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A General Equilibrium Model *with Informal Financial Markets*

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Abstract

The paper presents a general equilibrium framework for short-run macroeconomic analysis in a developing country context where controls on interest rates and foreign exchange restrictions lead to the emergence of informal financial markets. The complexity of the model precludes an analytical treatment. A simulation approach, based on parameters derived from estimates in the existing literature, is used to assess the properties of the model, which differ in important ways from those of standard open-economy models.

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Summary

The paper presents a general-equilibrium framework for short-run macroeconomic analysis in a developing country where agents are subject to foreign exchange restrictions and face interest rate ceilings. These ceilings and restrictions lead to the emergence of informal markets. Expectations are formed rationally, and nominal wages are determined through one-period labor contracts. Asset demand functions are derived within the framework of a portfolio approach. Interactions between stocks and flows in the model are consistently formulated.

The complexity of the model precludes an analytical treatment. Therefore, a simulation approach, based in part on parameters derived from the existing literature, is used to assess its properties. Experiments using policy variables that are typically altered in stabilization programs illustrate the workings of the model. Specifically, the simulations analyze the macroeconomic effects of a temporary increase in government spending on home goods, a temporary increase in central bank credit to commercial banks, a longer-run increase by 1 percentage point of official interest rate on bank loans, and a once-and-for-all devaluation of the official exchange rate. Policies are announced before being implemented and are assumed to be fully credible.

The simulation experiments highlight the importance of wealth and income effects associated with the existence of informal loan and foreign currency markets. As in standard models, anticipated expansionary fiscal and credit policies are associated with a rise in output, prices, and the informal interest rate, as well as a current account deficit and a depreciation of the parallel exchange rate. These results are quantitatively sensitive, however, to structural characteristics not often incorporated in standard models. Moreover, unlike the prediction derived from other models, an increase in lending and deposit interest rates in the formal financial sector may lead to a fall, rather than an increase, in private bank deposits, and may well be associated with a temporary contraction in output. An anticipated once-and-for-all devaluation of the official exchange rate is associated with a fall in the parallel market premium, both in the short- and the long-run. Again, in contrast to standard models, the devaluation also has a temporary expansionary effect in the transition period following the announcement and a contractionary effect when implemented.

I. Introduction

Recent developments in macroeconomics for developing countries have focused on the role of informal credit and foreign currency markets in the design of stabilization policies. In most developing countries with an underdeveloped system of financial intermediation commercial banks play a predominant role as a source of funds for firms, both for short-term working capital purposes and for long-term fixed capital formation. Bank credit is, however, often rationed, with bank lending rates typically fixed by the authorities and unresponsive to excess demand for credit. As a consequence of this "financial repression", unorganized money markets tend to develop and become an essential source of funds. 1/ Similarly, the imposition of trade controls and exchange restrictions on foreign transactions have often led to the emergence of parallel markets in foreign currency.

The macroeconomic role of financial repression in developing countries has proven to be controversial. While there is widespread agreement on the microeconomic distortions implied by interest rate ceilings, the consensus does not extend to the short-run macroeconomic effects of removing such ceilings or moving administered interest rates closer to market-clearing levels. Analysts in the McKinnon-Shaw tradition would argue that raising controlled interest rates need have no effect on aggregate demand, and would simply shift the composition of such demand from consumption to investment. By contrast, adherents of the "New Structuralist" school emphasize the presence of informal loan markets, and suggest that raising controlled interest rates would draw funds away from such markets, thereby raising interest rates there, as well as constraining aggregate demand. 2/

1/ The parallel or "curb" market is an informal --sometimes illegal-- credit market in which loan suppliers and demanders can transact freely at uncontrolled interest rates. In some countries, the volume of loans transacted in the curb market is believed to be at least as great, and perhaps several fold greater, than that transacted in official credit markets. Empirical evidence on the role of informal loan markets is provided by Chandavarkar (1987). See also González-Vega and Zinser (1987) for the Dominican Republic, and Timberg and Aiyar (1984) for India. Credit allocation policies in developing countries are critically reviewed by Virmani (1985).

2/ See Arida and Taylor (1989), Bruno (1979), van Wijnbergen (1982, 1983) and Taylor (1983, pp. 86-103). The New Structuralist view has been subject to a number of criticisms; see Agénor (1989), Buffie (1984), Dauhajre (1987), and Owen and Solis-Fallas (1989).

The macroeconomic effects of parallel markets for foreign exchange has also attracted a great deal of interest recently. 1/ Parallel markets in foreign exchange have typically emerged in response to foreign exchange controls. These controls, imposed for balance of payments reasons, generate an unofficial market which is both dependent upon conditions in the official market and responsive to market forces. The price, output and welfare implications of a parallel foreign currency market will vary according to whether unofficial transactions are illegal and participants face penalties which raise expected costs of transacting in this market.

While repressed credit markets and parallel foreign exchange markets coexist in many developing countries, they have only recently been integrated in a common analytical framework by Montiel (1991). However, the requirement of analytical tractability led Montiel (1991) to adopt a very simple macroeconomic model which did not embody several key developing-country features. In particular, leakages between official and parallel foreign exchange markets, which will be shown to play an important role below, were excluded. In addition, the model developed here incorporates other structural features which are commonly perceived as relevant in developing countries, such as trade taxes and imported intermediate inputs in the production process. It allows for the existence of nominal wage contracts, thereby creating the scope for Keynesian unemployment. Agents are also assumed to be forward-looking. 2/ In a forward-looking world, every policy announcement and every event that has a possible implication for future policy affects expectations, and these must be taken into account for a proper understanding of the dynamic effects of policy shocks. The general equilibrium nature of the model makes it particularly suitable for an analysis of the transmission process of macroeconomic policies. Its complexity, however, precludes a purely analytical treatment. A simulation approach, that is, the numerical solution of the model with specific functional forms and parameter values, is used to assess its properties. 3/ Parameter

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1/ See Agénor (1990*b*) for a review of the literature.

2/ Forward-looking expectations have by now become a major feature of developing-country macroeconomic analysis although the hypothesis remains subject to controversy, both in developing countries and elsewhere. See, for instance, Pesaran (1988).

3/ In macroeconomics, simulation is most often associated with specific, estimated econometric models. By contrast, Camilleri et al. (1984), Nguyen and Turnovsky (1983) and Levin (1989) use simulation as it is used here, as basically a theoretical tool to analyze abstract and fairly general models. They described this alternative approach to simulation as "theoretical simulation", in order to highlight its complementarity with the solution of small analytical models.

estimates are either taken directly or inferred from the existing literature on developing countries.

The remainder of the paper is organized as follows. The structure of the model is described in Section II. Simulation experiments, involving changes in policy variables and shocks related to the external economic environment, are examined in Section III. Section IV concludes and discusses some possible extensions of the analysis. The Appendix presents the parameter estimates used in the simulations.

II. Specification of the Model

We consider a small, open economy in which there are four types of agents: the private sector (households and producers), the government, the central bank, and the commercial banks. The exchange rate system consists of an official market which coexists with an illegal (or quasi-illegal) parallel market for foreign exchange. Commercial transactions of the private sector are settled partly in the official market at the fixed exchange rate s. The rest of the commercial transactions and all capital transactions are settled in the parallel market at the free exchange rate b, which is determined by market forces. The central bank determines the total amount of foreign currency sales in the official market, using a rationing rule based on the composition of private consumption imports, after provision has been made for imports of intermediate goods and government imports.

The economy produces two goods: a home good, Q_h, which is used only for final domestic consumption, and an export good, Q_x, for the sole purpose of exports. The capital stock in each sector is fixed over the time frame of the analysis, and labor is perfectly mobile across sectors. A consumer good is imported which is not produced at home and is an imperfect substitute for the home good. Due to the existence of tariffs, foreign exchange controls, and a positive premium between the official and parallel exchange rates, exports are in part smuggled out, and consumer imports are in part smuggled in. Producers also import an intermediate input which is not produced domestically. The central bank provides unlimited access to foreign exchange through the official market to producers for the purchase of imported intermediate inputs. 1/

1/ In principle, unlimited access to the official market may generate the incentive to over-invoice imports of intermediate goods, and this should depend on the same factors affecting the propensity to under-invoice exports (see below). For simplicity, we abstract from this possibility.

The financial system is characterized by the absence of organized markets for securities and equities, by exchange controls, and by legal ceilings on bank borrowing and lending rates, a situation which leads to the emergence of a parallel market for foreign exchange and an informal --or "curb"-- loan market. Households can hold four categories of assets: domestic currency notes, deposits with the banking system, foreign currency-denominated assets, and loans extended through the informal credit market. 1/ Domestic currency notes bear no interest, and are held only for transaction purposes. Interest rates charged by commercial banks on their loans are controlled by the monetary authority. As a result, interest rates on bank deposits are also given under the zero-profit condition. The rate of return on foreign currency-denominated assets depends on the world interest rate and exchange rate expectations. Holdings of all assets are financed from agents' net worth or by borrowing through the banking system or through the informal loan market. 2/

Bank credit and curb market loans are taken to be perfect substitutes in the private sector's portfolio. This permits all rationing-induced "spill-over" effects of changes in the stock of bank credit to be concentrated in a single market --the informal loan market-- by permitting bank credit and curb market loans to be treated as a single asset. While interest rates on assets and liabilities of the banking system are fixed by applicable legal norms, the interest rate on curb market loans, as well as the price of foreign exchange in the parallel market, are determined by prevailing market conditions.

Under the small country assumption, the domestic price of intermediate imports, P_n, is exogenously determined by world prices, P_n^*. The price of the home good, P_h, is determined endogenously in the home market and is explained below. The domestic price of final imports, P_I, as well as the domestic price of exports, P_x, are also determined endogenously, as a result of smuggling activities.

1/ The menu of assets could be further extended to include land and physical capital.

2/ Foreign borrowing of private agents that is repatriated (as it would be) through the parallel exchange market does not affect the model, since only net private holdings of foreign-currency denominated assets matter.

1. Aggregate supply

Technology for the production of the home good is characterized by a separable, Cobb-Douglas function:

$$Q_h = \phi(\bar{K}_h)F(L_h, N_h) = \phi(\bar{K}_h)(L_h)^{\alpha_L}(N_h)^{\alpha_N}, \qquad (1)$$

where Q_h denotes gross output, $\bar{K}_h$ the stock of capital (assumed constant), L_h labor, N_h the imported intermediate input, and α_L and α_N the elasticities of output with respect to labor and intermediate inputs, respectively. Under the assumption of profit maximization and perfect competition, the following supply equation can be derived: 1/

$$\log Q_h = -\frac{1}{1-\alpha}\left[\alpha_L \log(\omega/P_h) + \alpha_N \log(P_n/P_h)\right], \qquad (1')$$

where ω denotes the nominal wage rate, $P_n = sP_n^*$, and $\alpha = \alpha_L + \alpha_N < 1$.

The index of domestic consumer prices, P, is defined as a geometric average of the price of the home good, and the price of imported consumer goods, P_I: 2/

$$P = P_h^{\delta} P_I^{1-\delta}, \qquad 0 < \delta < 1, \qquad (2)$$

where δ denotes the value share of the home good in final domestic consumption. The domestic currency price of imported consumer goods depends on the world price of imported goods, P_I^*, which is exogenously determined, and on a weighted average of the official and parallel exchange rates:

$$P_I = (s^{\sigma} b^{1-\sigma})P_I^*, \qquad 0 \leq \sigma \leq 1 \qquad (3)$$

where σ denotes the proportion of imports carried through official channels. The coefficient σ is related below to the rationing rule

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1/ For the derivation of equation (1'), see Islam (1984).

2/ The price index (2) and the consumption and import behavioral equations that follow reflect the assumption that the instantaneous utility function for consumption of the private sector is of the Cobb-Douglas type.

followed by the authorities in the official market for foreign exchange. 1/

Labor contracts last one period and are negotiated one period in advance, so that the wage rate is known by firms at the beginning of the period --that is, before output and home good prices are realized. Nominal wages adjust slowly to their equilibrium value, and are determined by:

$$\Delta \log \omega = \Psi(\log \bar{\omega} - \log \omega_{-1}), \qquad 0 \leq \Psi \leq 1 \tag{4}$$

where $\bar{\omega}$ denotes the equilibrium level of the nominal wage, and Ψ is the speed of adjustment of the nominal wage to its market-clearing level. The market-clearing wage is derived from the labor-market equilibrium condition, with labor demand being derived from the first-order conditions for profit maximization. This yields 2/

$$\bar{\omega} = \alpha_L (P_h Q_h + P_x Q_x)/\bar{L}_s, \tag{5}$$

where $\bar{L}_s$ denotes the (exogenous) level of labor supply.

From the first-order conditions for profit maximization, the demand function for imported intermediate inputs can be derived as

$$N_h = \alpha_N P_h Q_h / P_n. \tag{6}$$

Consider now the supply of exports. Since the economy being considered is that of a small country where the export price is fixed in the world market, the foreign demand for exports is infinitely elastic and the volume of exports is supply-determined. For simplicity, a production function identical to (1) is assumed for the export good:

$$Q_x = \phi(\bar{K}_x) F(L_x, N_x), \tag{7}$$

1/ Market prices of imported goods depend on the marginal cost of foreign exchange. Thus, an equation like (3) would hold when certain categories of goods can be imported freely at the official exchange rate, while others cannot. If all imported goods are rationed, σ would be zero.

2/ If there is a production lag between the time when labor is paid and that when output is sold, total labor costs would also depend on the informal interest rate. See, for instance, Buffie (1984).

where the quantities $\bar{K}_X$, L_X, N_X are appropriately defined. Following the same reasoning as above, the following supply equation can be obtained:

$$\log Q_X = -\frac{1}{1-\alpha}\left[\alpha_L \log(\omega/P_X)] + \alpha_N \log(P_n/P_X)\right], \tag{7'}$$

where P_X, the supply price of exports, is defined as

$$P_X = [b\Phi + s(1-\tau_X)(1-\Phi)]P_X^*. \tag{8}$$

In equation (8), $0 < \tau_X < 1$ measures the "ad valorem" rate of taxation of exports, and Φ denotes the proportion of undeclared exports. The above expression shows that the relevant supply price for producers of exported goods (in domestic currency terms) is an average of the price of smuggled exports, bP_X^*, weighted by the proportion of smuggled exports, Φ, and the after-tax price of official exports, $s(1-\tau_X)P_X^*$, weighted by the proportion of exports that are legally sold abroad, $(1-\Phi)$. The behavior of Φ is explained below.

From (7'), the demand function for imported inputs by the export sector is given by

$$N_X = \alpha_N P_X Q_X / P_n. \tag{9}$$

The officially recorded level of domestic output must exclude that part of the domestic production for exports that is illegally smuggled out. Thus, recorded real gross aggregate output at factor cost Z_g can be defined as

$$Z_g = [P_h Q_h + (P_X - b\Phi P_X^*)Q_X]/P = [P_h Q_h + (1-\tau_X)(1-\Phi)sP_X^* Q_X]/P, \tag{10}$$

where P is used as the deflator. To obtain <u>net</u> aggregate output at factor cost, Z, real imports of intermediate goods must be subtracted from Z_g:

$$Z = Z_g - (P_n N/P) = [P_h Q_h + (1-\tau_X)(1-\Phi)sP_X^* Q_X - P_n N]/P, \tag{11}$$

where $N = N_h + N_X$.

2. Aggregate demand, income and wealth

Total expenditure by the private sector, E^P, is given by

$$\log E^P = h_1 \log Z^d + h_2 \log(A_{-1}/P) - h_3(i_L - E\pi_{+1}), \quad 0 < h_1 < 1 \quad (12)$$

where A denotes total wealth of the private sector, Z^d real disposable income, and i_L the nominal interest rate in the informal credit market. $E\pi_{+1}$ denotes the expected rate of inflation for period $t+1$, formed at t. Equation (12) indicates that total private spending is a positive function of income and wealth, and a negative function of the real rate of interest --defined as the nominal interest rate in the informal credit market corrected for the expected change in consumer prices. Real disposable income, Z^d, is defined as

$$PZ^d = (1 - \tau)PZ + \Phi b P^*_x Q_x + (i_L - i_c)L^P_{-1} - [(1 - \mu)i_L - i_d]D^P_{-1}, \quad (13)$$

where τ denotes the income tax rate, L^P the stock of domestic bank credit held by the private sector, D^P the stock of deposits held by the private sector in the banking system, i_c the interest rate on bank loans, and i_d the interest rate on bank deposits. The first term in equation (13) represents after-tax factor income derived from legally recorded production activities. The second term represents income derived from the smuggling of exports --which is therefore not taxed-- and is equal to illegal exports in foreign currency terms, $\Phi P^*_x Q_x$, valued at the parallel exchange rate, b. Finally, the last two terms represent the implicit subsidies and taxes from the existence of interest rate controls. 1/

To understand how the last two expressions are derived, note that the existence of interest rate ceilings imposes implicit taxes and subsidies on private agents, as creditors and debtors with the banking system. In the general case $i_L > i_c$, so that the interest rate ceiling provides an implicit subsidy to debtors equal to $(i_L - i_c)L^P_{-1}$. Similarly, if μ denotes the reserve requirement on bank deposits,

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1/ Conventional interest income is not included in (13), because the contribution of such income to household resources is already captured by the wealth term A_{-1}/P in (12).

interest rate regulation imposes an implicit tax on creditors equal to $[(1 - \mu)i_L - i_d]D^P_{-1}$. 1/ The net effect depends therefore on $(i_L - i_c)L^P_{-1} - [(1 - \mu)i_L - i_d]D^P_{-1}$. Since i_c will typically be greater than i_d, controls will provide a net implicit subsidy if agents are sufficiently indebted with respect to commercial banks, that is, if $L^P_{-1}/D^P_{-1} > [(1 - \mu)i_L - i_d]/(i_L - i_c)$.

The notion of a "financial repression tax" (or subsidy) provides a general way of formulating the impact of interest rate controls. As shown by Montiel (1991), an index of financial repression, ρ, can be formally defined as

$$\rho = (i_L - i_c)/i_L, \qquad 0 \leq \rho \leq 1 \tag{14}$$

where ρ measures the present value of the subsidy, per unit of bank credit, which is implied by the prevailing interest rate ceilings. When interest rate ceilings are not binding, $i_c = i_L$ and $\rho = 0$. As the curb loan interest rate rises relative to the controlled rate i_c, the constraints become more and more binding and ρ approaches unity. Equation (14) can be explicitly introduced in (10) by replacing $(i_L - i_c)$ by ρi_L. 2/

The nominal value of agents' financial wealth, A, is defined as the sum of holdings of domestic currency notes CC, bank deposits D^P, bank credit (which is a liability) L^P, and foreign exchange bF^P: 3/

$$A = CC + D^P + bF^P - L^P. \tag{15}$$

1/ It can be noted that $(1 - \mu)i_L$ represents the interest rate that banks would pay on deposits, in the absence of interest rate ceilings.

2/ In Montiel (1991), the financial repression tax is assumed to affect wealth (stocks) rather than income (flows).

3/ Note that foreign currency holdings are valued at the parallel market exchange rate, b. Also note that since loans in the informal credit market take place between households and firms, they cancel out in the definition of private sector wealth.

The budget constraint of the private sector, which determines flow changes in financial wealth, takes the form

$$\Delta A = P(Z^d - E^P) + i_d D^P_{-1} + i^*_f bF^P_{-1} - i_c L^P_{-1} + \Delta bF^P_{-1}, \qquad (16)$$

where i^*_f denotes the world interest rate. The first term in equation (16) represents the portion of disposable income that is not spent (domestic savings). The second and third terms measure interest income derived, respectively, from bank deposits and holdings of foreign-currency denominated assets. Interest payments on foreign assets are assumed to be repatriated through the parallel market, and are therefore valued at the unofficial exchange rate. The fourth term represents interest payments on bank credit. Finally, the last term captures valuation changes due to fluctuations in the parallel exchange rate.

Consider now the determination of the composition of households' financial portfolio. Desired holdings of foreign currency-denominated assets are defined as

$$\log[bF^P/(A - CC)] = \lambda_0 - \lambda_1 i_L - \lambda_2 i_d + \lambda_3 i_f, \qquad (17)$$

where i_f denotes the perceived rate of return on foreign assets, defined as

$$i_f = (1 + i^*_f)(Eb_{+1}/b) - 1 \cong i^*_f + E\tilde{b}_{+1}, \qquad (18)$$

where $E\tilde{b}_{+1} \equiv E\Delta \log b_{+1}$ denotes the (one-period ahead) expected rate of depreciation of the parallel exchange rate. Equation (18) indicates that a rise in the interest rate on curb market loans or bank deposits induces a fall in desired holdings of foreign assets, while a rise in the perceived interest rate on foreign interest-bearing assets (due to a rise in the world interest rate *per se* or to a higher expected rate of depreciation of the parallel market exchange rate) raises the desired proportion of interest-bearing financial wealth that households would like to hold in the form of foreign assets in their portfolios.

Desired holdings of bank deposits, which consist only of interest-bearing deposits, are given by

$$\log(D^P/(A - CC)] = \alpha_0 - \alpha_1 i_L + \alpha_2 i_d - \alpha_3 i_f. \qquad (19)$$

Equation (19) indicates that desired holdings of bank deposits rise as a proportion of interest-bearing financial wealth with an increase in the deposit rate or a fall in the interest rate on curb market loans or in the rate of return on foreign assets.

The demand for domestic currency notes reflects a pure transaction motive, and is given by

$$\log(CC/P) = \varphi_1 \log(Z) + \varphi_2 \log(\Phi q P_x Q_x / P), \qquad \varphi_2 > \varphi_1 \tag{20}$$

where the assumption $\varphi_2 > \varphi_1$ is taken to capture the view that illegal activities require a more intensive use of currency notes than legally recorded ones. 1/

Finally, from the expenditure function (12), aggregate demand for the home good can be written as:

$$Q_h = G_h + \delta PE^P / P_h, \tag{21}$$

where G_h denotes exogenous real government spending on home goods.

3. The current account and the balance of payments

To derive the current account of the economy in the presence of fraudulent trade transactions, it is important to distinguish between reported trade flows, that is, officially measured transactions with the rest of the world, and unreported flows.

Given private expenditure as outlined above, the demand by the private sector for imported consumer goods can be determined as a constant share of total expenditure: 2/

1/ Note that the familiar adding-up constraints on the interest-bearing components of wealth bear on the parameters of equations (17) and (19) only, and not on (20). Consequently, in the former equations, the quantity $A - CC$ (which measures interest-bearing financial wealth) appears as the scale variable.

2/ Note that this is consistent with the foreign exchange regime assumed above, since imports of consumer goods are not subject to quantity constraints, they are simply channeled through two different markets. Under this specification, the quantity of consumer goods imported through the official market is responsive to relative price changes, but the share of such goods in total private consumption is not.

$$I^P = (1 - \delta)PE^P/P_I. \qquad (22)$$

The government imports $P_I^* G_I$ of final goods, in foreign currency terms, and the central bank provides unlimited access for these imports. Producers also have unlimited access to the official foreign exchange market for imports of intermediate inputs. By contrast, the central bank satisfies only a portion σ of total private sector demand for imported final goods.

Formally, the central bank sets the total amount of foreign currency sales in the official exchange market equal to a minimum quantity $P_n^* N + P_I^* G_I$ --which corresponds to the demand by domestic producers for imported inputs plus the demand for final imports by the public sector-- plus a fraction σ of private sector demand for consumer imports, given by equation (22). 1/ Total sales of foreign exchange (expressed in foreign currency), F_S, are therefore equal to

$$F_S = P_n^* N + P_I^* G_I + \sigma P_I^* I^P. \qquad 0 \leq \sigma \leq 1 \qquad (23)$$

The officially recorded current account, C, is equal to the value of recorded exports minus the value of recorded imports of final goods by the private sector and the government authorized by the central bank, plus imports of intermediate goods and interest income on net foreign assets of the public sector and the central bank. Measured in foreign currency terms, C is therefore given by

$$C = (1 - \Phi)P_x^* Q_x + i_\ell^* (F_{-1}^g + R_{-1}) - F_S, \qquad (24)$$

where Φ measures the fraction of exports that are smuggled out of the country, so that officially recorded exports amount only to $(1 - \Phi)P_x^* Q_x$. Equation (24) also assumes, as previously mentioned, that interest income on foreign currency-denominated assets are repatriated through the parallel market for foreign exchange. 2/ Note

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1/ This formulation allows us to link the rationing scheme with the determination of the domestic price of imports.

2/ This is, admittedly, a simplyfing assumption. In practice, one is likely to observe repatriation through both legal and illegal channels. The decision regarding which market agents choose to surrender foreign exchange receipts derived from interest payments

that since intermediate imports are not rationed and there is no under-invoicing by producers, their full value is recorded in the official trade statistics. Foreign exchange demand by the private sector for final imports not eligible for the official market, that is $(1 - \sigma)P_I^* I^D$, spills over to the parallel market.

The coefficient Φ is assumed to depend positively on the exchange rate ratio $q = b/s$. The particular functional form adopted here is given as

$$\Phi(q,\tau_x) = 1 - [(1 - \tau_x)/q]^{\nu}. \qquad \nu > 0 \tag{25}$$

The function $\Phi(q,\tau_x)$ can be shown to satisfy the following properties:

$$\partial\Phi/\partial q > 0, \quad \partial\Phi/\partial\tau_x > 0, \quad \partial^2\Phi/\partial q^2 < 0, \quad lim\Phi = 1 \text{ for } q \to \infty.$$

The first two properties indicate that the higher the tax rate on exports, or the higher the premium, the higher will be the under-invoicing share. The magnitude of $\partial\Phi/\partial q$ and $\partial\Phi/\partial\tau_x$ can in general be expected to be inversely related to the perceived implicit and explicit costs of engaging in illegal transactions and to the degree of enforcement of exchange restrictions. The third property indicates that there are rising costs to engaging in illegal activities (related perhaps to a higher probability of being detected). Finally, the fourth property indicates that when the premium is high enough, relative to the tax rate on exports, the under-invoicing share tends to unity. Note also that even if the premium $(q - 1)$ is zero (that is, if $b = s$), the existence of an export tax still provides an incentive to fake invoices.

Consider now the capital account. Net private capital flows through the official foreign exchange market are prohibited, and public capital inflows are treated as exogenous. The capital account surplus is therefore equal to minus the change in net holdings of external assets of the public sector:

$$\Delta F = - \Delta F^g \tag{26}$$

Using (24) and (26), the change in net foreign assets of the central bank --measured in foreign currency terms-- is given by

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(continued from page 12) should also depend on the level of the premium. The above assumption simplifies considerably the workings of the model.

$$\Delta R = C - \Delta F^{g}. \tag{27}$$

The unreported current account, $\tilde{C}$, which determines the rate of change of the private stock of foreign currency-denominated assets, is in turn given by

$$\tilde{C} \equiv \Delta F^{p} = \Phi P^{*}_{x} Q_{x} + i^{*}_{\ell} F^{p}_{-1} - (1 - \sigma) P^{*}_{I} I^{p}. \tag{28}$$

4. Banks, budget deficits and the money supply

Bank assets consist of reserves held at the central bank, denoted RR, and credit extended to households and producers, L^{p}. Their liabilities are the deposits held by the public, D^{p}, and credit received from the central bank, L^{b}. The balance sheet of the banking system is therefore given by:

$$RR + L^{p} = D^{p} + L^{b}. \tag{29}$$

Banks are assumed to hold no excess reserves. Given a required reserve ratio of μ, reserve holdings are given by

$$RR = \mu D^{p}. \qquad 0 < \mu < 1 \tag{30}$$

Reserves held at the central bank pay no interest, but credit extended to commercial banks by the monetary authorities carries an interest charge which, for convenience, is set equal to the interest rate which banks charge their customers for loans, i_{c}. Under these conditions, the zero-profit condition for the banking system is given by:

$$i_{c} = i_{d}/(1 - \mu), \tag{31}$$

which determines the interest rate paid on bank deposits, i_{d}. The banks' willingness to accept deposits is infinitely elastic, implying that the actual level of deposits held in the banking system is determined by the demand side, that is, the borrowers' demand. Equation (31) fixes the relative price between the lending and deposit rates. Since $\mu > 0$, in general $i_{d} < i_{c}$.

The central bank does not lend directly to households. Its balance sheet equates base money (defined as the sum of currency notes in circulation plus commercial bank reserves) to the sum of

international reserves valued at the official exchange rate and the stock of domestic credit extended to the government and commercial banks minus the central bank's net worth, denoted Ω:

$$CC + RR = sR + (L - L^p) - \Omega, \tag{32}$$

where total domestic credit L, consists of credit to the private sector by commercial banks L^p, and credit to the public sector L^g and to banks by the central bank, L^b:

$$L = L^p + (L^g + L^b). \tag{33}$$

Changes in the central bank's net worth are given by the difference between interest income on foreign reserves, lending to commercial banks and the government, and net transfers to the government budget, t^g: 1/

$$\Omega = \Omega_{-1} + i^*_\ell sR_{-1} + i_c(L^b_{-1} + L^g_{-1}) + \Delta sR_{-1} - t^g, \tag{34}$$

The model's dynamic specification is completed with a description of the behavior of the non-financial public sector. The government's revenue sources consist of income taxes on the private sector, export taxes, income from holdings of foreign-currency denominated assets, and transfers from the central bank. It consumes both home and imported goods, and pays interest on its domestic debt. It borrows on external markets as well as from the central bank. Consequently, the government deficit, denoted D, can be written as follows:

$$D = \tau PZ + \tau_x(1 - \Phi)sP^*_x Q_x + i^*_\ell sF^g_{-1} + t^g - (P_h G_h + sP^*_I G_I) - i_c L^g_{-1}. \tag{35}$$

The deficit is financed by borrowing either at home or abroad:

$$s\Delta F^g = D + \Delta L^g. \tag{36}$$

The model can be operated in several different modes, according to the deficit financing rule. In what follows, it will be assumed that government expenditure is exogenous and that a ceiling is imposed on foreign financing. Deficits are therefore financed by central bank credit --a typical situation in many developing countries. Equation (36) therefore determines the evolution of L^g.

1/ The importance of a proper accounting of central bank net worth is emphasized by Anand and van Wijnbergen (1989).

Finally, the money supply can be defined as

$$M = CC + D^P. \tag{37}$$

5. The complete model

Table 1 in the Appendix provides a summary of the equations of the model. The basic innovations of the model are its detailed account of the macroeconomic effects of government restrictions and the treatment of expectations. Controls on interest rates and foreign exchange allocation lead to the emergence of informal credit and foreign currency markets, and these determine how various macroeconomic shocks affect prices, output and portfolio decisions. The dynamics of the model arise essentially from forward-looking expectations and asset accumulation, in contrast with early macroeconomic models for developing countries which rely on partial adjustment and adaptive expectations mechanisms. This implies, for example, that unlike in earlier models, anticipated future shocks will have immediate effects, and the current effects of current shocks will in general depend on their expected duration.

In this setting, the central bank retains five instruments of policy --the level of controlled bank loan interest rates i_c, the required reserve ratio μ, the amount of credit it extends to the commercial banking system L^b, the proportion of private final imports satisfied in the official foreign exchange market σ, and the official exchange rate s. The fiscal authority determines the income tax rate τ and the rate of taxation of exports, τ_x, as well as the levels of spending on home and imported goods, G_h and G_I.

III. Simulation Properties of the Model

The estimation of a model as complex as the one presented above represents a difficult task under rational expectations. In view of this complexity and the lack of reliable and detailed data of adequate length for a sufficient number of countries, as well as the complete absence of data for certain variables, a useful strategy is to adopt a calibration procedure. 1/ This approach permits the analysis of the

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1/ Whalley (1985) provides a perceptive discussion of the pros and cons of calibration versus estimation procedures, in the context of Computable General Equilibrium models.

model without undue restrictions on its structure. The parameters used are based on available econometric estimates where possible, but do not pertain to any individual real-world economy. Rather, they reflect conditions underlying a wide variety of possible systems. In adopting this procedure, some key parameters were subjected to sensitivity analysis, in order to determine the robustness of observed patterns in the behavior of the model. 1/

Expectations are "consistent" in the sense that they are formed using the future simulated values from the model itself. 2/ Agents are "rational" in that they know the model, all past and current data, and the values of all future exogenous variables, although some shocks may come as "surprises", and use this information to form their expectations. With the use of consistent expectations, current effects of anticipated policies can be appraised, and the dynamic effects of policy changes that alter the time pattern of key macroeconomic variables can be determined. 3/

The parameter set, as well as the starting values of exogenous variables used in the simulations, are presented in the Appendix. Using these values, a baseline which approximates the steady state solution of the model is first calculated. Once the baseline is established, the properties of the model are examined by subjecting it to a variety of shocks. We study here the effects of four domestic policy shocks, affecting variables which have featured prominently in stabilization programs in developing countries. These shocks consist of changes in government expenditure on home goods, in central bank credit to commercial banks, in the interest rate on bank loans, and in the official exchange rate. The first two shocks are assumed to be

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1/ As mentioned earlier, this view of simulation is thus basically a compromise between analytical modelling and a more "empirical" simluation approach, such as econometric simulation.

2/ The consistency between expectations and solution values is enforced by a Fair-Taylor type iterative process. The solution period is set to 40, and terminal conditions take the form of a "no change" assumption whereby expectations formed for periods beyond the terminal date are equal to the last solved values. For a description of this type of algorithm, see for instance Taylor (1986).

3/ In principle, this simulation procedure does not imply that the model is immune from the "Lucas critique" (see Lucas, 1976), according to which a policy change sufficiently atypical as to amount to a change in "policy regime" could well induce behavioral responses by private sector agents that shift the parameters of the model's equations. However, the analysis of policy changes that lie within a short range of policy variations would not be subject to this critique. See Sims (1987) for a further discussion.

transitory in nature, the interest rate shock is maintained during five periods, and the exchange rate change is assumed to be permanent. 1/ The results reported here refer to anticipated shocks which, although announced in period t, are implemented in period $t+5$ and are fully credible. 2/ For the first three experiments, the nominal wage is maintained at its market-clearing level calculated in the baserun solution. This assumption allows us to focus on transmission mechanisms to the real sector other that wage flexibility *per se*. For the exchange rate experiment, wages are assumed to adjust rapidly --but not completely-- to their new equilibrium level, due to the permanent nature of the shock. Finally, in the initial steady state, $L^P_{-1}/D^P_{-1} > [(1 - \mu)i_L - i_d]/(i_L - i_c)$ that is, using (31), $L^P_{-1}/D^P_{-1} > (1 - \mu)$, so that interest rate ceilings provide indeed a net subsidy, rather than imposing a tax, to households, allowing our simulations to take into account the existence of a "quasi-fiscal" deficit (an excess of expenditure over income in the financial public sector), which is a common phenomenon in many developing countries.

1. A rise in government spending on home goods

Consider first a temporary (one-period only), fully anticipated increase by 10 percent in government spending on home goods G_h, financed by central bank credit. Figure 1 depicts deviations from baseline values for some key endogenous variables in the model: the real output of home goods, the domestic price level, total domestic credit (which is endogenous in the model), the stock of net foreign assets of the central bank, the informal interest rate, and the parallel exchange rate.

The anticipation of a future credit-financed increase in government spending on home goods has macroeconomic consequences

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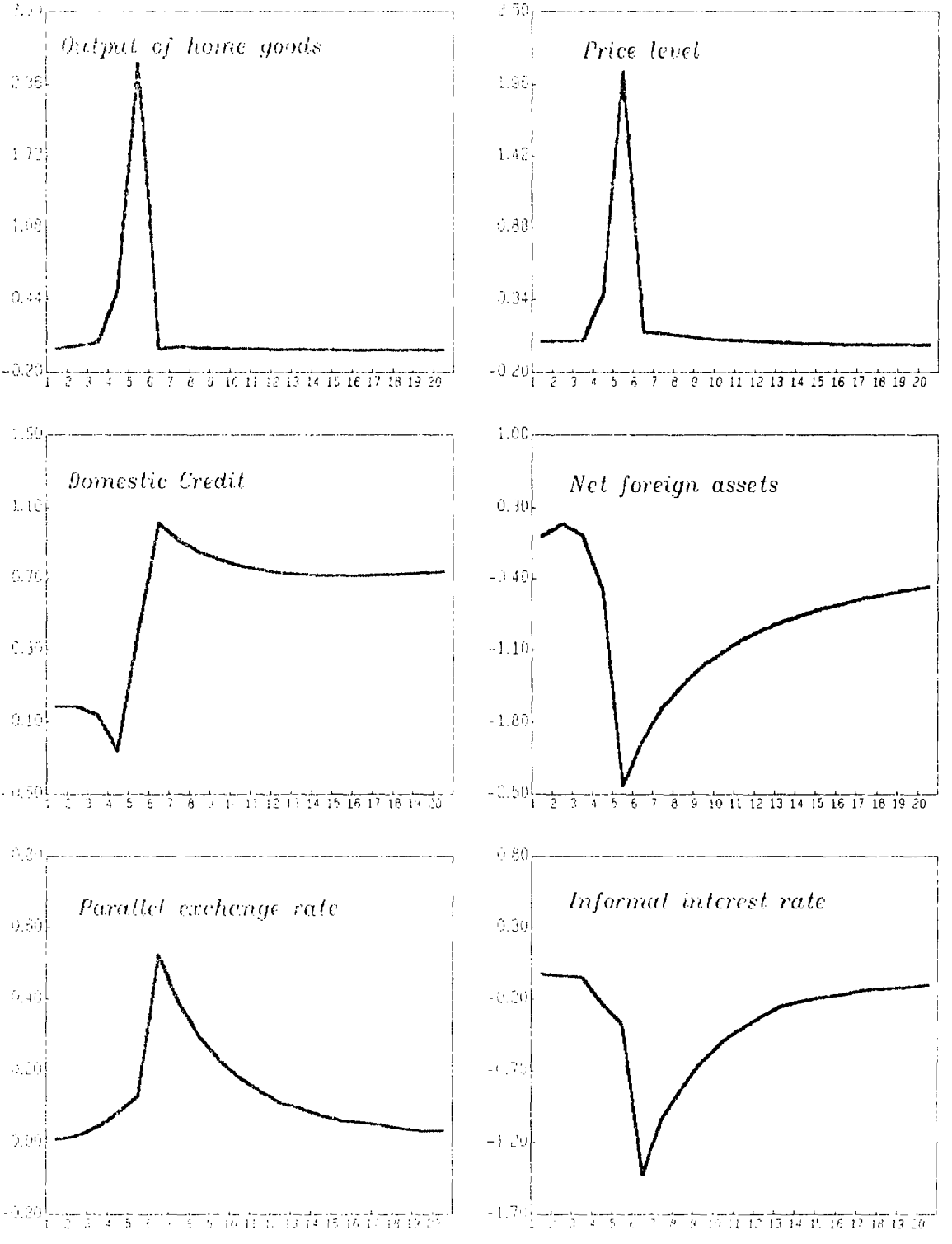
1/ Transitory shocks are better suited to the analysis of stabilization issues and have the convenient computational feature that the steady-state values of the expectational variables remain unchanged. However, interest rate and exchange rate changes have often a more permanent character, and they are modeled as such here.

2/ The experiments were also performed with unanticipated shocks. As a consequence of the assumption of no wage indexation, the major difference with the results reported below is that real output effects are higher, and price effects lower, at the announcement period. Qualitatively, however, the dynamics are basically identical to those discussed in the text for the periods following implementation of policies.

Figure 1. Temporary Increase in Spending on Home Goods of 10 Percent
(Percentage deviations from baseline)



before the shock itself actually occurs, as shown by the behavior of the variables between period t and $t+4$. The price of home goods rises prior to the policy change. Since the nominal wage is maintained at its baseline level, the real product wage unambiguously falls and this, in turn, stimulates domestic supply. This last effect is rather weak initially, but increases in the period preceding the implementation of the spending shock.

These initial effects operate largely through the informal markets --the parallel exchange rate depreciates and the curb interest rate falls prior to implementation. The expected rate of return on foreign currency-denominated assets rises, as a result of an anticipated future depreciation of the parallel exchange rate associated with the forthcoming increase in the domestic money supply, due to the increase in credit-financed government spending. This gives agents the incentive to switch away from domestic assets and towards foreign currency assets before the shock occurs. As a consequence, the parallel rate depreciates. The rise in the premium induced by the increased demand for foreign exchange reduces the private sector's demand for deposits, causing households to shift assets into the informal loan market, which leads to a fall in the curb market interest rate. These phenomena exert income and wealth effects which increase private demand prior to the implementation of the fiscal shock. The future expected rise in domestic prices reinforces the drop in the nominal interest rate, causing the real rate of interest to fall initially. In turn, the fall in the real rate further stimulates private expenditure, contributing to the anticipatory increase in the domestic price level.

The short-run reduction in the rate of interest in the informal loan market has two offsetting effects. On the one hand, it reduces the implicit subsidy provided by controls and decreases real disposable income. On the other, it magnifies the size of the decline in the real interest rate associated with expected inflation, as indicated above, and this stimulates private expenditure, offsetting in part the demand- reducing effect coming through disposable income. The net short-run effect through informal markets on private spending, operating trough both the premium and the informal loan rate, is expansionary prior to implementation of the spending shock.

Upon implementation, the rise in government spending is expansionary both directly and through its monetary effects. The increase in the money supply reinforces the direct expansionary impact of the fiscal shock, and operates again through the informal market for foreign exchange, that is, through a sharp increase in the premium. Although the curb interest rate falls when the policy is implemented, the real interest rate actually rises, because the removal of the fiscal stimulus in the next period produces an expected price decline, Thus the transitory nature of the shock diminishes its

expansionary effect with forward-looking agents. After the shock is removed, the system returns to its initial equilibrium only gradually, since the monetary effects of the once-and-for-all credit infusion take time to dissipate through the balance of payments. Finally, smuggled exports increase the flow of foreign exchange channelled illegally in the economy, but this is more than offset by a rise in smuggled imports, implying that the stock of foreign currency-denominated assets decreases over time. The portfolio implications of this tend to sustain the initial rise in the curb interest rate, keeping upward pressure on the premium and prolonging the return to the original equilibrium.

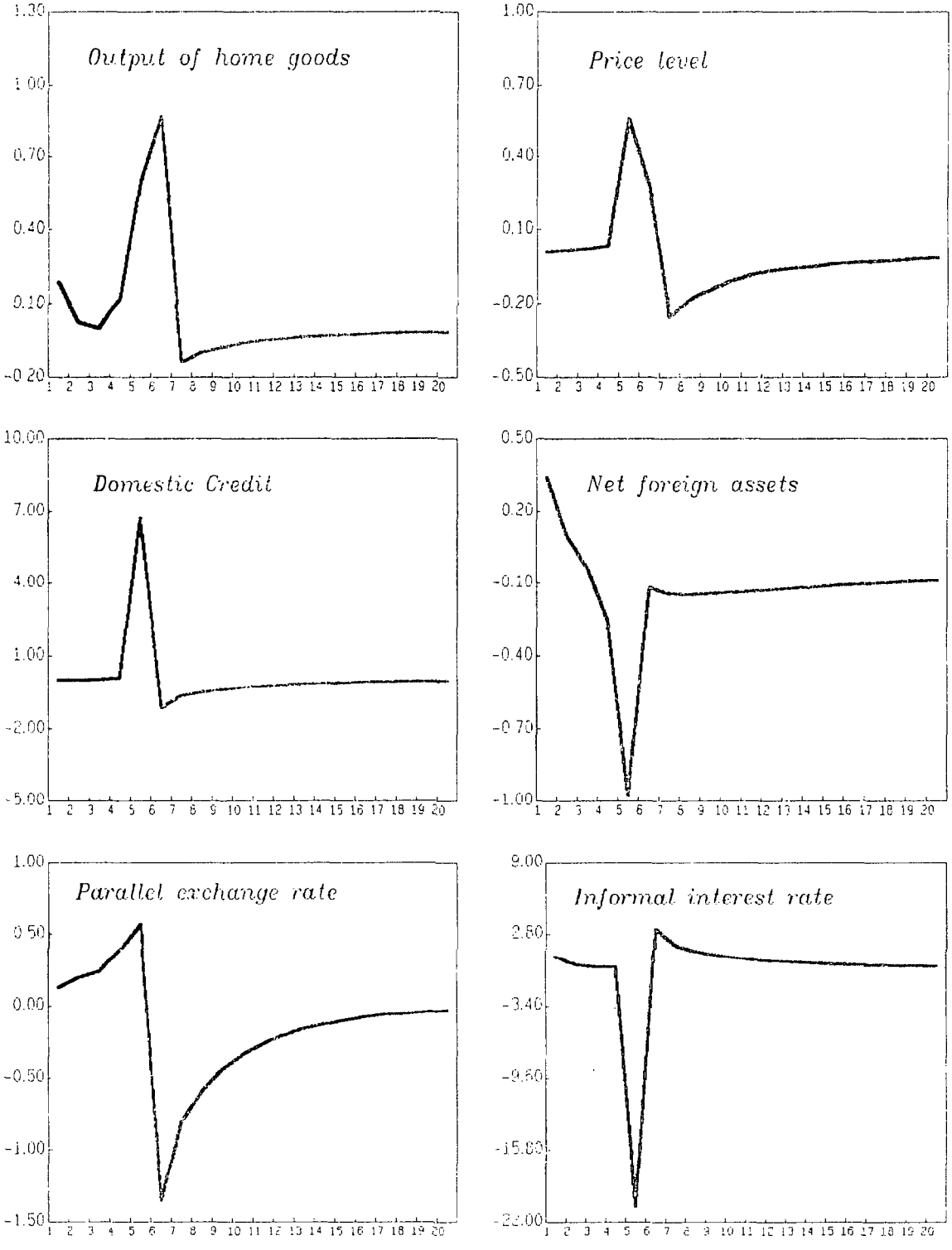
2. A rise in central bank credit to commercial banks

Consider now a fully anticipated, transitory increase by 10 percent in central bank credit to the commercial banks L^b, implemented in period $t+5$. Figure 2 shows deviations from baseline values for some of the key endogenous variables in the model.

Because the fiscal expansion considered previously was credit-financed, the outcome of this exercise resembles in many respects that of the fiscal policy experiment, except that the credit infusion is now removed after one period. As before, the anticipated increase in central bank credit generates output and price effects before the shock actually takes place. The anticipated rise in the premium leads to an immediate depreciation of the parallel exchange rate. This raises the domestic price of imported goods, and together with a wealth-induced expansion in aggregate demand, leads to an increase in the price level and to an output expansion in the home goods sector. Net foreign assets of the central bank fall, as a consequence of the higher level of domestic activity (which raises imports), and the increase in under-invoicing of exports (resulting from the higher premium). During the transition period (t, $t+4$), output and prices rise, the parallel exchange rate depreciates continuously, and the curb interest rate falls for the same reasons as those indicated for the fiscal shock.

When the increase in central bank credit actually occurs (in period $t+5$), loans to the private sector by commercial banks expand. As a result, the demand for credit in the informal market falls, and the curb interest rate drops sharply (by about 7 percentage points). The reduction in the financial repression tax lowers the implicit subsidy provided by controls on interest rates, therefore reducing disposable income --since households are net debtors-- and this has a negative effect on private spending. But the fall in the curb rate also reduces the real interest rate, which has a positive effect on private expenditure. The net effect is an expansion of private spending, which further stimulates output and raises prices.

Figure 2. Temporary Increase in Central Bank Lending of 10 Percent
(Percentage deviations from baseline)



The fall in the curb market interest rate gives agents the incentive to switch towards foreign currency-denominated assets, leading to a sharp spike in the premium. As the stock of foreign assets held by the private sector increases prior to period t+5, the undoing of the credit expansion leaves the private sector with a portfolio more heavily weighted toward foreign exchange than initially, and the parallel exchange rate appreciates beyond its initial level in the process of restoring portfolio equilibrium. The appreciation of the free exchange rate reduces the propensity to under-invoice exports, increases the flow of foreign exchange channelled through the official market, and reduces the rate of accumulation of foreign-currency denominated assets. Overall, therefore, the short- and long-term effects of a credit expansion are qualitatively quite similar to those resulting from an expansion of government expenditure on home goods described above.

3. An increase in bank loan interest rates

An alternative monetary policy tool frequently employed in developing countries is an increase in administered interest rates. This measure, which has been advocated by the McKinnon-Shaw school (see Fry, 1978), is intended to attract funds into the organized financial system, thereby making them available for lending to private agents. The effects of such a policy on aggregate economic activity are a priori indeterminate since, on the face of it, this policy would seem to increase the cost of credit while at the same time increasing credit availability.

Consider, then, a fully anticipated increase in the interest rate that banks charge on their loans to domestic agents (i_c) by one percentage point (equivalent to a 20 percent rise, in relative terms), implemented in period t+5 and left in place until period t+10. Figure 3 summarizes the results.

This measure affects economic activity through a number of channels. A key step in this transmission mechanism, however, is the portfolio reallocation to which this policy gives rise. An increase in the bank lending rate also raises (in the proportion $1/(1 - \mu)$) the interest rate paid on bank deposits. This rise in interest rates in formal financial markets causes individuals to attempt to move funds from both the informal loan market and from foreign-asset hoards into domestic deposits. As a result, the curb interest rate rises when the measure is implemented, and the free-market exchange rate appreciates, both on impact and, as is now familiar, when the measure first becomes anticipated. The magnitude of both effects depends on the degree of substitutability among these assets. As the parallel exchange rate appreciates, the domestic-currency value of financial wealth falls, to

an extent that depends on the weight of foreign currency assets in private portfolios. The reduction in the nominal value of wealth causes a secondary reallocation of portfolios, since the demand for interest-bearing assets is linearly homogeneous in (non-currency) financial wealth. Because of this wealth effect, the demand for domestic deposits may, in net terms, rise or fall. In this model, the combination of fairly high substitution elasticities between domestic deposits and foreign exchange and an important share of foreign assets in private portfolios leads to a reduction in domestic bank deposits at the announcement period which persists even after the administered interest rates in the domestic financial system are raised.

This measure has contractionary effects on prices and output for a number of reasons. First, the appreciation of the parallel exchange rate reduces the real value of private wealth. Second, the exchange rate appreciation also reduces the producer price for domestic exports. Third, the implicit subsidy provided by controls on interest rates falls, as the proportional increase in the controlled interest rate exceeds that in the curb market. The increase in the informal interest rate exerts direct contractionary effects on spending as well. Consequently, output and domestic prices fall when the measure is implemented.

It is worth noting that the anticipation of these effects brings the contractionary effect of this measure forward to the first period --that is, to the period in which the policy change is first announced. The reason is the combination of a negative wealth effect from the reduction in the premium and the fact that the anticipated price decrease in the fifth period raises the real interest rate in the fourth period, which reduces output and the price level in that period, which then affects price expectations and the real interest rate in the third period, and so on. The contractionary effects of the anticipated measure increase over time as the date of implementation approaches. However, in similar fashion, the anticipated reversal of the interest rate increase exerts an expansionary effect before it occurs. The increase in the bank lending rate is removed in the eleventh period, and thus the peak contraction occurs in periods six and seven.

The mechanisms through which an increase in bank lending and deposit rates could lead to a contractionary effect have not been thoroughly treated in the literature, in the sense that general equilibrium interactions have typically been neglected. 1/ The model

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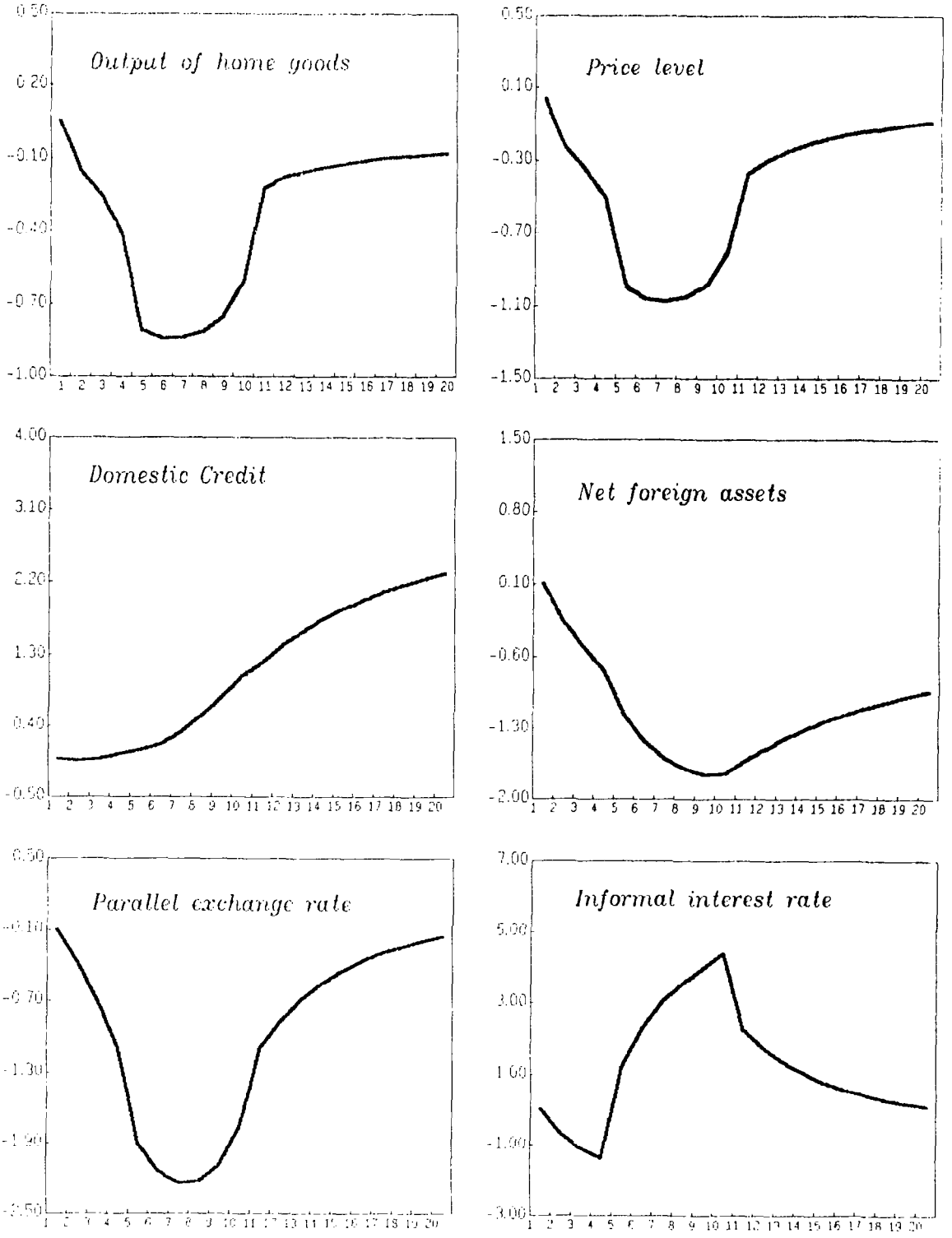
1/ In a different context, Lorie (1988) developed a fix-price disequilibrium macroeconomic model with credit rationing in which an increase in deposit interest rates (which leads, under profit maximization, to a rise in lending rates) becomes potentially contractionary because it increases the financing constraint faced by domestic firms.

Figure 3. Increase in Bank Lending Rate of 1 Percentage Point
(Percentage deviations from baseline)



developed here highlights the importance of market linkages and wealth effects in the determination of macroeconomic outcomes. These results suggest that the short-run macroeconomic effects of McKinnon-Shaw financial liberalization policies may prove to be problematic.

4. Devaluation of the official exchange rate

This sub-section examines the short- and long-run effects of a devaluation of the official exchange rate --an issue which, in the past few years, has been the subject of renewed controversy in developing-country macroeconomics. 1/ We consider a 10 percent devaluation which, as before, is announced in period t and implemented in period $t+5$, so that both the timing and the magnitude of the devaluation are known with certainty. Devaluation profits are retained by the central bank, rather than transferred to the government. As mentioned above, wages are assumed to adjust endogenously, with a coefficient of adjustment $\Psi = 0.8$, to their new equilibrium level. Figure 4 summarizes the results of this experiment.

At the outset, it should be noted that in our model, a mechanism frequently cited through which devaluation may adversely affect real output, that is, automatic wage indexation to price level movements, is absent. Nevertheless, an official devaluation has indeed a contractionary effect on domestic real output at the announcement and implementation periods. It should also be emphasized that this is a net effect and thus a function of the model's parameter values and initial conditions. Expansionary effects are also present (and indeed dominate in intervening periods), but are simply overwhelmed in this case.

The channels through which a devaluation of the official exchange rate affects real activity in our model are complex. The most important negative channel is through an increase in the real price of imported inputs, which functions as a negative supply shock. Second, the official devaluation directly increases the domestic price level (through its impact on the domestic price of imported goods), increasing thereby the demand for currency. Since monetary policy is unchanged, this causes households to shift funds out of deposits, curb market loans, and foreign currency assets. The result is a higher informal interest rate, and an appreciation of the parallel exchange rate. 2/ The higher curb interest rate has a direct contractionary

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1/ See, for instance, Lizondo and Montiel (1989), and Rojas-Suarez (1987).

2/ Note that the parallel market premium therefore falls as a result of both the devaluation of the official exchange rate and the appreciation of the free exchange rate. This is in contrast to what

effect on private spending, as does the reduction in private real wealth brought about by a reduced domestic-currency value of foreign assets and a higher price level. Moreover, export production falls, because the increase in the demand price of exports is dampened by the appreciation in the parallel exchange rate, while the supply price of exports bears the full impact of the increase in the price of imported intermediate goods. On the other hand, the induced increase in the curb market rate raises the implicit financial repression subsidy and thus real private disposable income. This has a positive effect on the demand for home goods, as does the switch in expenditure due to (officially-measured) real exchange rate depreciation. At the same time, positive supply effects arise from a reduction in the real wage. In our model, however, these expansionary effects are overwhelmed by the contractionary effects outlined earlier.

Interestingly, the effects of an anticipation of an official devaluation are the reverse of those produced by the devaluation itself, that is, they are expansionary. Output rises in period $t+4$ because the anticipated price increase and parallel exchange rate appreciation in period $t+4$ combine to lower the real interest rate in period $t+4$. The anticipated appreciation of the unofficial exchange rate lowers the rate of return on foreign assets, causing individuals to shift into more lending through informal markets, thereby lowering the equilibrium curb market rate initially. Together with an expected price level increase, this lowers the real interest rate and increases domestic demand in period $t+4$. Because the induced price level change in this period is much smaller than the price level jump induced by the devaluation in period $t+5$, however, these effects become progressively weaker as one moves backward in timebefore the devaluation is implemented, and are overwhelmed at the announcement period by the negative wealth effects resulting from the appreciation of the unofficial exchange rate. These results help underline the importance of a proper account of dynamic features and expectational phenomena in assessing the macroeconomic consequences of devaluation, as emphasized by Buffie (1984), and Lizondo and Montiel (1989).

The official devaluation proves to be very effective in improving the current account in this model. The reason is clear --conventional expenditure-switching effects are here strongly reinforced by expenditure-reducing effects. In addition, the fall in the parallel market premium reduces the propensity to under-invoice sales abroad, resulting in a higher level of recorded exports. Because the

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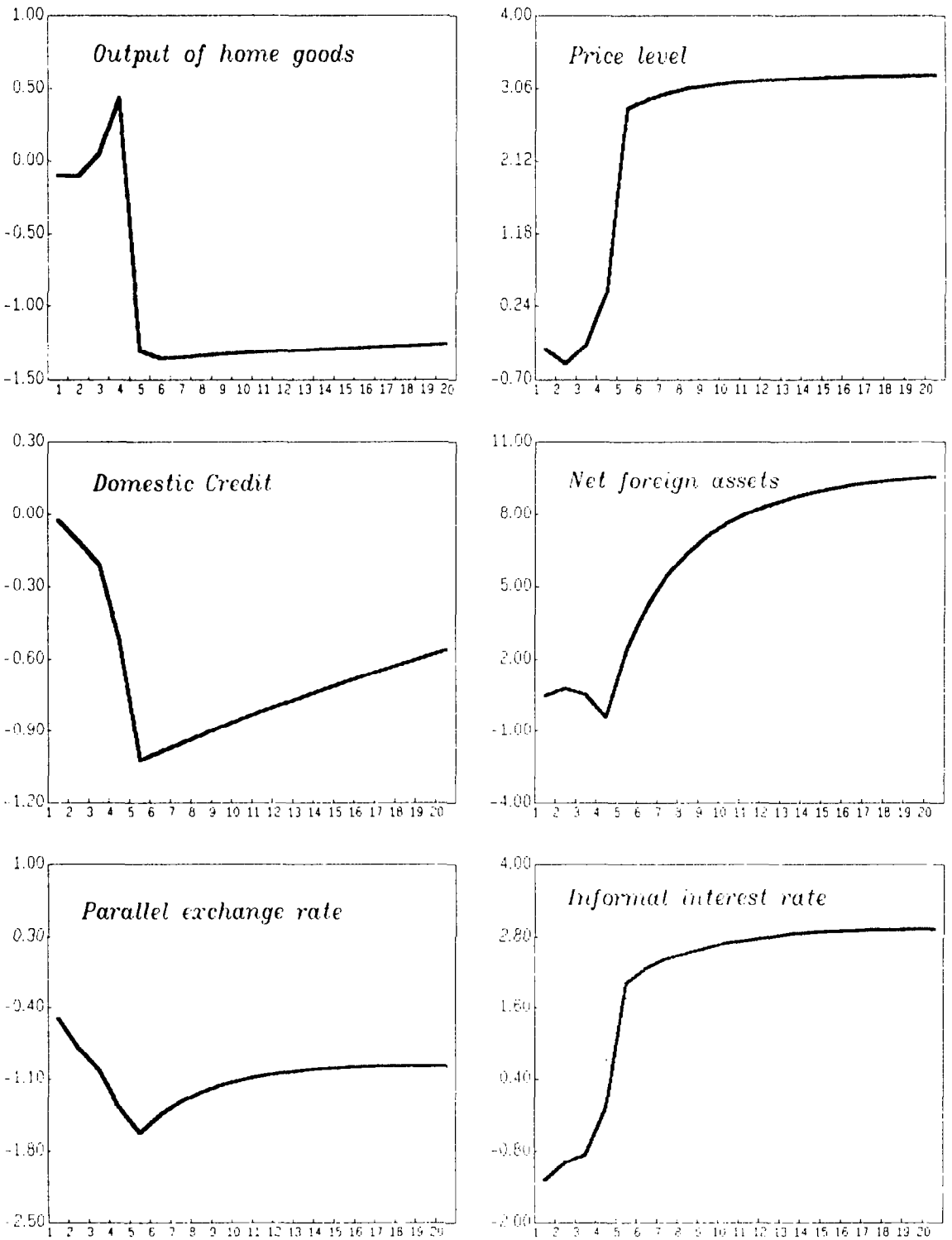
(continued from page 23) is normally observed in dual exchange market models, in which the reduction of the premium is brought about strictly by changes in the official exchange rate. Our results differ due to the presence of the curb loan market. The informal interest rate is affected by the price level effects of the devaluation.

Figure 4. Devaluation of the Official Exchange Rate of 10 Percent
(Percentage deviations from baseline)



resulting reserve inflow is only partially monetized and since other financial policies are unchanged, the real effects of the official devaluation are slow to dissipate.

IV. Concluding Remarks

The purpose of this paper has been to develop a macroeconomic model for a developing economy subject to a variety of distortions: nominal wage stickiness embodied in wage contracts, ceilings on interest rates, and foreign exchange restrictions. The model provides a consistent, albeit complex, framework for a quantitative analysis of the macroeconomic implications of these features for the conduct of stabilization policies.

The model has been calibrated using a set of plausible parameters derived partly from existing econometric estimates for developing countries. Shocks involving policy instruments that have featured prominently in stabilization efforts have been analyzed, under the assumption of consistent forward-looking expectations: we have considered the dynamic macroeconomic effects of changes in government expenditure on home goods, in central bank credit to commercial banks, in the administered interest rate on bank loans, and in the official exchange rate. The simulation results have highlighted the role that informal markets play in an economy subject to a variety of government restrictions. They also highlight the fact that, under rational expectations, shocks begin to exert macroeconomic effects when (credible) policy announcements are made, or when they first become anticipated, rather than when they actually occur. Finally, the results also illustrate how the dynamics of the model are strongly affected by the initial composition of asset holdings. In particular, whether the parallel exchange rate depreciates or appreciates, or whether the curb market interest rate rises or falls, depends to a large extent on the size of the initial stock of foreign currency-denominated assets held by private agents in their portfolios, and on whether households are net creditors or net debtors with respect to the commercial banks. The speed of adjustment, however, has been shown to be quite rapid across shocks.

Although only a limited number of policy simulations have been reported here, it should be emphasized that the model is well suited to address a number of substantive research or policy-oriented issues. For instance, a modification in the rationing rule in the official foreign exchange market (for instance, a rise the proportion of private imports channelled through the official market) has substantial effects on prices and the parallel exchange rate, through stock-flow interactions built into the model. Similarly, a rise in the export tax rate is associated with a fall in export tax revenue and officially recorded inflows of foreign exchange. A higher tax

rate on exports reduces the relative price of exports perceived by domestic producers, and this in turn tends to reduce supply and to increase the incentive to divert exports from the official market to the parallel market. Finally, an increase in world interest rates may prove to be expansionary, despite its impact on external debt payments. When the interest rate on foreign assets rises, private agents attempt to reallocate their portfolios moving away from domestic assets and towards foreign assets. Since the central bank does not accomodate this desired portfolio shift, the parallel exchange rate depreciates. If the private sector is a net external creditor, the positive wealth effect associated with the exchange rate change stimulates private expenditure, as well as output of home goods.

The key implications of the simulation experiments can be summarized as follows. Anticipated expansionary fiscal and credit policies are associated with a rise in output and prices, a fall in the informal interest rate, as well as a current account deficit and a depreciation of the parallel exchange rate. An increase in lending and deposit interest rates in the formal financial sector may lead to a fall, rather than an increase, in private bank deposits, and may well be associated with a contraction in output. An anticipated once-and-for-all devaluation of the official exchange rate is associated with a fall in the parallel market premium, both in the short- and the long-run. The devaluation also has a temporary expansionary effect in the transition period following the announcement, and a contractionary effect when implemented, which is slow to dissipate. This result highlights the importance of allowing for a proper time frame in judging whether or not devaluations are contractionary. In all of those cases, informal markets for foreign exchange and credit play key roles in transmitting the influences of shocks, and the economy's dynamic response is influenced to an important degree by "leakages" into parallel markets. Our results, therefore, demonstrate that short-run macroeconomics in developing countries can ill-afford to ignore the influence of such "unofficial" transactions.

APPENDIX

Structure and Calibration of the Model

The equations of the model are presented in summary form in Table 1. Variables are defined in Table 2. 1/

The model presented in this paper is calibrated, rather than estimated. Available estimates of key macroeconomic parameters differ greatly with regard to countries and periods covered, specification of estimated equations, and econometric methodology. The parameter set used here is based partly on available evidence, in particular on the econometric estimates derived by Haque, Lahiri and Montiel (1990), using pooled time-series cross-section data for 31 developing countries. 2/

Table 3 presents the key parameters of the model (excluding all constant terms, which are determined residually), as well as initial values of the exogenous variables. The initial values of endogenous variables are derived by an iterative method which approximates the steady state solution, that is, the static, long-run solution of the model. The normalization rule used to solve the model enforces all macro-equilibrium conditions. For instance, equilibrium in the market for the home good is given by equating the supply of home goods with total demand; for solution purposes, the demand equation is used to determine the price of home goods.

Some features of the parameter set are noteworthy. The elasticity of output with respect to labor and imported inputs are consistent with the results reported elsewhere in the literature. The

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1/ Using (14) and (31), equation (13) has been re-written as

$$PZ^d = (1 - \tau)PZ + \Phi b P^*_x Q_x + \rho i_L [L^P_{-1} - (1 - \mu)D^P_{-1}].$$

2/ Note that not all parameter estimates are chosen from empirical studies which explicitly incorporate rational expectations, or any other particular assumption in our model. However, the suitability of parameter values for our purposes depends not only on the presence or absence of particular assumptions in the models from which they are derived but also on the overall structure of those models. Therefore, values which come from models incorporating rational expectations, or any other particular assumption, but whose structure differs from our model will not be necessarily superior to values obtained from other types of models.

APPENDIX

speed of adjustment of the nominal wage to its market-clearing level Ψ is set to 0 throughout, except for the exchange rate experiment where $\Psi = 0.8$. The interest elasticity of private sector expenditure is close to the elasticity for consumption derived by Rossi (1988) and accords well with the evidence on saving elasticities reported by Fry (1988, p. 142). The particular form chosen for the under-invoicing share, although arbitrary, provided reasonable results in the simulation experiments for low values of ν. 1/ The required reserve ratio on bank deposits, μ, is set to 0.4, an assumption which is consistent with reserve ratios actually observed in many highly inflationary, financially-repressed economies. The estimates of the (semi-) elasticities of the demand for bank deposits relative to the curb interest rate ($\alpha_1 = -0.6$) and the administered deposit rate ($\alpha_2 = 1.1$) reported in Table 3 are slightly lower than those reported by van Wijnbergen (1982, p. 156; 1985) for Korea ($\alpha_1 = -0.9$, $\alpha_2 = 1.6$), but experiments with values closer to these last estimates did not change significantly the results.

Finally, the results were subjected to limited sensitivity analysis, using an alternative parameter set with plausible values. However, sensitivity analysis cannot "prove" in any sense that the chosen parameter values are "true" values, nor that the conclusions derived are completely general.

1/ Empirical evidence is too sparse to provide any guidance as to whether or not the under-invoicing function is appropriate.

APPENDIX

Table 1. Equations of the Model

Supply of home goods

$$\log Q_h = 1/(1 - \alpha)[\alpha \log P_h - \alpha_N \log P_n - \alpha_L \log \omega]. \qquad \alpha,\ \alpha_L,\ \alpha_N < 1$$

Supply of export goods

$$\log Q_x = 1/(1 - \alpha)[\alpha \log P_x - \alpha_N \log P_n - \alpha_L \log \omega].$$

Supply price of exports

$$P_x = [b\Phi + s(1 - \tau_x)(1 - \Phi)]P_x^*. \qquad 0 < \tau_x < 1$$

Nominal wage contracts

$$\Delta \log \omega = \Psi(\log \bar{\omega} - \log \omega_{-1}). \qquad 0 \leq \Psi \leq 1$$

Market-clearing wage

$$\bar{\omega} = \alpha_L(P_h Q_h + P_x Q_x)/\bar{L}.$$

Official output at factor cost

$$PZ = P_h Q_h + (1 - \tau_x)(1 - \Phi)sP_x^* Q_x - P_n N.$$

Demand for imported intermediate inputs

$$N = \alpha_N(P_h Q_h + P_x Q_x)/P_n.$$

Domestic price level

$$P = P_h^{\delta} P_I^{1-\delta}. \qquad 0 < \delta < 1$$

Domestic price of final imports

$$P_I = (s^{\sigma} b^{1-\sigma})P_I^*. \qquad 0 \leq \sigma \leq 1$$

APPENDIX

Table 1. Equations of the Model (continued)

Private sector expenditure

$$\log E^P = h_1 \log Z^d + h_2 \log(A_{-1}/P) - h_3(i_L - E\pi_{+1}). \qquad 0 < h_1 < 1$$

Real disposable income

$$PZ^d = (1 - \tau)PZ + \Phi b P^*_x Q_x + \rho i_L [L^P_{-1} - (1 - \mu)D^P_{-1}]. \qquad 0 < \tau < 1$$

Demand for the home good

$$Q_h = G_h + \delta PE^P/P_h.$$

Financial repression tax

$$\rho = (i_L - i_c)/i_L. \qquad 0 \leq \rho \leq 1$$

Financial wealth

$$A = M + bF^P - L^P.$$

Budget constraint of the private sector

$$\Delta A = P(Z^d - E^P) + i_d D^P_{-1} + i^*_\ell bF^P_{-1} - i_c L^P_{-1} + \Delta bF^P_{-1}.$$

Demand for foreign assets

$$\log[bF^P/(A - CC)] = \lambda_0 - \lambda_1 i_L - \lambda_2 i_d + \lambda_3 i_\ell.$$

Rate of return on foreign assets

$$i_\ell \cong i^*_\ell + E\tilde{b}_{+1}.$$

Demand for domestic currency notes

$$\log(CC/P) = \varphi_1 \log(Z) + \varphi_2 \log(\Phi q P_x Q_x/P). \qquad \varphi_2 > \varphi_1$$

APPENDIX

Table 1. Equations of the Model (continued)

Demand for bank deposits

$$\log(D^P/(A - CC)] = \alpha_0 - \alpha_1 i_L + \alpha_2 i_d - \alpha_3 i_\ell.$$

Private Demand for final imports

$$I^P = (1 - \delta)PE^P/P_I.$$

Official sales of foreign exchange

$$F_S = P_n^* N + P_I^* G_I + \sigma P_I^* I^P. \qquad 0 \leq \sigma \leq 1$$

Official current account

$$C = (1 - \Phi)P_x^* Q_x + i_\ell^*(F^g_{-1} + R_{-1}) - F_S.$$

Under-invoicing share

$$\Phi = 1 - [(1 - \tau_x)/q]^\nu, \qquad q = b/s, \qquad \nu > 1, \qquad 0 \leq \Phi \leq 1.$$

Net foreign assets of the central bank

$$\Delta R = C - \Delta F^g.$$

Unreported current account

$$C_U = \Delta F^P = \Phi P_x^* Q_x + i_\ell^* F^P_{-1} - (1 - \sigma)P_I^* I^P.$$

Balance sheet of commercial banks

$$RR + L^P = D^P + L^b.$$

Reserve holdings by commercial banks

$$RR = \mu D^P. \qquad 0 \leq \mu \leq 1$$

Interest rate on bank deposits

$$i_c = i_d/(1 - \mu).$$

APPENDIX

Table 1. Equations of the Model (concluded)

Balance sheet of the central bank

$$CC + RR = sR + (L - L^p) - \Omega.$$

Total domestic credit

$$L = L^p + (L^b + L^g).$$

Central bank's net worth

$$\Omega = \Omega_{-1} + i^*_{\ell} sR_{-1} + i_c(L^b_{-1} + L^g_{-1}) + \Delta sR_{-1} - t^g.$$

Government deficit

$$D = \tau PZ + i^*_{\ell} sF^g_{-1} + \tau_x(1 - \Phi)sP^*_x Q_x + t^g - (P_h G_h + sP^*_I G_I) - i_c L^g_{-1}.$$

Deficit financing

$$L^g = L^g_{-1} - D + s\Delta F^g.$$

Money stock

$$M = CC + D^p.$$

Parallel market premium

$$p = q - 1.$$

APPENDIX

Table 2. Definition of Variables

A	Nominal private financial wealth
b	Parallel market exchange rate
C	Reported current account
CC	Private holdings of domestic currency notes
C_U	Unreported current account
D	Fiscal deficit
D^P	Private sector deposits in commercial banks
Δ	First-difference operator
E^P	Private sector expenditure
$E\pi_{+1}$	Expected inflation rate for period t+1 formed at t
$E\bar{b}_{+1}$	Expected rate of depreciation of the parallel exchange rate formed at t for period t+1
Φ	Under-invoicing share of exports
F^P	Private holdings of foreign currency
F^g	Net foreign assets of the public sector (exogenous)
G_h	Real government spending on home goods
G_I	Real Government spending on final imported goods (exogenous)
I^P	Private imports of final goods
i_c	Interest rate on bank loans (exogenous)
i_d	Interest rate on bank deposits
i_ℓ	Rate of return on foreign-currency denominated assets
i^*_ℓ	World interest rate (exogenous)
i_L	Interest rate on curb market loans
L	Total domestic credit
L^P	Bank credit to the private sector
L^b	Credit to commercial banks by the central bank (exogenous)
L^g	Bank credit to the public sector (exogenous)
$\bar{L}_s$	Labor supply (exogenous)
M	Domestic money stock

APPENDIX

Table 2. Definition of Variables (concluded)

N	Total imports of intermediate inputs
P	Consumer price index
ρ	Parallel market premium
P_h	Price of home goods
P_I	Domestic price of final imports
P_I^*	World price of final imports (exogenous)
P_n^*	World price of imported intermediate inputs (exogenous)
P_x	Supply price of exports
P_x^*	World price of exports (exogenous)
q	Ratio of parallel to official exchange rate
Q_h	Production of home goods
Q_x	Production of export goods
R	Net foreign assets of the central bank
RR	Required reserves
ρ	Financial repression tax
s	Official exchange rate (exogenous)
τ	Income tax rate (exogenous)
τ_x	Tax rate on exports (exogenous)
t^g	Transfers from the central bank to the government
ω	Nominal contract wage
$\bar{\omega}$	Equilibrium nominal wage
Z_g	Officially recorded gross domestic product
Z	Officially recorded net domestic product

APPENDIX

Table 3. Parameters and Initial Values

Parameters		
$\alpha_L = 0.3$	$\alpha_N = 0.2$	$\gamma = 0.0$
$\delta = 0.8$	$\sigma = 0.2$	$h_1 = 0.7$
$h_2 = 0.1$	$h_3 = -0.5$	$\mu = 0.4$
$\lambda_1 = -0.5$	$\lambda_2 = -0.6$	$\lambda_3 = 0.9$
$\varphi_1 = 0.4$	$\varphi_2 = 0.7$	$\alpha_1 = -0.6$
$\alpha_2 = 1.1$	$\alpha_3 = -0.5$	$\nu = 0.1$
$\Psi = 0.0^*$	$\Phi = 0.4^{**}$	$\rho = 0.25^{**}$
Exogenous variables		
$P_n^* = 1.0$	$P_x^* = 1.0$	$P_I^* = 1.0$
$s = 1.0$	$\tau = 0.3$	$\tau_x = 0.1$
$i_c = 0.05$	$i_\ell^* = 0.06$	$G_I = 120$
$G_h = 340$	$F^g = 2800$	$L^b = 1400$

*Set to 0.8 for the exchange rate experiment.

**Initial baseline value.

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