock

Chart 6a

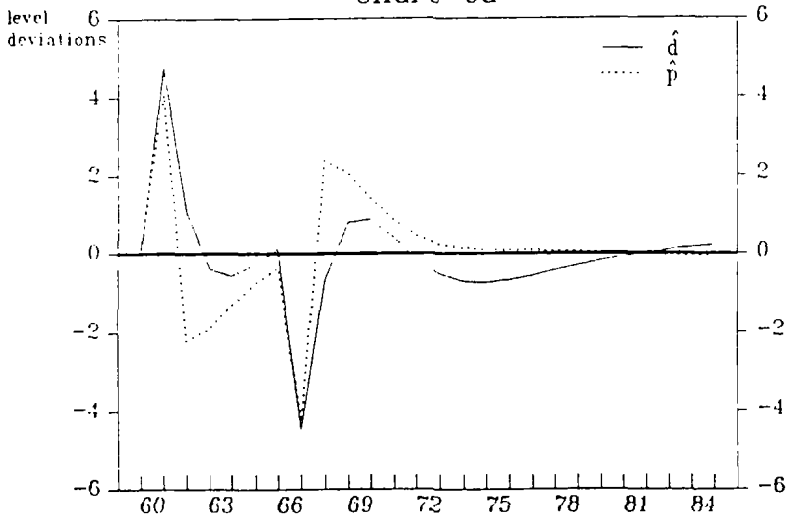


Chart 6b

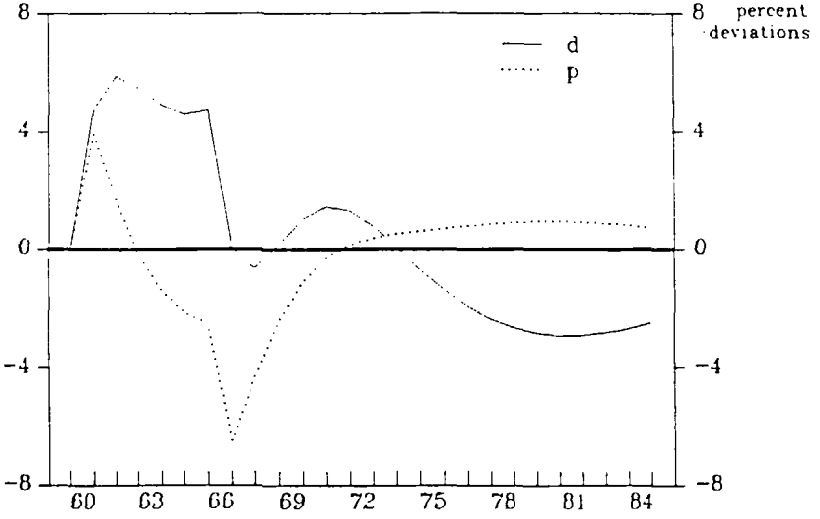


Chart 6c

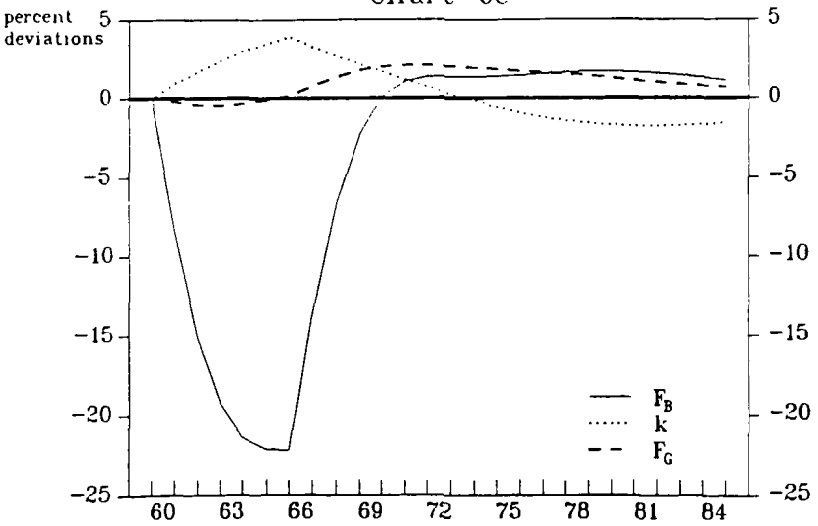
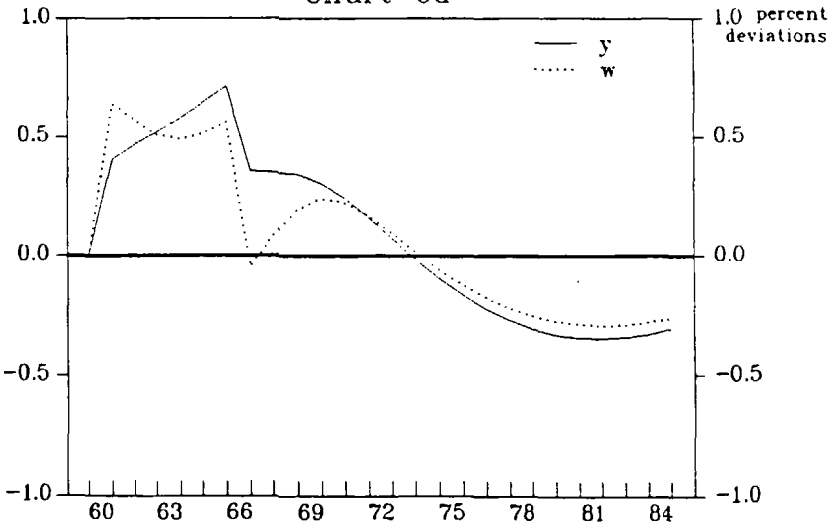


Chart 6d



** All charts reflect deviations from the baseline.

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