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Anticipated Exchange Rate Reforms

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Abstract

Exchange rate reforms in developing countries have often aimed at floating the exchange rate in an attempt to unify the official and parallel markets for foreign exchange. This paper examines the anticipatory dynamics associated with such reforms. The analysis shows that if the future unified exchange rate is more depreciated than the prevailing official rate, a pre-announced reform will lead to a depreciation of the parallel rate upon announcement and, during the transition period, a rising premium, an increase in the rate of reserve losses, and possibly to an output contraction and an appreciation of the real exchange rate.

JEL Classification Numbers:

F31, F41

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I. Introduction

Widespread exchange and trade restrictions in developing countries have typically led to the emergence of illegal markets for goods and foreign currencies, with parallel exchange rates deviating in some cases considerably from official rates. 1/ The existence of such markets, despite some potential gains, has been shown to entail a variety of costs (high volatility of exchange rates and prices, incentives to engage in rent-seeking activities and to divert export remittances or unrequited transfers from the official to the parallel market, *etc.*). The unification of foreign exchange markets has thus been an important objective of macroeconomic policy in countries with sizable parallel currency transactions.

The process of unification has as its ultimate objective to absorb and legalize the parallel market for foreign exchange, eliminating the inefficiencies and market fragmentation associated with a quasi-illegal activity. In practice, unification attempts have often taken the form of adopting a uniform floating exchange rate. 2/ The analytical work in this area has shown that the impact of such a policy shift on the short- and long-run behavior of the exchange rate and inflation can be ambiguous. In the long run, the macroeconomic effects depend on the fiscal impact of the exchange rate reform. As argued by Pinto (1989, 1991), the parallel market premium represents an implicit tax on exports repatriated through official channels, since governments in developing countries are typically net buyers of foreign exchange from the private sector. For a given fiscal deficit, there exists a trade-off between the premium and inflation, which represents a tax on domestic currency balances. The unification process, which results in the loss of the implicit tax on exports, may therefore entail a substantial (and permanent) rise in the rate of inflation and the rate of depreciation of the exchange rate, if the authorities attempt to compensate for a fall in revenue by an increase in monetary financing of the fiscal deficit and a higher tax on domestic money holdings. 3/

1/ See, for instance, the data presented in the World Currency Yearbook.

2/ Although, in theory, unification could also take the form of adopting a uniform fixed rate or crawling peg regime--with changes in net foreign assets clearing the official foreign exchange market--few developing countries have adopted this approach in recent years.

3/ Pinto's analysis assumes that agents are subject to rationing in the official market for foreign exchange. Lizondo (1991) has shown, however, that Pinto's emphasis on the trade-off between the premium and inflation in the unification process remains largely valid if the official market clears through changes in foreign reserves.

The short-run effects of a pre-announced future adoption of a unified, flexible exchange rate arrangement have been examined by Kiguel and Lizondo (1990), in the context of a currency substitution model developed earlier by Lizondo (1987). If the unification attempt is fully anticipated, agents will--in order to avoid capital losses--adjust their portfolios towards foreign-currency denominated assets if the uniform floating exchange rate is expected to be more depreciated than the existing parallel rate, and towards domestic-currency denominated assets if it is to expected to be more appreciated. As a result of this portfolio adjustment, the parallel market rate will depreciate immediately--at the moment the unification attempt is announced or when expectations are formed--towards the level asset holders expect the post-unification floating rate to be. Under perfect foresight, the parallel market rate will experience an initial jump and will keep depreciating steadily towards that level at the time of unification. The experience of several African countries with floating-rate arrangements during the eighties tends to corroborate these analytical predictions. 1/ Peru's attempt in August 1990 to unify its foreign exchange markets by floating its exchange rate also provides some support in this regard. The parallel market premium, which stood at close to 200 percent at the end of 1989, rose to more than 400 percent a month before the reform--which was widely anticipated-- was implemented. The premium fell immediately afterwards--as a result of a large depreciation of the official exchange rate--and dropped below 20 percent by December 1990.

Existing analytical studies of exchange market unification are subject, however, to a number of limitations. Lizondo (1987) and Pinto (1989, 1991) assume that the unification process occurs overnight--a particularly restrictive informational assumption, even in the context of developing countries. Kiguel and Lizondo (1990) do examine the dynamic effects of a pre-announced reform, but provide only a graphical analysis of the unification process. In addition, the real effects of a unification attempt have received only scant attention in the literature. 2/ The purpose of this paper is to examine the dynamic implications for output, parallel market premia, inflation and official reserves of a perfectly anticipated, pre-announced exchange rate reform which consists in the adoption of a

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1/ On these experiments, see Roberts (1989) and Pinto (1989). The data presented in Agénor (1990) indicate that the parallel market premium rose substantially in the months before the reform of the exchange system was implemented and fell sharply afterwards. A significant premium reemerged subsequently in countries where money growth was not kept under control.

2/ While Pinto (1989, 1991) focuses on the inflationary impact of exchange-rate unification, Lizondo (1987) and Lizondo and Kiguel (1990) examine only exchange rate and balance of payments effects. In both analyses, output is taken as fixed at its full-employment level.

flexible exchange rate aimed at unifying a dual exchange rate regime. The analysis assumes forward-looking agents and explicitly considers leakages between foreign exchange markets.

The rest of the paper is organized as follows. Section II presents a basic model of a dual exchange rate regime with leakages. The dynamics of the premium and foreign reserves implied by this setup in the pre- and post-reform periods are examined in section III. Section IV extends the analysis to consider real effects of anticipated reforms. Section V provides some concluding comments. 1/

II. A Basic Framework

Consider a small open economy which operates an informal dual exchange rate regime in which an official, pegged exchange rate coexists with a freely determined parallel rate. The official rate applies to current account transactions which are authorized by the authorities, while the parallel rate is used for capital account transactions and the remainder of current account items. Private agents are endowed with perfect foresight and hold domestic currency and foreign-currency denominated bonds in their portfolios. The interest parity condition, properly modified to reflect repatriation of the principal on foreign bonds at the parallel exchange rate and repatriation of interest receipts at the official rate, is assumed to hold continuously. Domestic output consists of a single exportable good sold abroad and is taken as exogenous. In each period, exporters surrender a given proportion of their foreign exchange earnings at the official exchange rate, and repatriate the remaining proceeds via the parallel market.

Formally, the model is described by the following log-linear equations, where all parameters are defined as positive:

$$m_t - p_t = -\alpha i_t, \qquad (1)$$

$$i_t = i^* + \dot{s}_t - \gamma(s_t - e_t), \qquad \gamma > 0 \qquad (2)$$

$$m_t = \Theta R_t + (1 - \Theta)D_t, \qquad 0 < \Theta < 1 \qquad (3)$$

$$p_t = \nu s_t + (1 - \nu)e_t, \qquad 0 < \nu < 1 \qquad (4)$$

1/ The analysis in Section II dwells, in part, on Flood and Marion (1983), who developed a model of exchange-rate regimes in transition, based on the Italian two-tier foreign exchange market in 1973-74. Issues similar to those considered here are also examined by Calvo (1989), Djajic (1989), and Obstfeld and Krugman (1985).

$$\dot{R}_t = -\Phi(s_t - e_t), \tag{5}$$

$$\dot{D}_t = 0, \tag{6}$$

where m_t denotes the nominal money stock, D_t domestic credit, R_t the stock of net foreign assets held by the central bank, p_t the domestic price level, $\bar{e}_t$ the official exchange rate, s_t the parallel exchange rate, i_t the domestic nominal interest rate and i^* the (constant) foreign interest rate. All variables, except interest rates, are measured in logarithms.

Equation (1) describes money market equilibrium. Equation (2) depicts a modified interest parity condition, which is based on the assumption that the principal on foreign bonds is acquired and repatriated at the parallel exchange rate, but interest income--a current-account item--is repatriated at the official exchange rate. 1/ Equation (3) is a log-linear approximation which defines the domestic money stock as a weighted average of domestic credit and foreign reserves. Equation (4) indicates that the price level depends on the official and parallel exchange rates. This results from the assumption that some commercial transactions are settled in the parallel market, with the price of these imports reflecting the marginal cost of foreign exchange--that is, the parallel rate. The purchasing power parity assumption holds therefore at a composite exchange rate, and the foreign price level has been set to unity (so that its logarithm is zero) for simplicity. 2/ Equation (5) describes the behavior of net foreign assets. 3/ The negative effect of the premium--defined as the difference between the official and the parallel exchange rates--on the behavior of reserves results from its impact on under-invoicing of exports. The higher the parallel exchange rate is relative to the official rate, the greater the incentive to falsify export invoices and to divert export proceeds to

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1/ A formal derivation of expression (2) is provided by Flood and Marion (1983). The coefficient γ represents the mean value of the foreign interest rate. Assuming that interest income is also repatriated through the parallel market would imply setting $\gamma = 0$.

2/ The coefficient ν can be viewed as an approximation to the share of transactions settled illegally in the parallel market relative to total trade transactions.

3/ Note that, although interest receipts are assumed to be repatriated at the official exchange rate, they are not accounted for in equation (5) for simplicity.

the unofficial market. 1/ Finally, equation (6) indicates that the stock of credit is assumed constant.

III. Solution and Dynamics in Anticipation of Reform

In the pre-reform dual exchange rate system, the forward-looking parallel rate s_t and the predetermined level of official reserves R_t are endogenous variables while the official exchange rate e_t is assumed set at $\bar{e}$ by the authorities. In the post-reform, unified flexible rate regime, by contrast, $s_t = e_t = \epsilon_t$ and reserves remain constant. We now examine the behavior of endogenous variables in the two regimes.

1. The pre-reform dual rate regime

Setting $e_t = \bar{e}$, $D_t = \bar{D}$ and $i^* = 0$ and solving (1)-(6) yields

$$\begin{bmatrix} \dot{s}_t \\ \dot{R}_t \end{bmatrix} = \begin{bmatrix} (\alpha\gamma+\nu)/\alpha & -\Theta/\alpha \\ -\Phi & 0 \end{bmatrix} \begin{bmatrix} s_t \\ R_t \end{bmatrix} + \begin{bmatrix} -(1-\Theta)\bar{D}/\alpha + (1-\nu-\alpha\gamma)\bar{e}/\alpha \\ \Phi\bar{e} \end{bmatrix}. \tag{7}$$

The two eigenvalues of this system are given by

$$\rho_2,\ \rho_1 = \left\{(\alpha\gamma + \nu) \pm [(\alpha\gamma + \nu)^2 + 4\alpha\Phi\Theta]^{1/2}\right\}/2\alpha.$$

System (7) is saddle-point stable with one negative root (denoted by ρ_1) and one positive root, ρ_2. Solving for the particular solutions yields, for $t < T$,

$$s_t = s^* + A exp(\rho_1 t) + B exp(\rho_2 t), \tag{8a}$$

$$R_t = R^* + \kappa_1 A exp(\rho_1 t) + \kappa_2 B exp(\rho_2 t), \tag{8b}$$

1/ A more general model of reserve changes would involve including a positive term (Ω, say) in equation (6), which would capture the central bank's policy regarding assignment of transactions between markets. The higher the proportion of exports--and the lower the proportion of imports--legally assigned to the official market, the higher Ω would be. Such a formulation would imply a positive premium in the steady state derived below.

$$s^* = \bar{e}, \qquad R^* = [\bar{e} - (1 - \Theta)\bar{D}]/\Theta, \tag{8c}$$

$$\kappa_1 = - [\alpha\rho_1 - (\alpha\gamma+\nu)]/\Theta > 0, \quad \kappa_2 = - [\alpha\rho_2 - (\alpha\gamma+\nu)]/\Theta < 0, \tag{8d}$$

where A and B are as yet undetermined coefficients, and s^* and R^* denote the steady-state values of the parallel rate and foreign exchange reserves.

Let us first suppose that the existing dual rate system is expected to last forever. Stability would then require setting $B = 0$ in the solutions (8*a*) and (8*b*). Using an initial condition on reserves would thus allow the determination of A. The economy's equilibrium path is the unique non-explosive path *SS* (which passes through the stationary point *E*) depicted in Figure 1. For a positive (negative) premium, reserves are falling (increasing), as indicated by the arrows pointing west (east) in the Figure. Along the saddle path, the parallel exchange rate and foreign reserves evolve according to

$$s_t - s^* = - (\rho_1/\Phi)(R_t - R^*),$$

which indicates that *SS* has a positive slope. 1/

However, if the authorities announce their intention to switch to a floating rate arrangement in the future, agents will anticipate the abandonment of the dual rate system. In this context, the coefficient B will not be zero. Instead, as shown below, agents will set coefficients A and B at values that satisfy constraints imposed by a perfectly anticipated transition to the post-reform regime.

2. The post-reform flexible rate regime

Let $T > 0$ represent the future transition date announced at period $t = 0$--that is, the initial instant at which the authorities intend to switch to the flexible rate regime. In the post-reform flexible rate system $\epsilon_t = e_t = s_t$, a condition which yields (from

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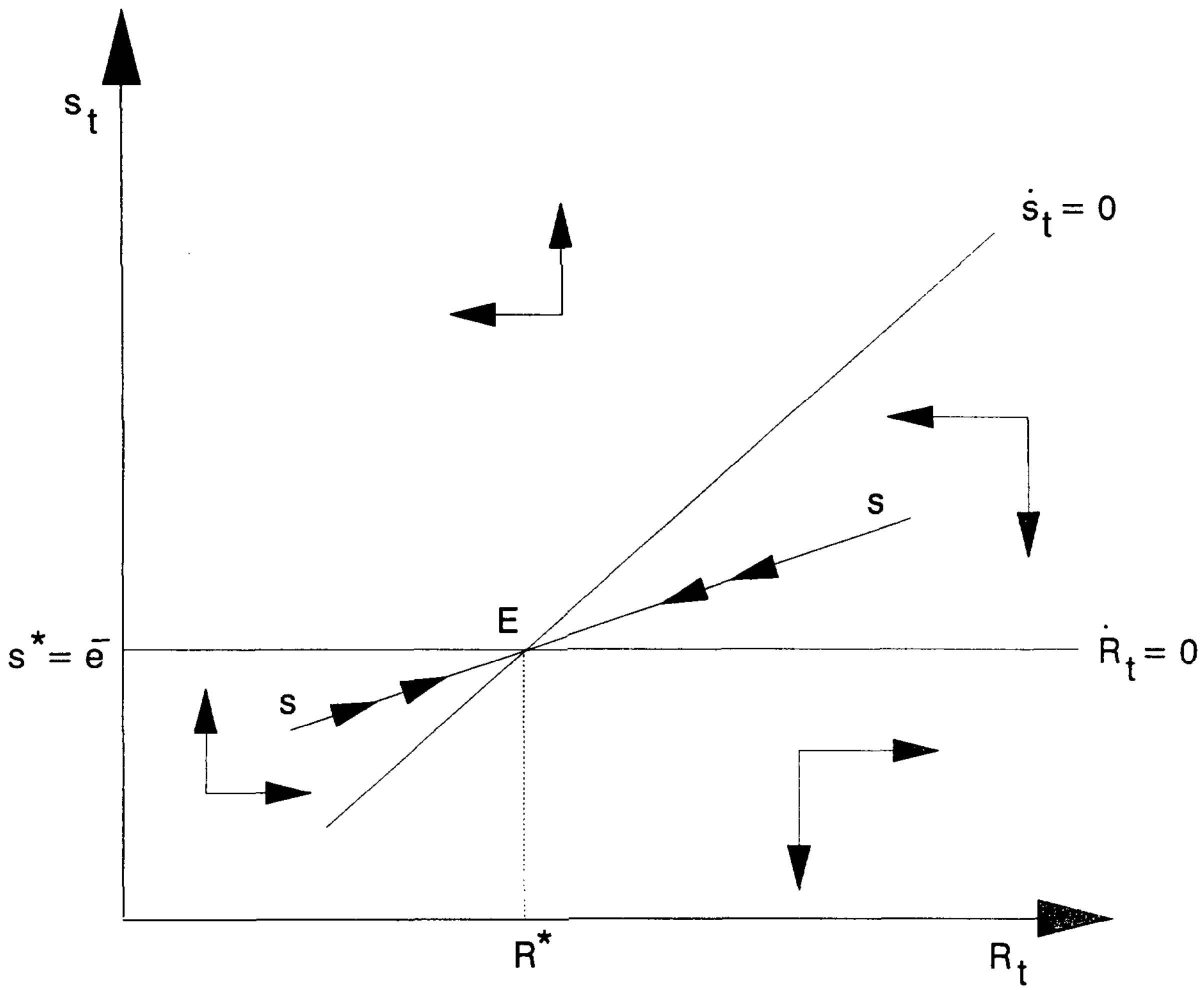
1/ The Figure assumes that the slope of *SS* is less than the slope of $\dot{s}_t = 0$. An increase in the interest elasticity α would rotate the curves $\dot{s}_t = 0$ and *SS* clockwise. An increase in $\bar{D}$ would shift the curve $\dot{s}_t = 0$ to the left and move point *E* horizontally to the left. A rise in the propensity to under-invoice Φ translates into a clockwise rotation of the saddle path *SS*. Finally, a devaluation of the official exchange rate leads to an upward shift of the $\dot{R}_t = 0$ curve and a rightward (leftward) shift of the $\dot{s}_t = 0$ curve if $1 - \nu$ is greater (lower) than $\alpha\gamma$. Nevertheless, a devaluation always leads to an equi-proportional depreciation of the parallel exchange rate and an increase in reserves in the steady-state (equation 8*c*).

Figure 1
Steady-state Equilibrium in the Dual-Rate Regime



equation (7)) $\dot{R}_t = 0$. Therefore reserves remain constant beyond $t \geq T$, say, at R_T^+. Under these assumptions, the unified flexible exchange rate is determined by

$$\alpha\dot{\epsilon}_t - \epsilon_t = -\bar{m}, \qquad t \geq T \tag{9}$$

where

$$\bar{m} = \Theta R_T^+ + (1 - \Theta)\bar{D}. \qquad t \geq T \tag{10}$$

Equation (9) is a linear differential equation in ϵ_t, whose solution is

$$\epsilon_t = C exp(t/\alpha) + \bar{m}. \qquad t \geq T \tag{11}$$

Ruling out speculative bubbles requires setting $C = 0$. The exchange rate in effect at the initial instant the economy switches to a unified floating rate regime is therefore $\epsilon_T^+ = \bar{m}$.

3. Dynamics in anticipation of reform

We now examine how reserves and the premium will evolve when agents perfectly anticipate the transition from a dual rate regime to a flexible system. Essentially, this requires establishing conditions which "connect" the two regimes. In the present model, there are two such requirements: an initial condition on reserves, and a price continuity condition, which prevents a jump in the parallel exchange rate at the moment the reform is implemented: 1/

$$R_0 = \bar{R}_0, \qquad s_T = \epsilon_T^+ = \bar{m}, \qquad \text{for } t \geq T. \tag{12}$$

Conditions (12) allow us to determine the constants A and B in the solutions for reserves and the parallel exchange rate obtained for

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1/ The price continuity principle has been used extensively in the literature on speculative attacks (see Agénor, Bhandari and Flood, 1991). However, it cannot be justified here as a condition to eliminate speculative profits at the time of transition, as in Flood and Marion (1983). To do this would require assuming that agents have a direct--and costless--access to official reserves. Here, capital account transactions through the official foreign exchange market are prohibited, and agents can only deplete official reserves by illegally diverting export remittances to the parallel market--presumably at a fixed (albeit non-prohibitive) cost. Consequently, speculative attacks on official reserves cannot occur in the present framework.

the dual rate regime (equations 8*a* and 8*b*). These solutions are given by 1/

$$A = [(\epsilon_T^+ - \bar{e})\kappa_2 - (\bar{R}_0 - R^*)exp(\rho_2 T)]/\Delta. \qquad (13a)$$

$$B = [(\bar{R}_0 - R^*)exp(\rho_1 T) - \kappa_1(\epsilon_T^+ - \bar{e})]/\Delta, \qquad (13a)$$

where $\Delta = \kappa_2 exp(\rho_1 T) - \kappa_1 exp(\rho_2 T) < 0$.

Substituting equations (13) in equations (8) yields the complete solutions for the parallel exchange rate and foreign reserves in the dual-rate regime. These solutions are given by

$$s_t = s^* + \frac{(\epsilon_T^+ - \bar{e})}{\Delta}[\kappa_2 exp(\rho_1 t) - \kappa_1 exp(\rho_2 t)] \qquad (14a)$$

$$+ \frac{(\bar{R}_0 - R^*)}{\Delta}[exp(\rho_1 T+\rho_2 t) - exp(\rho_2 T+\rho_1 t)]$$

$$R_t = R^* + \frac{\kappa_1\kappa_2(\epsilon_T^+ - \bar{e})}{\Delta}[exp(\rho_1 t) - exp(\rho_2 t)] \qquad (14b)$$

$$+ \frac{(\bar{R}_0 - R^*)}{\Delta}[\kappa_2 exp(\rho_1 T+\rho_2 t) - \kappa_1 exp(\rho_2 T+\rho_1 t)],$$

for $0 \le t < T$.

Equations (14) characterize the paths of reserves and the parallel rate prior to the reform. To examine the effect of a future regime switch on these variables, let $\tilde{s}_t$ and $\tilde{R}_t$ denote the solution paths that would have prevailed in the absence of any reform announcement. As discussed above, these solutions are obtained by setting $B = 0$ in equations (8) and using the initial condition on reserves to solve for A, so that

$$\tilde{s}_t = s^* + (G/\kappa_1)exp(\rho_1 t), \qquad \tilde{R}_t = R^* + Gexp(\rho_1 t), \qquad (15)$$

1/ Setting $t = 0$ in equation (8*b*), $t = T$ in equation (8*a*) and using (12) yields

$$Aexp(\rho_1 T) + Bexp(\rho_2 T) = \epsilon_T^+ - \bar{e}, \qquad \kappa_1 A + \kappa_2 B = \bar{R}_0 - R^*.$$

Solving this system yields equations (13).

with $G = \bar{R}_0 - R^*$. Using equations (8) and (15),

$$s_t - \tilde{s}_t = (A - G/\kappa_1)exp(\rho_1 t) + Bexp(\rho_2 t), \tag{16a}$$

$$R_t - \tilde{R}_t = (A - G)exp(\rho_1 t) + Bexp(\rho_2 t), \tag{16a}$$

with A and B given by equations (13).

Equations (16) show how the path of the parallel exchange rate and foreign reserves--relative to a "no-change" environment--depends on the relation between the initial value of reserves $\bar{R}_0$ and its steady-state value in the (permanent) dual rate regime R^*, as well as the difference between the value of the official exchange rate that would have been observed at time T in the absence of reform, $\bar{e}$, and the level of the exchange rate that prevails at the moment the floating regime is implemented, ϵ_T^+. A realistic case for developing countries is an initial situation in which a positive premium exists up to an instant before the future reform is announced, that is, where $\tilde{s}_0 > \bar{e} = s^*$. From equation (15), such a condition obtains for $\bar{R}_0 > R^*$.

In such a situation, it can be shown that an announcement at $t = 0$ of a future reform at T would lead if $\epsilon_T^+ > \bar{e}$ to an immediate depreciation of the parallel exchange rate--relative to its previously anticipated path--and a fall in reserves. 1/ On the contrary, if $\epsilon_T^+ < \bar{e}$ a reform announcement would lead to an immediate appreciation of the parallel rate and an increase in the stock of net foreign assets. 2/

The reason for the initial jump in the parallel exchange rate at $t = 0$ is as follows. If there is initially a positive premium, agents

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1/ For a depreciation to occur requires, in addition to the condition $\epsilon_T^+ > \bar{e}$, that the parallel exchange rate an instant before the announcement be less than the unified exchange rate, that is, $\tilde{s}_0 < \epsilon_T^+$. From equation (15), this condition can be written as $\epsilon_T^+ - \bar{e} > (\bar{R}_0 - R^*)/\kappa_1$. Since $exp(\rho_1 T) \leq 1$, this condition is also sufficient to ensure that $B > 0$. Note that the condition $\epsilon_T^+ > \bar{e}$ is sufficient for the above inequality to hold if $\bar{R}_0 - R^*$ is "small", that is, if the initial value of the premium is not "too high."

2/ In this case the parallel exchange rate always appreciates after the annoucement since, by assumption, $\epsilon_T^+ < \bar{e}$ implies $\epsilon_T^+ < \tilde{s}_0$.

realize that the future reform will imply a depreciation of the official exchange rate, a rise in prices, and therefore a reduction in real money balances. Under perfect foresight, these future effects will be reflected in the expected--and actual--rate of depreciation of the parallel exchange rate, leading agents to reduce immediately their demand for domestic currency. But since the nominal money stock is constant (reserves cannot jump at $t = 0$), equilibrium in the money market can be maintained only if an immediate rise in prices occurs--or only if the parallel exchange rate depreciates. This result is qualitatively similar to what Kiguel and Lizondo (1990) obtain in a similar--but somewhat different--framework.

The behavior of the parallel exchange rate and foreign reserves in the pre- and post-reform regime under the assumptions $\bar{R}_0 > R^*$ and $\bar{e} < \tilde{s}_0 < \epsilon_T^+$ is illustrated in Figure 2. 1/ The first panel of the Figure shows that at $t = 0$, the parallel exchange rate jumps upward and depreciates thereafter at an accelerating pace until it reaches ϵ_T^+ at T. The official exchange rate remains constant at $\bar{e}$ until T, at which time it jumps to ϵ_T^+--bringing the premium down to zero. The path of reserves relative to the "no-change" scenario is illustrated in the second panel of Figure 2. No jump in the level of reserves occurs at $t = 0$, but the rate of reserves depletion accelerates over time towards its post-reform steady-state value, R_T^+, obtained by setting $t = T$ in equation (14*b*). 2/

The dynamic behavior in anticipation of reform is also illustrated in Figure 3, which extends Figure 1. As assumed above, the position of the economy before the reform announcement is such that $\bar{R}_0 > R^*$ (corresponding to a positive premium) and is located on a point such as *F* on the saddlepath *SS*. The steady-state equilibrium in the post-unification regime is *E'*, corresponding to a stock of net foreign assets equal to R_T^+ and a unified, constant exchange rate equal to ϵ_T^+. 3/ At the moment the future reform is announced, the parallel

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1/ For $t < 0$ the equation driving the parallel rate is (15), while it is (14*a*) for $0 \leq t \leq T$.

2/ Unification before the dual rate regime reaches its steady-state reduces reserve losses due to leakages; equation (14*b*) shows that since $\epsilon_T^+ - \bar{e} > 0$, $R_T^+ > R^*$.

3/ Regardless of the path followed in the dual rate regime, the economy must reach point *E'* at time *T*. Note that point *E'* is necessarily located northeast of point *E*, since $R_T^+ > R^*$.

Figure 2
Behavior of Reserves and the Parallel Exchange Rate

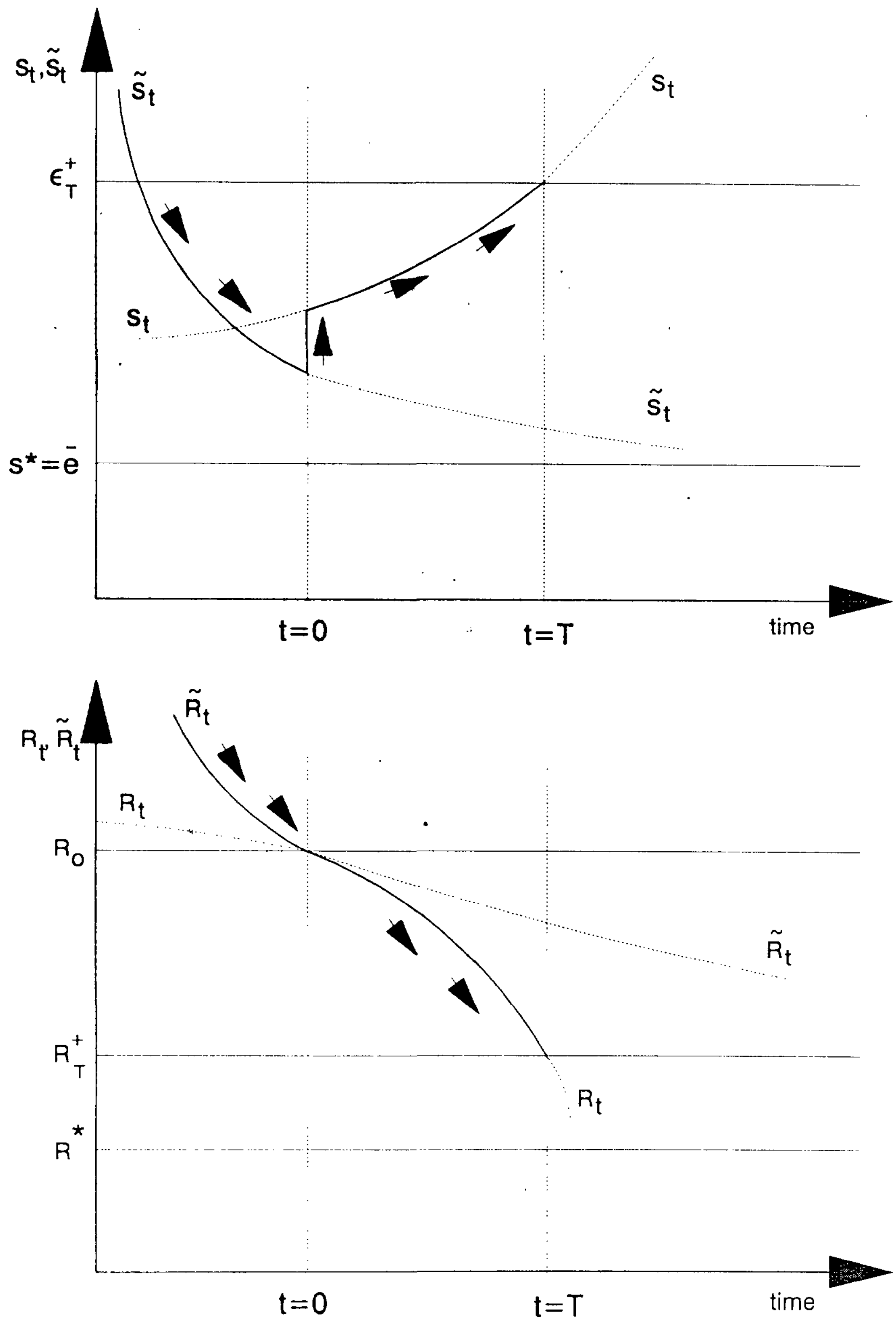
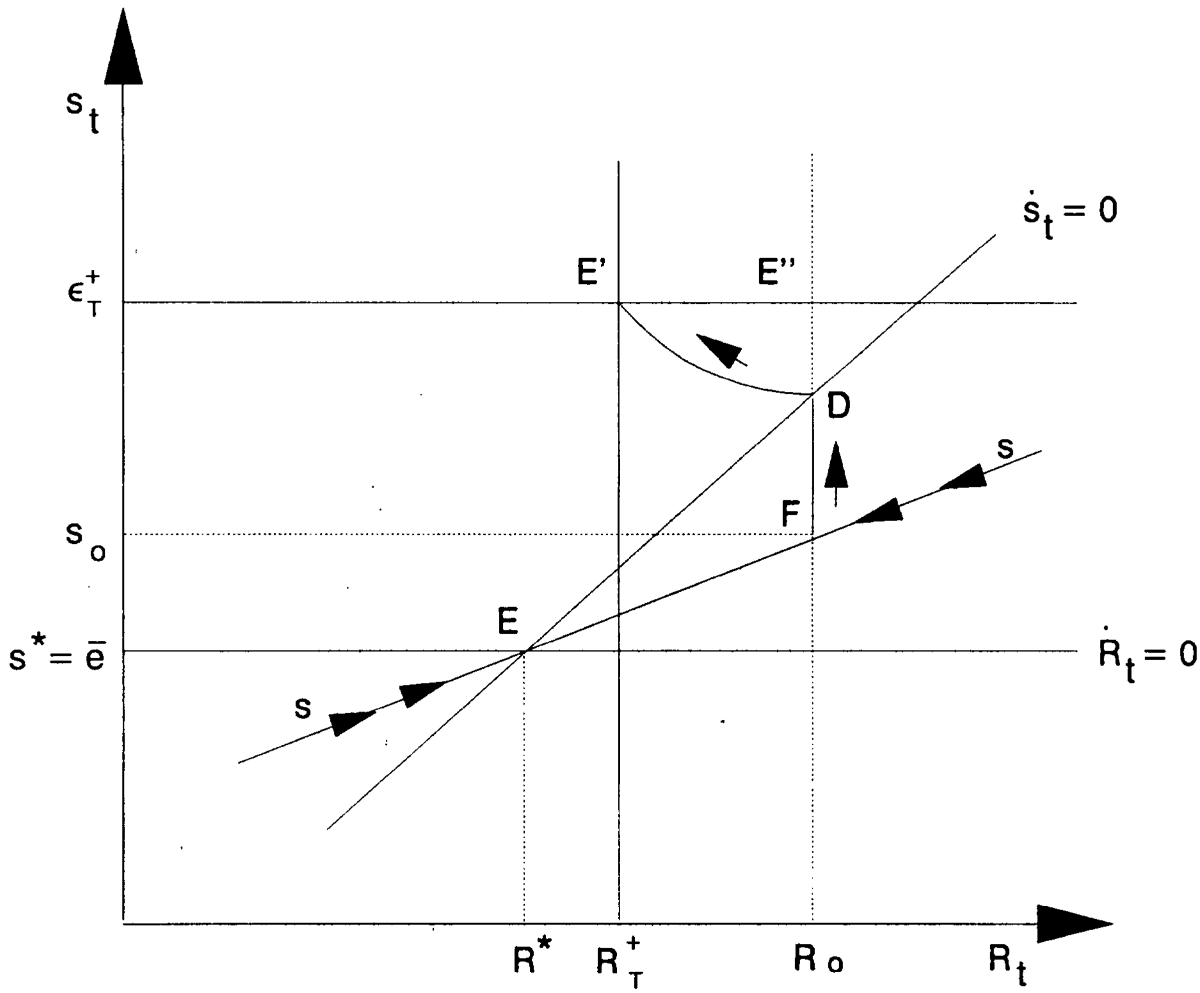


Figure 3
Dynamics upon Unification of Foreign Exchange Markets



exchange rate jumps to a point such as D on the curve $\dot{s}_t = 0$ and moves thereafter towards point E', which is reached--without further jumps--at the moment the reform is implemented, T. 1/

Having studied the economy's path in the pre- and post-reform phases, we can now briefly consider how this path is related to the length of the transition period, T. First, if the exchange rate reform is announced to occur in the very distant future--that is, for $T \rightarrow \infty$--the announcement effect on the path of the parallel exchange rate and reserves in the transition interval is negligible. By contrast, if the reform occurs "overnight"--that is, for $T \rightarrow 0$--the economy will move immediately to its post-reform steady state, without temporarily following an unstable path. 2/ In terms of Figure 3, the parallel exchange rate would immediately jump from point F to point E'', with no change in the initial stock of reserves.

IV. Real Effects of Anticipated Reforms

We now extend the analysis of the previous section to consider the real-sector implications of a pre-announced exchange-rate reform. Output, and the real exchange rate are now treated as endogenous.

1. An extended framework

Aggregate demand is assumed to be inversely related to the real interest rate and the real exchange rate--measured as the difference between a weighted average of the official and parallel exchange rates and the price level: 3/

1/ The condition under which the parallel exchange rate will jump to a point such as D is given by, using equation (14a) and the equation of the sadlle path given above,

$$s_0 = -(\rho_1/\Phi)(\bar{R}_0 - R^*) = \bar{e} + \frac{(\bar{R}_0 - R^*)}{\Delta}[exp(\rho_1 T) - exp(\rho_2 T)],$$

which can be solved for the appropriate value of T.

2/ Setting $T \rightarrow \infty$ in equations (13) indicates that $A \rightarrow G/\kappa_1$ and $B \rightarrow 0$, so that the solutions for s_t and R_t coincide with those for $\tilde{s}_t$ and $\tilde{R}_t$. Similarly, setting $T \rightarrow 0$ in equations (14) yields $s_0 \rightarrow \epsilon_T^+$, and $R_0 \rightarrow \bar{R}_0$.

3/ As before, all coefficients are defined as positive in what follows.

$$y_t = \bar{y} + c_1[\sigma s_t + (1 - \sigma)\bar{e}_t - p_t] - c_2(i_t - \dot{p}_t), \tag{17}$$

where $\bar{y} > 0$ and $0 \leq \sigma \leq 1$.

Prices are now assumed to be set as a mark-up on wages ω_t and prices of imported inputs, measured in domestic currency and valued at the marginal cost of foreign exchange--that is, the parallel market exchange rate:

$$p_t = \eta\omega_t + (1 - \eta)s_t, \qquad 0 < \eta < 1 \tag{18}$$

In addition to the parallel market premium, the behavior of reserves also depends on the real exchange rate and aggregate output,

$$\dot{R}_t = - \Phi(s_t - \bar{e}) - b_1 y_t + b_2[\sigma s_t + (1 - \sigma)\bar{e}_t - p_t]. \tag{5'}$$

The demand for money function is now given by

$$m_t - p_t = \upsilon y_t - \alpha i_t, \tag{1'}$$

while equations (2), (3) and (6) remain unchanged. The last step in the description of the model relates to wage formation. Here we adopt the forward-looking wage scheme used by Willman (1988), which follows the overlapping contract model developed by Calvo (1983). Formally, wage formation is given by

$$\omega_t = \mu\int_t^{\infty} exp[\mu(t-k)]p_k dk, \tag{19}$$

where $\mu > 0$ represents a discount factor. In equation (18), ω_t represents the wage rate stipulated in new and renewed contracts at time t. Assuming that wage contracts are made directly between employers and individual employees, ω_t defined by (19) measures the marginal labor cost of production and hence is the relevant price to incorporate in the mark-up pricing equation (18).

Differentiating (19) with respect to time yields

$$\dot{\omega}_t = \mu(\omega_t - p_t). \tag{20}$$

Substituting equation (18) in (20) yields

$$\dot{\omega}_t = \Psi(\omega_t - s_t). \qquad \Psi \equiv \mu(1 - \eta) \tag{20'}$$

The complete model consists now therefore of equations (1'), (2), (3), (5'), (6), (17), (18), and (20').

2. Solution under alternative regimes

Since the solution of the model follows essentially the same procedure as above, we only briefly highlight its features. In the pre-reform, dual exchange rate regime, the model solves for the parallel rate, the wage rate, and official reserves. As shown in the Appendix, there are no unambiguous results in the general case. However, if the real interest elasticity of aggregate demand is zero, and if the income elasticity of money demand is small enough, 1/ then the complete solution can be can be shown to be

$$s_t = \bar{e} + \sum_{k=1}^{3} A_k exp(\rho_k t), \qquad (21a)$$

$$\omega_t = \bar{e} + \sum_{k=1}^{3} A_k \frac{(\Psi - \rho_k)}{\Psi} exp(\rho_k t), \qquad (21b)$$

$$R_t = R^* + \Theta^{-1} \sum_{k=1}^{3} A_k [\frac{(\Psi - \rho_k)}{\Psi}\pi_1 - (\alpha\rho_k - \pi_2)] exp(\rho_k t), \qquad (21c)$$

where ρ_k denotes the roots of the system (with ρ_1 being the only negative root), and π_1, π_2 are coefficients defined in the Appendix. R^* is given by equation (8c) and the A_k are as yet undetermined coefficients.

When agents expect the dual rate regime to last forever, the stable path solution is obtained as before by setting $A_2 = A_3 = 0$ and imposing the initial condition on reserves, since there are now two "jump" variables. In the post-reform, unified flexible exchange rate regime, official reserves must remain constant. From (20′), the steady state requires also that the wage rate be equal to the unified exchange rate in the new regime--a condition which, in turn, implies from (18) that the real exchange rate is zero in the post-reform steady state if $\sigma = 1$. Assuming, as before, that the real interest elasticity of aggregate demand is zero and that the income elasticity of money demand is small enough implies therefore that the condition $\dot{R}_t = 0$ for $t \geq T$ always holds. Consequently, in the flexible rate regime, equation (5′) becomes irrelevant for the determination of wages and the parallel exchange rate. As shown in the Appendix, the solution for these variables is given by

$$\epsilon_T^+ = \omega_T^+ = \bar{m}. \qquad (22)$$

1/ Formally, these conditions are $c_2 \to 0$, and $\nu \leq 1/c_1$.

3. Model dynamics

As shown in Section III, a pre-announced exchange rate reform affects the behavior of the parallel exchange rate immediately after it becomes known to the public. In addition to effects on real money balances and foreign reserves, such changes have, in the general setting considered now, an impact on output, wages and inflation, and the real exchange rate.

The determination of the coefficients A_k in equations (21) proceeds as before. There are now three conditions: the initial condition on reserves, and the conditions on the flexible exchange rate and nominal wages beyond period T (equation 22). These solutions are given in the Appendix. In the general case, these values are fairly complicated and do not allow a clear characterization of the solution path. Suppose, however, that the initial situation is such that a positive premium prevails, the parallel exchange rate is "below" the unified floating rate, and that the reform is announced sufficiently in advance. The behavior of output, prices, wages, the real exchange rate and the trade balance can then be characterized as in Figure 4. 1/ Nominal wages and the parallel exchange rate jump upwards at the moment the reform announcement is made, since agents discount back to the present the future official depreciation and increase in prices that the regime switch will entail. The domestic price level increases by more than the parallel exchange rate, leading to a real exchange rate appreciation, and a fall in output--relative to its "undisturbed" path. 2/ Equilibrium in the money market is therefore maintained not only by a depreciation of the parallel exchange rate and a rise in prices (as before) but also by an adjustment in real output. Prices also rise by more than nominal wages, implying a fall in real wages on impact. Finally, the trade balance may deteriorate or improve, depending on whether the positive effect of the reduction in output is less or greater than the negative effects resulting from a real exchange rate appreciation on trade flows and from the rise of the premium on the propensity to under-invoice. In the Figure, it is assumed that the net effect on the trade balance is negative. At period T, all variables reach their

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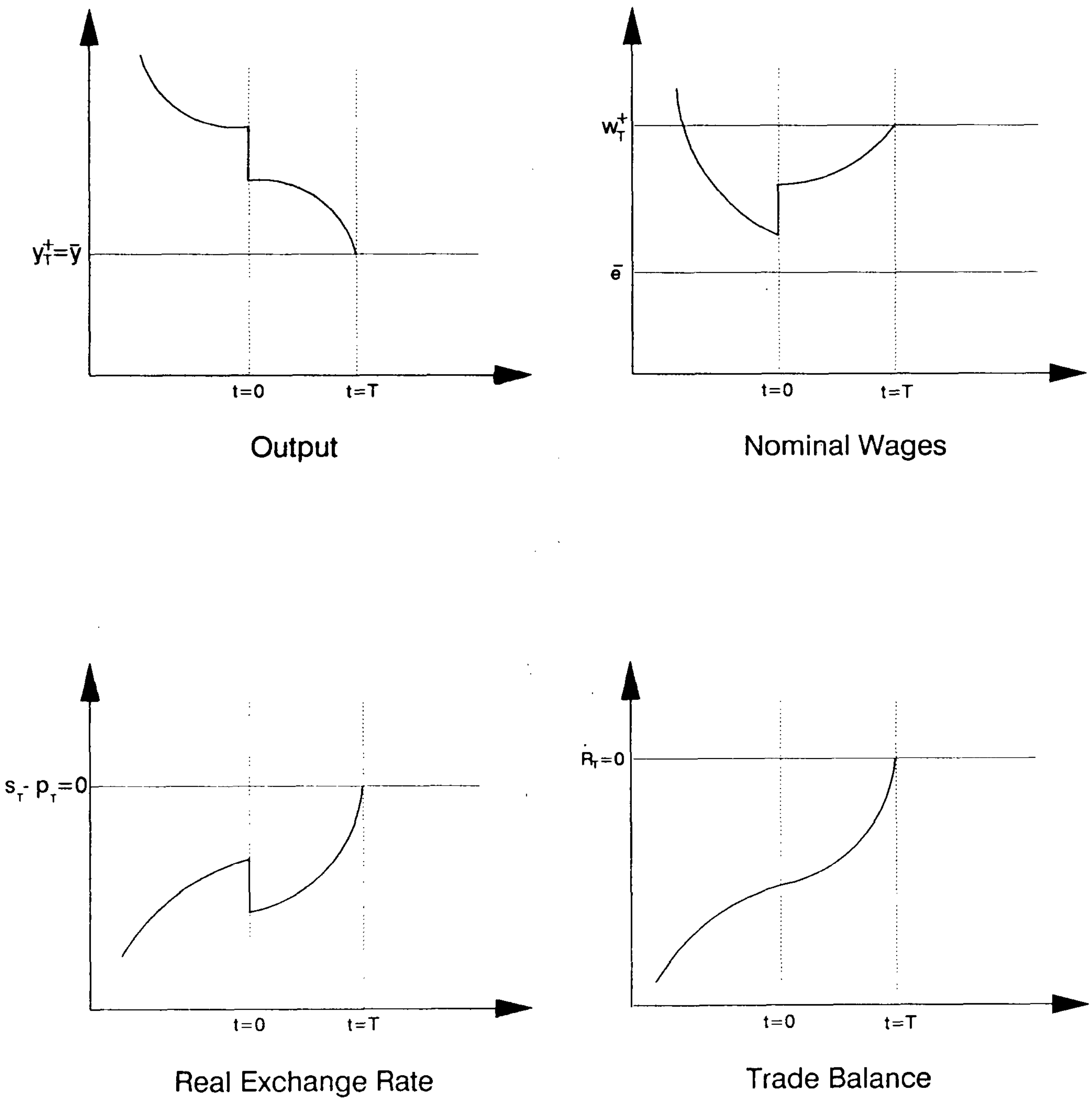
1/ The path of reserves and the parallel exchange rate is qualitatively similar to what is shown in Figure 2 and is therefore omitted for simplicity. The real exchange rate in what follows is assumed to be measured as the difference between the parallel rate and the price level, that is, by setting $\sigma = 1$.

2/ Note that this result does not depend on whether the real exchange rate is measured in the "standard" way by using the official exchange rate ($\sigma = 0$) or by using the parallel exchange rate ($\sigma = 1$). In fact, in the former case, the real exchange rate appreciation is more pronounced than in the general case.

Figure 4

Behavior of Output, Prices, Wages and the Trade Balance



new, constant steady-state values, without further jumps in wages or the parallel exchange rate. 3/

V. Summary and Conclusions

Exchange rate reforms in developing countries have often consisted in floating the exchange rate in an attempt to unify the official and parallel markets for foreign exchange. The purpose of this paper has been to examine the behavior of output, prices, foreign reserves and the trade balance in anticipation of such reforms. The analysis has been conducted first in the context of a simplified model which explicitly considers leakages between foreign exchange markets. The model indicates that a future reform leads, at the moment the announcement is made, to an instantaneous depreciation of the parallel exchange rate and no change in the stock of foreign reserves. In the transition period, the parallel exchange rate keeps depreciating (and the premium keeps rising) while net foreign assets keep falling--both at an accelerating rate. No "jumps" occur when the reform is actually implemented, and the parallel market premium drops to zero. The reason for the jump in the parallel exchange rate upon announcement of the reform is as follows. If there is initially a positive premium, agents realize that the future reform will imply a depreciation of the official exchange rate, a rise in prices, and therefore a reduction in real money balances. Under perfect foresight, these future effects are reflected immediately in the expected--and actual--rate of depreciation of the parallel rate, leading agents to reduce demand for the domestic currency. But since the initial money stock is constant, equilibrium in the money market can be maintained only if an immediate rise in prices occurs--or if the parallel exchange rate depreciates.

Extensions of the model to incorporate sticky prices, forward-looking wage contracts and to endogenize output and the real exchange rate indicate that the implications of the simplified framework for foreign reserves (or the trade balance) and the premium remain largely unaltered. In addition, the analysis of the extended model suggests that, in the transition period, a pre-announced reform may be associated with an appreciation of the real exchange rate, and a fall in output.

The analysis developed in this paper can be extended in various ways. First, the date at which the reform will take place in the future may not be perfectly known by agents. Second, it may be assumed that agents are uncertain about the type of exchange rate regime the authorities would adopt following a reform attempt. For instance, instead of assuming that the authorities will adopt a

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3/ If, in equation (18), the price level was assumed to depend also on the official exchange rate, prices would experiment a jump at $t = T$ as a result of the depreciation occuring in the official market.

unified floating exchange rate system, they could envisage a transition to a uniform fixed exchange rate regime. A likely outcome of the introduction of uncertainty about the reform date and/or the nature of the post-transition regime is that expectations of a reform would cause a jump in the parallel exchange rate at the moment the reform is implemented as well as volatile exchange rate movements prior to transition if this type of uncertainty varies over time. 1/ Third, it may be assumed that the domestic credit rule is stochastic. Such an extension would be particularly fruitful, since it would allow use of analytical techniques developed recently in the continuous-time literature on target zones. 1/ Finally, use of a large sample of reform episodes in developing countries would allow an empirical verification of the predictions of the model. Although these extensions may prove useful, the basic methodological implication of this paper is likely to remain unaltered: to understand the dynamics associated with exchange rate reforms in developing countries with sizable parallel currency markets, it is critically important to allow for adjustment behavior in anticipation of such reforms.

1/ A formal proof of this proposition can be derived by extending the procedure developed in Flood and Marion (1983).

1/ See Krugman (1991). Following Flood and Marion (1983), Froot and Obstfeld (1991) examine the unification issue in the context of a stochastic dual-rate model in which both exchange rates are floating. Analytically, the problem considered here would be similar to the two-state variable problem studied by Miller and Weller (1991).

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Solution of the Model with Real Effects

In this Appendix, we present the solution of the extended model, setting for simplicity $\sigma = 1$ in equations (17) and (5′). First, note that, from (18) and (2),

$$i_t - \dot{p}_t = \eta(\dot{s}_t - \dot{\omega}_t) - \gamma(s_t - e_t),$$

while from (18), $s_t - p_t = \eta(s_t - \omega_t)$. Substituting these relations in (17) yields, with $\bar{y} = 0$,

$$y_t = c_1\eta(s_t - \omega_t) - c_2[\eta(\dot{s}_t - \dot{\omega}_t) - \gamma(s_t - e_t)]. \tag{A1}$$

Substituting (2), (3), (A1) and (18) in (1′) yields

$$\Omega\dot{s}_t - \nu\eta\dot{\omega}_t = - \Theta R_t - (1 - \Theta)\bar{D} + \eta(1 - \nu c_1)\omega_t \tag{A2}$$

$$+ [(1 - \eta) + \nu c_1\eta + \gamma(\alpha + \nu c_2)]s_t - \gamma(\alpha + \nu c_2)e_t.$$

Similarly, Substituting (A1) in (5′) yields

$$\dot{R}_t = - (\Phi + b_1c_2\gamma)(s_t - e_t) + \eta(b_2 - b_1c_1\eta)(s_t - \omega_t) \tag{A3}$$

$$+ b_1c_2\eta(\dot{s}_t - \dot{\omega}_t).$$

In the pre-reform, dual exchange rate regime, equations (A2), (A3) and (20′) form a system of differential equations in s_t, R_t and ω_t in "non-normal" form. To solve this system, we postulate the solution to be of the form

$$s_t = \kappa_1e^{\rho t}, \quad R_t = \kappa_2e^{\rho t}, \quad \omega_t = \kappa_3e^{\rho t}, \tag{A4}$$

where the κ_i are not all zero. Substituting these expressions in the homogenous part of the system defined by (A2), (A3) and (20) yields

$$e^{\rho t}[\kappa_1(\Omega\rho - \pi_2) + \Theta\kappa_2 - \kappa_3(\nu c_2\eta\rho + \pi_1)] = 0, \tag{A5a}$$

$$e^{\rho t}[- \kappa_1(\pi_4 + \rho\pi_7) + \rho\kappa_2 + \kappa_3(\pi_6 + \rho\pi_7)] = 0, \tag{A5b}$$

$$e^{\rho t}[\kappa_1\Psi + \kappa_3(\rho - \Psi)] = 0. \tag{A5c}$$

where

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$$\pi_1 = \eta(1 - \nu c_1) \gtreqless 0,$$

$$\pi_2 = (1 - \eta) + \nu c_1 \eta + \gamma(\alpha + \nu c_2) > 0,$$

$$\pi_3 = \gamma(\alpha + \nu c_2) > 0,$$

$$\pi_4 = - (\Phi + b_1 c_2 \gamma) + \eta(b_2 - c_1 b_1) \gtreqless 0,$$

$$\pi_5 = (\Phi + b_1 c_2 \gamma) > 0,$$

$$\pi_6 = \eta(b_2 - c_1 b_1) \gtreqless 0,$$

$$\pi_7 = b_1 c_2 \eta > 0.$$

and $\Omega = \alpha + \nu c_2 \eta > 0$.

Assuming the conventional Marshall-Lerner to hold implies that π_6 is positive, so that a rise in nominal wages appreciates the real exchange rate and reduces reserves. However, this condition is not sufficient to ensure that a nominal depreciation of the parallel exchange rate raises reserves (that is, that $\pi_4 > 0$): this is because such a rise increases the flow of exports receipts diverted to the parallel market, despite its positive effect on the real exchange rate and export volumes. We will in what follows assume that $\pi_1 > 0$, an assumption which requires the income elasticity of money demand not to be "too large" ($\nu < 1/c_1$).

Equations ($A5$) must be identically satisfied for ($A4$) to be a solution. This requires therefore all equations in brackets to be zero. To obtain non-trivial solutions for the κ_i requires that

$$\begin{vmatrix} (\rho\Omega - \pi_2) & \Theta & -(\nu c_2 \eta \rho + \pi_1) \\ -(\pi_4 + \rho\pi_7) & \rho & \pi_6 + \rho\pi_7 \\ \Psi & 0 & (\rho - \Psi) \end{vmatrix} = 0,$$

which gives

$$\tau_3 \rho^3 + \tau_2 \rho^2 + \tau_1 \rho + \tau_0 = 0, \qquad (A6)$$

where

$$\tau_0 = \Theta\Psi(\pi_6 - \pi_4) > 0,$$

$$\tau_1 = \Theta\pi_4 + \Psi(\pi_1 + \pi_2) \lesseqgtr 0,$$

$$\tau_2 = \Theta\pi_7 - \pi_2 + \Psi(\nu\eta c_2 - \Omega) \equiv \Theta\pi_7 - \pi_2 - \alpha\Psi \lesseqgtr 0,$$

$$\tau_3 = \Omega > 0.$$

A sufficient condition for τ_1 to be positive is $\pi_4 > 0$. The sign of τ_2 is in general indeterminate. Consider the case where the effect of the real interest rate on output is negligible; that is, $c_2 \to 0$. Then $\tau_2 < 0$. By Descartes' rule of signs, the polynominal (*A*6) has 2 roots with positive real parts and only one root with negative real part (denoted ρ_1), whatever the value of τ_1. 1/ The general solutions can be written as

$$s_t = s^* + \sum_{k=1}^{3} A_k\kappa_1(k)exp(\rho_k t), \qquad \omega_t = \omega^* + \sum_{k=1}^{3} A_k\kappa_2(k)exp(\rho_k t),$$

$$R_t = R^* + \sum_{k=1}^{3} A_k\kappa_3(k)exp(\rho_k t),$$

where the $\kappa_j(k)$ denote a triplet of values associated with each root ρ_j. The particular solutions are given by

$$s^* = \omega^* = \pi_5\bar{e}/(\pi_6 - \pi_4), \qquad R^* = \Theta^{-1}\left[\left(\frac{\pi_5(\pi_1+\pi_2)}{\pi_6 - \pi_4} - \pi_3\right)\bar{e} - (1 - \Theta)\bar{D}\right],$$

1/ To show that the real parts of the other two roots is positive, write the polynomial (*A*6) as

$$\rho^3 - (\rho_1 + \rho_2 + \rho_3)\rho^2 + (\rho_1\rho_2 + \rho_1\rho_3 + \rho_2\rho_3)\rho - \rho_1\rho_2\rho_3 = 0. \quad (A6')$$

Equations (*A*6) and (*A*6′) imply that

$$\rho_2\rho_3 = - \tau_0/\tau_3\rho_1 > 0, \qquad \rho_2 + \rho_3 = - (\tau_2 + \rho_1) > 0,$$

which in turn proves that ρ_2 and ρ_3 have positive real parts.

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so that $\pi_5/(\pi_6 - \pi_4) = (\pi_1 + \pi_2 - \pi_3) = 1$ for $c_2 \to 0$. Adopting the normalization rule $\kappa_1(k) \equiv 1$ and solving $(A5)$ for successive values of ρ_k yields

$$s_t = \bar{e} + \sum_{k=1}^{3} A_k exp(\rho_k t),$$

$$\omega_t = \bar{e} + \sum_{k=1}^{3} A_k \frac{(\Psi - \rho_k)}{\Psi} exp(\rho_k t),$$

$$R_t = R^* + \Theta^{-1} \sum_{k=1}^{3} A_k [\frac{(\Psi - \rho_k)}{\Psi}(\nu c_2 \eta \rho_k + \pi_1) - (\Omega \rho_k - \pi_2)] exp(\rho_k t).$$

Setting $c_2 \to 0$ yields equations (21) in the text. If the dual rate regime is expected to last forever, so that $A_2 = A_3 = 0$,

$$A_1 = \Theta(\bar{R}_0 - R^*)[\frac{(\Psi - \rho_1)}{\Psi}\pi_1 - (\alpha\rho_1 - \pi_2)]^{-1} > 0, \quad \text{for } \bar{R}_0 > R^*$$

which implies that, an instant before the announcement, $\tilde{s}_{0-} < \tilde{\omega}_{0-}$.

In the post-reform, flexible exchange rate regime, $s_t = e_t = \epsilon_t$, $\dot{R}_t = 0$ and $R_t = R_T^+$ for $t \geq T$. The simultaneous system is then formed of $(A2)$ and $(20')$, that is

$$\begin{bmatrix} \dot{\epsilon}_t \\ \dot{\omega}_t \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ -\Psi & \Psi \end{bmatrix} \begin{bmatrix} \epsilon_t \\ \omega_t \end{bmatrix} + \begin{bmatrix} -\bar{m}/\Omega \\ 0 \end{bmatrix}, \tag{A7}$$

where

$$a_{11} = [1 - \eta + \eta\nu(c_1 - \Psi c_2)]/\Omega \gtreqless 0,$$

$$a_{12} = (\eta/\Omega)[1 - \nu(c_1 - \Psi c_2)] \gtreqless 0.$$

and $\bar{m} = \Theta R_T^+ + (1 - \Theta)\bar{D}$. Assuming as before that $c_2 \to 0$ yields $a_{11} > 0$ and $a_{12} > 0$. Under these assumptions the system $(A7)$ will be globally unstable. Solving for the particular solution yields

$$\epsilon_T^+ = \omega_T^+ = \bar{m}/(a_{11} + a_{12})\Omega = \bar{m}. \tag{A8}$$

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To determine the coefficients A_k in equations (21), set $R_0 = \bar{R}_0$, and $\epsilon_T^+ = \omega_T^+ = \bar{m}$:

$$\epsilon_T^+ - \bar{e} = \sum_{k=1}^{3} A_k exp(\rho_k T), \quad \omega_T^+ - \bar{e} = \sum_{k=1}^{3} A_k \frac{(\Psi - \rho_k)}{\Psi} exp(\rho_k T), \tag{A9a}$$

$$\bar{R}_0 - R^* = \Theta^{-1} \sum_{k=1}^{3} A_k [\frac{(\Psi - \rho_k)}{\Psi}(\nu c_2 \eta \rho_k + \pi_1) - (\Omega \rho_k - \pi_2)]. \tag{A9b}$$

Solving this system yields

$$\Delta^{-1} A_1 = (\epsilon_T^+ - \bar{e})[\delta_3 (q_2 - 1) exp(\rho_2 T) + \delta_2 (1 - q_3) exp(\rho_3 T)]$$
$$+ (\bar{R}_0 - R^*)(q_3 - q_2) exp[(\rho_2 + \rho_3)T],$$

$$\Delta^{-1} A_2 = (\epsilon_T^+ - \bar{e})[\delta_3 (1 - q_1) exp(\rho_1 T) + \delta_1 (q_3 - 1) exp(\rho_3 T)]$$
$$+ (\bar{R}_0 - R^*)(q_1 - q_3) exp[(\rho_1 + \rho_3)T],$$

$$\Delta^{-1} A_3 = (\epsilon_T^+ - \bar{e})[\delta_2 (q_1 - 1) exp(\rho_1 T) + \delta_1 (1 - q_2) exp(\rho_2 T)]$$
$$+ (\bar{R}_0 - R^*)(q_2 - q_1) exp[(\rho_1 + \rho_2)T],$$

where, for $k = 1, 2, 3$,

$$q_k = (\Psi - \rho_k)/\Psi,$$

$$\delta_k = \Theta^{-1}[\frac{(\Psi - \rho_k)}{\Psi}(\nu c_2 \eta \rho_k + \pi_1) - (\Omega \rho_k - \pi_2)],$$

$$\Delta = exp(\rho_1 T)[\delta_3 (q_2 - q_1) exp(\rho_2 T) + \delta_2 (q_1 - q_3) exp(\rho_3 T)]$$
$$+ \delta_1 (q_3 - q_2) exp[(\rho_2 + \rho_3)T].$$

From the definitions given above, $q_1 > 0$, while q_2, $q_3 \gtrless 0$. As a result, we also have $q_2 - q_1 < 0$, $q_1 - q_3 > 0$, and--if q_3 denotes the highest positive root--$q_3 - q_2 < 0$. Thus, $\Delta \gtrless 0$. Setting $c_2 \to 0$ yields $\delta_1 > 0$, while δ_2, $\delta_3 \gtrless 0$. In general, therefore, the sign of

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the coefficients A_k cannot be determined *a priori*.

Assume, however, that T is large enough. Then, for $\bar{R}_0 - R^* > 0$ and $\epsilon_T^+ > \bar{e}$:

$$\Delta \rightarrow \delta_1(q_3 - q_2)exp[(\rho_2+\rho_3)T],$$

$$A_1 \rightarrow (\bar{R}_0 - R^*)/\delta_1 > 0,$$

$$A_2 \rightarrow (\epsilon_T^+ - \bar{e})(q_3 - 1)exp(-\rho_2 T)/(q_3 - q_2) > 0,$$

$$A_3 \rightarrow (\epsilon_T^+ - \bar{e})(1 - q_2)exp(-\rho_3 T)/(q_3 - q_2) < 0,$$

with $|A_3| > |A_2|$. Setting $t = 0$ in equations (21), it can be established that $\omega_{0^+} > s_{0^+}$, which, in turn, implies that $p_{0^+} > s_{0^+}$.

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